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Symposium on the Use of Herbicides in Forestry

February 21-22, 1978
Crystal City Marriott Hotel
Arlington, Virginia

United States Department of Agriculture
United States Environmental Protection Agency

SYMPOSIUM ON THE USE OF HERBICIDES IN FORESTRY

February 21–22, 1978

Crystal City, Marriott Hotel
Arlington, Virginia

United States Department of Agriculture
United States Environmental Protection Agency

COORDINATOR
David E. Ketcham

MODERATORS
Jan B. Wine, EPA
Barry Flamm, USDA

An addendum of papers presented after the Symposium is being distributed to recipients of these proceedings.

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20250

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TO ALL WITH AN INTEREST IN THE NATIONAL SYMPOSIUM ON THE USE OF HERBICIDES IN FORESTRY

The information presented at the February 22-23, 1978, Symposium on the Use of Herbicides in Forestry has resulted in the issuance of a revised Forest Service policy on pesticide use, a copy of which is enclosed. The new policy emphasizes our commitment to work closely with the U.S. Environmental Protection Agency (EPA) in the registration of all pesticides and to use only pesticides that are fully registered for the intended use.

No bans on either materials or methods are included in the revised policy because this type of action is automatic in response to any suspension or cancellation notices issued by EPA. The policy emphasizes the use of integrated pest management techniques for solving our pest problems. Where it is necessary to use pesticides, the new policy more clearly indicates that they will be applied only under very exacting conditions and in a carefully supervised manner. The policy strengthens current policy on the use of alternatives such as mechanical and manual brush control methods wherever feasible. Aerial applications will receive special scrutiny under the new policy and this method will only be used where there are significant advantages over other possible methods.

The revised policy also includes a provision for posting treated areas to inform potential users that herbicides have been applied.

I believe this new policy reflects our continuing concern over the possible adverse effects from the use of pesticides. It also permits enough management flexibility to enable us to carry out our land management responsibilities. We hope you concur. The FS policy will be incorporated into our USDA policy on management of pest problems.

Your continued interest in this issue is much appreciated.

M. RUPERT CUTLER
Assistant Secretary for Conservation,
Research, and Education

Enclosure

FOREST SERVICE MANUAL
Washington, DC

INTERIM DIRECTIVE NO. 1 April 27, 1978

DURATION: One year after issuance date unless previously terminated or reissued

CHAPTER: 2140—PESTICIDE-USE MANAGEMENT

POSTING NOTICE: This is the first ID issued in FSM 2100

This is a revision of FS policy on pesticide-use management.

2140.3—Policy. It is Forest Service policy, as required by Secretary's Memorandum No. 1929 dated December 12, 1977, to develop, practice, and encourage the use of integrated pest management methods, systems, and strategies which provide adequate protection against significant pests with the least hazard to man, his possessions, wildlife, and the natural environment. Natural control and selective measures are to be adopted as rapidly as possible. Integrated pest management may include the use of chemical pesticides; however, the following considerations and precautions must be observed prior to and during their use:

1. Pesticides may be recommended and used in operational projects only after consideration of alternatives—based on competent analyses of effectiveness, specificity, environmental impacts, and benefit-cost—clearly demonstrates that use of the pesticide is essential to meet management goals. The full range of alternatives—including manual, mechanical, and silvicultural methods—must be considered. High-priority attention should be given to the utilization of employment opportunity programs and other oportunities to create jobs.

2. The requirements of Title I of the National Environmental Policy Act of 1969 (P.L. 91–190) must be met by following the process required in FSM 1950. Title I of NEPA requires Federal agencies to ". . . maintain conditions under which man and nature can exist in productive harmony."

3. Only pesticides registered by the U.S. Environmental Protection Agency (EPA) in full accordance with Federal Insecticide, Fungicide, and Rodenticide Act, as amended, may be used, except as otherwise provided in regulations, orders, or permits issued by EPA. All such exceptions will be closely monitored. EPA-approved label instructions will be followed to the letter.

4. The herbicides 2,4,5-T, Silvex, or other materials containing TCDD may be used *only* where no other environmentally acceptable and economically feasible alternative, nonchemical or chemical, is registered

or available. Cost-effectiveness will not be the sole criterion. When a decision is made to use these pesticides, the Assistant Secretary for Conservation, Research, and Education shall be provided the opportunity to review the decision prior to implementation.

5. Where endangered or threatened animal or plant species habitat is involved, pesticides may be used only after it is determined, in conjunction with Federal and State wildlife management agencies through the environmental impact statement process, that such use will adversely affect neither the species nor its critical habitat.

6. Pesticides will not be used in Wilderness areas; exceptions to this prohibition may be only where necessary to prevent the loss of significant aspects of the Wilderness area or to prevent significant losses to resource values on public or private lands bordering the Wilderness. The use of pesticides in a designated Wilderness must be approved by the Chief.

7. Pesticide application and use must be controlled in a manner that assures adequate safety. Spills, accidents, misapplication, and any other contamination are to be avoided. Quality control monitoring will include a determination of the adequacy of application procedures and accomplishment of objectives. Treated areas will be posted with appropriate signs indicating the name of the material used and date of application to ensure that potential forest users, such as berry-pickers, are informed of possible exposure to pesticides. In addition, the project officer will confirm that all persons in or near the treatment area are notified in time to leave the area.

8. Pesticides and pesticide containers will be transported, stored, and disposed of in accordance with Federal, State, and local laws and regulations in a manner which will safeguard public health and wildife, prevent damage to plants, and prevent soil and water contamination.

9. All Forest Service project applications will be supervised by Forest Service personnel trained in pesticide use and with authority to suspend operations, such as when atmospheric conditions change abruptly or other factors make it necessary.

10. The rights-of-way management plans of highway, road, transmission line, railroad, and other maintenance departments and county weed control plans will be reviewed and approved by the Forest Supervisor to ensure that all uses of pesticides on National Forest System lands conform to this directive and Department policy and that chemical treatments are necessary and properly applied. Use of alternatives to chemical herbicide treatment may be required.

11. When applying pesticides in sensitive situations, appropriate environmental monitoring will be carried out to determine amount of drift, if any, into nontarget areas and to detect unanticipated nontarget effects.

12. A comparison of ground and aerial applications—including costs, safety, effectiveness, and possible consequences of drift to adjacent lands or water—must be made whenever herbicides are to be used. Aerial application methods shall be used only when advantages over ground methods are significant. Herbicide aerial applications should be made with invert emulsions, particulating agents, or similar materials to ensure positive placement. The possibilities of drift to nontarget areas will be minimized in all applications.

13. Special attention will be given to all restricted-use pesticide handling and use precautions. Restricted-use pesticides shall be used only by personnel who are certified or who are under the direct supervision of a certified applicator (FSM 2143.2).

In addition, it is Forest Service policy to conduct and support research to develop and to evaluate the effectiveness and environmental safety of pest management technology—including new and improved pesticides, formulations, application timing, pest management tools, and methods—and to effectively transfer this technology to minimize costs and adverse environmental and health impacts.

JOHN R. McGUIRE
Chief

ID No. 1
4/27/78

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20250

April 27, 1978

Subject: Pesticide Policy

To: John R. McGuire
Chief, FS

The intense public controversy over the use of 2,4,5-T and other dioxin-contaminated herbicides on the National Forests is a matter of great concern to me. I know that you are exercising close oversight on this matter and that your field personnel have been reminded of the need for extreme care in the use of all pesticides.

While I have been assured that proper use of this pesticide does not represent an undue risk, there are conflicting reports and unanswered questions. USDA is cooperating with the EPA in its review of the benefits and risks associated with use of 2,4,5-T—the so-called "RPAR" process. Until this review is completed and the controversy resolved, I wish to personally review Forest Service decisions to use 2,4,5-T, Silvex, and any other dioxin-contaminated herbicides.

In your Interim Directive setting the FS Pesticide Policy (2140.3), please provide for my review of these decisions prior to implementation. The short period required for my review will not cause serious delays in field applications where analyses and plans are adequate.

M. RUPERT CUTLER
Assistant Secretary for
Conservation, Research, & Education

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

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REPLY TO: 2140 Pesticide Use Management April 27, 1978

SUBJECT: ID No. 1

TO: Regional Foresters

The enclosed ID and letter from Assistant Secretary Cutler to me define a new pesticide use policy for the FS. As you are aware, the primary issue of public concern is 2,4,5-T and other herbicides containing dioxin (TCDD). Specific instructions are contained in this ID concerning those herbicides. I wish to call your attention particularly to paragraphs 1, 4, and 7.

Paragraph 1 emphasizes the need to consider all alternatives for management. We must do a thorough and objective analysis.

Paragraph 4 provides for *all decisions to use 2,4,5-T,* Silvex, or other materials containing TCDD, to be reviewed by the Assistant Secretary prior to implementation. *We will implement the review process immediately* for all decisions that have not been implemented.

Dr. Cutler has assured us of prompt review; however, it will be necessary for you to provide adequate information for him to judge your decision. He will be looking closely at both the human health risk and your analysis of alternatives. I urge you to examine your decisions closely in the context of his letter of April 27 and this ID.

If you have questions concerning status of decisions made prior to April 27 but not yet implemented, call John C. Barber (447-3331).

Paragraph 7 requires that areas treated with pesticides be appropriately signed to warn potential users. It also requires the project officer to confirm that all persons in or near the area have been notified. The length of time signs must be posted will depend on the individual situation, but they must be posted until you are sure that the area presents no unnecessary risk to the user from eating or handling contaminated plants or other material.

This ID is being transmitted by telecopier to ensure prompt distribution to Regional Foresters. Normal mail distribution will be made as quickly as possible, probably within 2 weeks.

JOHN R. McGUIRE
Chief

Enclosures

O'Connor (202) 447-4211
Patrick (202) 447-4026

FOREST SERVICE PESTICIDE USE POLICY ANNOUNCED

WASHINGTON, April 27—Forest Service decisions to use 2,4,5-T and related herbicides on national forests will now be reviewed by the assistant secretary of agriculture for conservation, research and education prior to implementation. That directive is contained in a new policy statement on pesticide use issued today by the Forest Service.

Assistant Secretary M. Rupert Cutler said while he has been assured proper use of this pesticide does not represent an undue risk, he is concerned by the public controversy over the use of 2,4,5-T and other dioxin-contaminated herbicides on the national forests.

"The U.S. Department of Agriculture is cooperating with the Environmental Protection Agency in its review of the benefits and risks associated with use of 2,4,5-T," Dr. Cutler said. "Until this review is completed and the controversy resolved, I wish to personally review Forest Service decisions to use 2,4,5-T, Silvex and any other dioxin-contaminated herbicides. The short period required for my review will not cause serious delays in field applications where analyses and plans are adequate," he said. The review will not affect previously approved projects which are currently underway.

The interim directive provides that areas to be treated with pesticides will be posted to insure potential forest users are aware of possible exposure. Before such application, persons in or near treatment areas will be notified in time to leave.

Trained Forest Service personnel will supervise all applications of pesticides and the Project Officer will have authority to suspend operations when any conditions such as a change in weather make it necessary. Appropriate environmental monitoring will be carried out to determine the amount of drift, if any, into nontarget areas and to detect unanticipated nontarget effects.

The herbicides 2,4,5-T Silvex or other materials containing dioxin will be used only where there are no environmentally acceptable and economically feasible alternatives.

The pesticide use policy is contained in a Forestry Service Interim Directive issued today which will guide field units in pesticide use.

5981 USDA 1221–78

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February 21 8.30 a.m.	Introduction	*David E. Ketcham* Coordinator
	Keynote addresses:	
	Purpose of symposium, current USDA policy, overview of the use of herbicides in forestry, environmental issues.	*M. Rupert Cutler* USDA
	EPA's involvement in the use of herbicides in forest and vegetation management, how EPA relates with USDA and the private sector, legal authorities (including history of FIFRA legislation), and registration and regulation of forest and management uses.	*Edwin L. Johnson* EPA
	Report on the first National Meeting of Citizens Opposed to the Use of Herbicides in the National Forests.	*Kent Shifferd* Coalition of Economic Alternatives
10:00 a.m.	BREAK	
10:30 a.m.	Moderator: *Jan B. Wine*, EPA	
	Problems associated with obtaining sound data required for registration of herbicides in order to assure that their usage be effective and not result in unreasonable adverse effects to man and his environment.	*Etcyl Blair* Dow Chemical Company
	Panel: Jack Early, National Agriculture Chemical Association Chester L. Foy, Weed Science Society of America Maureen Hinkle, Environmental Defense Fund William Wells, Office of Special Pesticides Review, EPA	
11:45 a.m.	LUNCH	
1:15 p.m.	Families of chemicals commonly used as herbicides—their methods of application, purity, emulsifiers and carriers, modes of action, and selectivity	*James Witt* Oregon State University

1:45 p.m.	Toxicology of families of chemicals used as herbicides in forestry.	*Morris Cranmer* National Center for Toxicological Research
2:15 p.m.	BREAK	
2:45 p.m.	Fate in the environment of families of chemicals used as herbicides in forestry: monitoring, breakdown and residues under conditions of use, physical movement, food chain accumulation, and human and environmental safety when applied.	*Virgil Freed* Oregon State University
	EPA monitoring study.	*Carolyn Offutt* EPA
	Human and environmental monitoring for herbicides used in forestry	*Frederick Kutz* EPA
	Panel: Philip Kearney, Agricultural Research Service Renate Kimbrough, Communicable Disease Center Calvin Menzie, Fish and Wildlife Service Matthew S. Meselson, Harvard University Logan Norris, Forest Service George Streisinger, University of Oregon Gunter Zweig, EPA	
	The evaluation of possible health hazards from TCDD in the Environment	*Matthew S. Meselson* Harvard University
4:30p.m.	ADJOURN	
February 22 8:30 a.m.	Continuation of previous day's topics	
	Assessment of hazards posed by TCDD	*George Streisinger* University of Oregon

8:45 a.m.	Moderator: *Barry Flamm*, USDA	
	Overview of the use of herbicides in resource management on public, industry, and nonindustrial private lands—including rationale for vegetation management in such activities as regeneration, competition for growing space, fuel management, wildlife habitat improvement, aesthetics, rights-of-way, water yield, etc.	Public: *Thomas Nelson* Forest Service Industrial private: *William Lawrence* and *Jack Walstad* Weyerhaeuser Corp. Nonindustrial private: *Thomas A. Dierauf* Virginia Division of Forestry
10:00 a.m.	BREAK	
10:30 a.m.	Timber management: alternative methods of vegetation management, comparison of alternatives, overall effectiveness in specific situations, environmental tradeoffs, benefit/cost analyses, long-term achievement of goals and objectives, and the resources required to achieve the goals and objectives.	*Mason Carter* Purdue University
	Panel: Dudley Mattson, EPA Michael Newton, Oregon State University Kent Shifferd, Coalition for Economic Alternatives T. H. Silker, Oklahoma State University Stevens Van Strum, Citizens Against Toxic Sprays	
11:45 a.m.	LUNCH	
1:15 p.m.	Range management: alternative methods of vegetation management, comparison of alternatives, overall effectiveness in specific situations, environmental tradeoffs, benefit/cost analyses, long-term achievement of goals and objectives, and the resources required to achieve the goals and objectives.	*Charles Scifres* Texas A&M University
	Panel: Ray Dalen, Forest Service Stephen Hager, Citizens Against Toxic Sprays Ron Kuhlman, Bureau of Land Management Howard Morton, University of Arizona (ARS) James Young, University of Nevada at Reno (ARS)	

2:00 p.m.	BREAK	
2:30 p.m.	Rights-of-way maintenance: alternative methods of vegetation management, comparison of alternatives, overall effectiveness in specific situations, environmental tradeoffs, benefit/cost analyses, long-term achievement of goals and objectives, and the resources required to achieve the goals and objectives. **Panel:** W. R. Byrnes, Purdue University Daniel Cassidy, Landscape Specialist Jeff Davis, New York Public Service Commission Edward Grassel, Bonneville Power Authority Hyland Johns, Asplundh Tree Expert Company	*W. A. Niering* Connecticut College
3:15 p.m.	Fire, wildlife, recreation, and water management: alternative methods of vegetation management, comparison of alternatives, overall effectiveness in specific situations, environmental tradeoffs, benefit/cost analyses, long-term achievement of goals and objectives, and the resources required to achieve the goals and objectives. **Panel:** Fred Arnold, EPA Mary Burks, Alabama Conservancy Gerald Mackie, HOEDADS, Incorporated Jerry Moore, EPA Charles Walker, Fish and Wildlife Service	*Lloyd Andres* University of California at Albany
4:00 p.m.	Summation of symposium and followup.	*John R. McGuire* Forest Service

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INTRODUCTION

MR. KETCHAM: I am Dave Ketcham, Symposium Coordinator. It is a real pleasure to welcome you to the USDA/EPA Symposium on the Use of Herbicides in Forestry.

We have a real controversial and challenging subject to discuss, one that is of tremendous interest to all of us. We have assembled a highly competent and articulate group of speakers and panelists for you today. They are knowledgeable about their subjects and they represent, I think, a varied and diverse viewpoint on the use of herbicides.

In case you are wondering, we did not select these people by accident. There was great malice aforethought. There were a number of us who worked on it. We had representatives from the Environmental Defense Fund, the Science and Education Administration within USDA, the Forest Service, and EPA. We also have a little different format here than we have had in previous similar symposiums. We have done this to get full and penetrating discussion of all the issues.

We have panels, for example, to discuss the issues rather than to try to do this from the floor. We figure with this many people and this particular subject with the short time we have, we wouldn't be able to make it all from the floor. So we do have the panelists to handle the detailed discussion. There are note-cards available so that any of you from the floor that have questions you want to hear discussed can pass them to the aisles, and we will have people to pick them up to give them to the panel moderators. They can then build your questions or comments into the discussions.

This is the best that we could do under the situation. Since we would like to do better during the session, we have set up an extra session for informal discussion this evening from 5:00 to 7:00 in room 207 in the hotel. You might make a note of that. If you forget it, you can ask me later. I have it written down.

Dr. Cutler will be there; Mr. Johnson will be there. Many of our speakers and panelists will be there, and, of course, we hope that you will be there too.

Following the symposium, we will welcome any comments that you might have on the symposium itself or on the issue. We would be very interested in your comments in the form of critique. In other words, if USDA or EPA should do something like this again, how can we do it better next time? We are trying a little different approach at this symposium. We will be interested in getting your feedback on how you think it worked. Of course, as I said, if you have other comments that you want to add to get input to Dr. Cutler or Mr. Johnson or any of the rest of us, we will be happy to have those, too, in written form.

Following the symposium, we will have published proceedings. All of the papers that are given here in the next few days will be included. A transcript of the panel discussions will be included, and we hope to have them out promptly. It takes time; but we will try to get them out within the next 2 to 3 months.

We have tried to hold our costs down here so that the cost of the symposium itself would not be a barrier to anybody who would like to attend. We found USDA and EPA could take care of everything except coffee breaks. So the National Forest Products Association has graciously consented to pick up the tab for that. Your coffee is courtesy of the National Forest Products Association. The coffee will be in the lobby at the break at 10 o'clock. We also have maps of the restaurants outside in the folders. I don't know whether you all get as lost around here as I do; but if you are looking for a place to eat, there are maps that you can pick up to help you find what you want for lunch.

As I said, any questions or problems or anything else here as the next 2 days go by, contact me or any of the staff, and we will be happy to help you.

I have been asked to announce that you are welcome to smoke in the lobby—but apparently not in here.

With those preliminary remarks, I would like to go ahead and move into our agenda.

Our first speaker has a bachelor's degree in Wildlife Management from the University of Michigan. He has master's and Ph.D. degrees with the Department of Resources with Michigan State University. His doctoral dissertation was on Forest Service litigation and its impact on policy, so this ought to make him uniquely qualified to talk on the subject we have today.

It is a real pleasure for me to present at this time our Assistant Secretary of Agriculture for Conservation, Research, and Education, DR. RUPERT CUTLER.

KEYNOTE ADDRESS

M. Rupert Cutler

A major task in our Department today is accelerating the discussion of pesticide issues in the best interests of people and the environment. On this broadly stated objective I am sure we are all of one mind. It is a good starting point for our discussions here. Starting out together, we should not wind up far apart.

I hope this will be a conference in which presentations and responses are as objective as possible. Let's try to avoid emotionalism. We have lots of room for the relevant, hard information that I know you have. The exchange of information is what we are here for.

A good way to examine the need for reform is to look at one's own shop first. It helps improve your objectivity, flexibility, and credibility. In this spirit we are reviewing the use of herbicides in forestry to further develop and apply the Department's updated pest management policy. We are respectful of the technology that has brought us this far. But we are amenable to change when the need to change is evident.

Our mission in the Agriculture Department is to assure enough food, fiber, and forest products for the American people and for foreign trade at a price the American consumer can afford. How well we accomplish this depends in large part on how well we can manage pests that attack our crops and trees, while at the same time we protect the environment as it is broadly defined.

The use of herbicides figures prominently into this responsibility. That is why I am vitally interested in what takes place today and tomorrow.

At all times we view herbicides as a part of the whole—the whole being integrated pest management. We have sworn an oath in the form of USDA Policy on Integrated Pest Management. That policy is to develop, practice, and encourage integrated pest management methods, systems, and strategies that are practical, effective, and energy-efficient.

We want the most protection against pests with the least hazard to man and nature. So the development of natural controls and selective measures is high on our list of priorities.

This policy is consistent with President Carter's Environmental Message to Congress last May in which he instructed the Council on Environmental Quality:

". . . to recommend actions which the Federal Government can take to encourage the development and application of pest management techniques which emphasize the use of natural biological controls like predators, pest-specific diseases, pest-resistant plant varieties, and hormones, relying on chemical agents only as needed."

After consulting with numerous outside organizations and individuals, the USDA Pest Management Work Group, established last spring, developed our present policy statement for the Secretary's approval. The Work Group will continue to review and advise its implementation. We are now committed to support accelerated development and application of effective and realistic pest management practices. We have the lead responsibility in the Federal departments for research, development, evaluation, technology transfer, and program assistance on pest management.

We have reorganized to better accomplish this. In my area of responsibility four agencies were combined into one, the Science and Education Administration (SEA). The new agency's main mission, cooperating with other Federal departments and agencies, the States, universities, and user groups, is to conduct and support research, extension, and teaching programs in the food and agricultural sciences.

These programs must be responsive to local, State, regional, national, and world needs. Natural and renewable resources, forestry, and range management are included. Integrated pest management programs are the kind of activities that fit very well into this new concept.

In forestry integrated pest management must be an integral part of the total management of forest resources. Truly integrated pest management requires real multidisciplinary participation not only in the research and development phases but also in the practical application of the materials.

With this general background I would like to turn to current matters that concern us all.

The Department of Agriculture has oversight responsibility for over 187 million acres of Federal forests and 350 million acres of cropland—both major areas of herbicide and pesticide use.

Herbicides are currently being used for a variety of management activities: (1) reforestation, (2) timber stand improvement, (3) fire protection [both field and around facilities], (4) rights-of-way maintenance, (5) range improvements, (6) noxious weed control, (7) wildlife habitat improvement, and (8) watershed management.

The amount of herbicides used in forestry, although small in comparison to agricultural uses, is significant.

About 120,000 pounds of 2,4,5-T were used on 48,000 acres of National Forest System lands during fiscal year 1976. Probably close to 1.5 million acres of commercial forest land are treated each year with herbicides. Without the development of still more alternatives, the use of herbicides would undoubtedly increase. More timber and other forest products and services are needed for an expanding population. And the forest land base is shrinking.

The ultimate test of this situation is in the marketplace. Softwood lumber prices exceeded the $1000 per thousand board feet mark for the first time recently. Sharply rising prices for lumber narrow our ability to provide adequate housing for everyone.

Generally speaking, herbicides are applied only once or twice to the same area over a rotation period of 40 to 100 years. They are the primary tool in rehabilitating unmanaged forests and in improving the productivity of newly regenerated forests. Where they are not used in forest brush control, yields can be cut 50 percent or more.

Clearly, chemicals are essential to the propagation and maintenance of forests. At issue is how they are used. Is it with the least possible impact on the environment?

The people of this country are highly aware of the environment and its complexities and have an appreciation for the diversity of species. They also are concerned about the impact on nontarget species, including us humans, of the over 1 billion pounds of pesticides that we release into our environment each year.

The best estimate is that there are 63,000 plus chemicals in common use today. In forestry we are concerned with about 70 herbicides, alone and in combination. It is this list we want to focus on at this symposium.

The use of herbicides is currently an intense public issue in the Pacific Northwest, California, the South, and the Lake States. Concern ranges from complaints of headaches by those living near treatment areas to allegations that forest herbicide applications cause cancer.

Those of us who must establish policy and make decisions have extensively reviewed the evidence presented by all interests. The facts are elusive.

Part of today's concern on herbicides' impact on the environment and human health—particularly 2,4-D and 2,4,5-T's impact—grew out of a 1969 charge that an increase in human birth defects in Vietnam was caused by "Agent Orange," a mixture of these two herbicides used to defoliate jungles. Complaints at home from people who lived near treated forest areas began to receive wide attention in the news. However, because of the more concentrated and volatile ingredients used in "Agent Orange," the Vietnam experience is not comparable to the current use of herbicides in the United States. The most that we can say is that a relationship exists, but one that easily can be overstated.

In 1970 the uses of 2,4,5-T in lakes, ponds, on ditch banks, and around homes and recreation areas were suspended. This action strengthened the contention that 2,4,5-T is hazardous to human health. Although uses on forests, rangelands, and noncrop areas were not affected, the dioxin contaminant (TCDD) is causing doubt now on the future uses of this herbicide—as well as the future uses of silvex in any situation.

We know that 2,4,5-T is useful in improving big game winter range. At the same time it is suspect in the deaths of almost 8000 steelhead trout in a fish hatchery operated by the Oregon State Fish and Game Department. This and similar issues will be discussed by the resource panels tomorrow.

Some environmental groups are pressing for action at all levels.

Last October, in a meeting with Forest Service Chief John McGuire, the Sierra Club Legal Defense Fund formally asked the Forest Service to discontinue the aerial application of all herbicides, particularly 2,4,5-T and silvex. Aerial applications that may drift and cause large-scale contamination were of special concern to them. Their request was denied because Forest Service scientists believe that aerial application is the only practical and economical way to apply herbicides on many forested sites. They also believe, as I understand them, that by using proper procedures in accordance with registered label instructions, even 2,4,5-T and silvex can be used safely without unreasonable risk to man or the environment. It is estimated that 75 percent of all pesticides used on agricultural and forested lands in the United States are applied by aircraft.

Because it is so toxic, we are especially concerned over the TCDD contaminant in 2,4,5-T and silvex formulations and its significance in terms of human exposure and environmental consequences. But we seem unable to determine at what level this contaminant occurs as a result of forestry operations, or even if there is some no-effect level.

We want to know more about possible adverse effects of burning areas treated with herbicides. It is possible to produce TCDD by heating or burning 2,4,5-T in a laboratory test with high concentrations and low oxygen conditions. I'm advised that this will not occur in open forest or rangeland burning. TCDD decomposes at temperatures above 800 degrees centigrade, considerably below the temperatures of 1200 degrees centigrade or more achieved in the field with a free exchange of air. This evidence may indicate that there is no reason for special concern. We should explore this during this symposium.

We need answers to the questions: What happens to the TCDD? Where does it go? How long does it last? Does it bioaccumulate? At what levels in the environment does it present an unreasonable threat?

The Forest Services uses herbicides only when needed, only when registered for the use intended, only at recommended rates, and under very controlled conditions. I am confident that most, if not all, other forest and rangeland managers follow these same high standards. Most applicators are highly experienced in the use of herbicides, and all applicators will be certified under an EPA-approved plan whenever restricted-use herbicides are used.

Many of our questions on safety, possible adverse nontarget effects, and human health relate directly to the registration process and probably can be more adequately addressed in that forum than they can be here. However, I am sure that much of the information exchanged at this symposium will have a direct bearing on key registration questions.

Assessments of risk are being made by EPA. These findings may enable applicators to continue to use even highly toxic materials if the risks are low and the benefits high. EPA makes important decisions on what herbicides will be available for future use in forestry. We will continue to work with EPA to ensure that the best available information is used in making risk/benefit evaluations.

Our joint assessment teams are currently doing this in an effective way for all pesticides that may be subjected to EPA's Rebuttable Presumption Against Registration process.

This is an extremely complex subject, and perhaps at this point it is worthwhile to discuss in detail some of the legal aspects of this problem.

Several lawsuits have challenged herbicide use in recent years based principally upon the National Environmental Policy Act (NEPA), and one case highlights the dimensions of this matter. The case in point is Citizens Against Toxic Sprays (better known by the acronym CATS) versus Butz which challenged the Forest Service's herbicide program for vegetation management in Oregon's Siuslaw National Forest. Of particular concern was the question of the safety of 2,4,5-T because of its potential for contamination by TCDD, one of the most toxic compounds ever synthesized. In an order rendered in March 1977, U.S. District Judge Skopil found that an elaborate Forest Service environmental statement was legally inadequate under NEPA because it failed to consider the effects of the herbicide program on human health or to acknowledge the serious questions of safety related to TCDD hazards. Nor did it discuss adequately alternatives to herbicide use.

The Government may pursue its appeal in this case, although the Forest Service is preparing a revised environmental statement so as to comply with the Court's order. However, the case is troubling for resource managers and administrators because it presents difficult questions of when, if ever, one has sufficient up-to-date information to make a reasoned judgment about the propriety of herbicide use.

In the CATS case the Forest Service relied on the registration of the herbicide by the Environmental Protection Agency as definitive on the question of safety and potential hazards to human health. Yet, under the Court's order, the Forest Service will need to reassess the issue of health and safety in the context of each use.

The problem to be resolved is how far must the user of the registered product go in considering health issues to meet the judicially decreed standards for NEPA compliance? At a minimum we will need to assess potential efforts of possible TCDD contamination on the forest ecosystems and how that might affect human health.

The Court's order also requires discussion in an environmental statement of the curent state of scientific knowledge and opinion about the phenoxy herbicides and TCDD. The actual mechanics of this are difficult. I suspect it is difficult for EPA, the agency responsible for the registration of such substances, much less for the Forest Service and other users of herbicides, to keep abreast of current research.

The eventual outcome of this and similar cases is unclear since the questions may have to be addressed in the appeals courts, the regulatory agencies, and the Congress. The law does push us to the ultimate resolution of the matter by formulating substances that are biodegradable without TCDD or like substances. The stakes for a solution are high, for a cessation of the use of herbicides could affect as much as 10 million board feet of timber annually harvested from the National Forests.

In closing, let me say that the primary purpose of this symposium is to share information useful in making decisions on the use of herbicides in forestry. The information, I assure you, will form the basis for improving and updating USDA policy on herbicide use.

Many of you have first-hand experience in using herbicides to control vegetation. You know something of the effects of herbicides on human health and the environment. I am pleased at the outstanding credentials of our speakers and panelists. The information presented here will be studied and discussed in other forums. To facilitate this, a complete proceedings will be published. A copy will be sent to each of you. The proceedings will include the exchanges that take place during panel discussion following each of our main speakers. Please make liberal use of the question slips to share any helpful information you may have. Thank you.

MR. KETCHAM: Thank you, Rupe. I guess most symposiums have one keynoter. We thought we could do it right and have two. Our next keynoter has a bachelor's degree in Civil Engineering from Yale University. He has a master's in Public Administration and another master's in Economics, both from Harvard. It is a real pleasure to introduce to you at this time our next speaker, the Deputy Assistant Administrator for Pesticides Programs of the Environmental Protection Agency, MR. ED JOHNSON.

MR. JOHNSON: Thank you, Dave. I would like to add my welcome to you for coming to the session today to the welcome given by Dave and Rupert. Many of you, I know, gave up your long holiday weekend to travel here so you could participate in this meeting. I think that kind of dedication and interest is typical of the whole issue and the questions involved in use of herbicides in forestry and vegetation management.

I look forward to sharing with you your views, the views of the scientists and the citizens here today, and especially to the question period that we will be having from 5:00 to 7:00 this evening.

KEYNOTE ADDRESS THE REGULATION OF HERBICIDES FOR USE IN FOREST MANAGEMENT

Edwin L. Johnson

It's really a pleasure to be here today and to be a part of this symposium. Dr. Cutler has given us a very informative and interesting overview of the USDA's involvement with forest herbicide use. I want to spend a few minutes now discussing my Agency's involvement with pesticides in general and with the special use of herbicides in forests. EPA is, of course, a regulatory agency. Our EPA Pesticide Program's primary involvement with forest-use herbicides lies in the enforcement of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

Other EPA programs regulate pollution from forestry and vegetation management practices which result in water or air pollution or solid waste disposal which may be accentuated or diminished by the choice to use herbicides or use their alternatives. Thus, issues involving the use of herbicides and their alternatives may be impacted by several Federal pollution laws, including the Water Pollution Control Act, Clean Air Act, Resource Recovery and Conservation Act, as well as the Pesticide Law. During the remainder of my time I will focus primarily on pesticide law; but as the symposium progresses, we must consider the effects of shifts from current herbicide use practices to alternatives in terms of changes in effect on other laws of pollution as well as their pesticidal aspects.

Under pesticide law we are responsible for the registration of new herbicides. We are responsible for the reregistration and classification of the herbicides which are already registered. And we are responsible for the cancellation or restriction of dangerous herbicides.

We also enforce the proper use of herbicides and the adherence to label directions for use and protection of nontarget animals, plants, and humans. Criminal and civil penalties are provided in the law for use of a pesticide in a manner inconsistent with its labeling. These provisions apply to all users—private or public—including USDA. There are only four ways to use a pesticide, regardless of the uses. Registered, Section 5 EUP, Section 18, and illegally under Section 3 or 24(c).

Along with our day-to-day registration and enforcement responsibilities, EPA wants to be involved with those interested in sound forest management in every way possible. We are interested in promoting good forest practices which rely upon the broadest consideration and integration of alternative pest management techniques. I will try to explain as simply as possible our regulatory mandate and our operating policies. I hope, in turn, as this symposium progresses, you can bring me up to date on new forest and vegetation management practices—their benefits and their risks. It is important that we at EPA understand both user needs and environmental and health risks so that we can properly regulate herbicides and other pesticides.

First, let me describe briefly the history of the regulation of pesticides in the United States. It dates back to 1910. The original Pesticides Act of 1910 provided that adulterated or misbranded products could not be manufactured or distributed. That was it. Since that time pesticide regulation has been broadened and strengthened. In 1938 Congress enacted legislation prohibiting the movement of foods in interstate commerce that were adulterated or misbranded. The Food and Drug Administration was charged with keeping illegal pesticide residues out of food. This was the beginning of the effort in the United States to establish tolerances for residues of pesticides in food and feed. Then, in 1947 when the original FIFRA was passed, provision was made for premarket registration of pesticide products to be shipped in interstate commerce. Now, under the FIFRA as amended in 1972, *all* pesticides must be federally registered, and they must be registered on a firm scientific data base. Several new EPA programs have grown out of this law. I will talk about these programs shortly.

Because the law is more stringent now than in the old days and science has moved forward rapidly in the development of analytical technology and health and environmental effects evaluation, regulation of pesticides has become a very complex proposition. For registration we now require a great deal of data on any proposed product: its toxicology, effects on the environment, its chemical composition and impurities, and its efficacy. We subject all proposed pesticides to a rigorous scientific review prior to registration. So now we have very stringent requirements, and we have a much better potential for protection of the public health than ever before. But as hard as these requirements may be for new registrations, we do not have the same data on older compounds—and generally the older the compound, the less data are available. So we must continue to improve our data and our risk/benefit assessments on the 1400 active pesticide ingredients, 1800 inerts, and unknown impurities which make up the 35,000 registered pesticide products. Included among these older pesticides are the forest herbicides we are here to discuss today, many of which were registered years ago.

Protection of the public health. No one would argue the importance of this goal. But, you say, what about the benefits of pesticides? Isn't our need for timber also important? Haven't alternatives to herbicides use often been found to be either unworkable or prohibitively expensive? Is the EPA's interest in zero public health risk going to blind them to the benefits of herbicides in forests? Are they going to cancel the herbicides necessary to keep our economy moving without concern for benefits? The answer is no. Our law requires consideration of both risks and benefits in reaching decisions. These assessments are both extremely complex in the case of forest herbicides. The Agency hopes to learn more today and tomorrow about risks and benefits of forest use of herbicides. We know you people who are dealing with these questions on a daily basis will be able to give us some good ideas. We hope to leave the symposium able to make future decisions more quickly and wisely.

Because of the widespread confusion about some of our programs, I want to spend the next few minutes talking about them. I want you to see the regulatory context which must overlay our discussions. First, a few words about registration of new pesticides. New registrations are about as scarce as pine cones on an oak. There are several reasons for this. For new chemicals it's primarily new data requirements; in other cases it's absence of data or trade secret and data confidentiality questions that are stumbling blocks. We think that we are well on the road to working out our problems. Last spring we went before the House Committee on Agriculture and the Senate Committee on Agriculture, Nutrition, and Forestry and asked for help. House and Senate bills are now awaiting resolution of differences by a conference committee scheduled to meet shortly. Though we want to maintain high safety standards, we realize that some of the requirements of our law, as presently worded, impose a severe burden on manufacturers and cause EPA to use its resources inefficiently. We have asked for several changes in the law.

I want to talk about a few of these proposed changes which I think are of particular interest to you.

First, we have asked that the Administrator be authorized to waive efficacy data requirements. We would like to be able to accept statements from experts in the field—State, Federal, and university researchers who are on the scene—that pesticides are effective. We, of course, intend to retain authority to call for efficacy data when we have any doubts. For instance, we will probably need efficacy data in order to make the difficult regulatory decisions on reregistration of herbicides for forest use.

Another change for which we have asked is the authority to develop an approach to registration which focuses on the safety of a broad chemical use—a technical product—rather than on every end-use product. This is called the *pesticide standard approach*. This approach would allow us to develop a data base and make risk/benefit findings of a broad nature for registration and reregistration decisions on the technical product. It would expedite basic risk/benefit decisions as well as registration of end-use products.

Another important issue is that of use of registration data. We have asked Congress for guidance as to what is—and what is not—a "trade secret." We have asked for clarification of what data can be used by EPA to support subsequent registrations and the ways that the costs of data development should be shared among registrants. We have asked for clarification of what is public information. We believe that the public should be unconditionally permitted to review the safety data upon which we rely. These changes will help us to treat manufacturers with fairness, to enhance the public's participation, to use EPA resources more effectively in the area of health and environmental protection, and to move the registration process forward once more.

Let me tell you now about our Rebuttable Presumption Against Registration (RPAR) process. RPAR, like the standards approach, is a part of the registration process. It is a public, intensive, risk/benefit review. The end result may be changes in or cancellation of the registrations of certain pesticides we suspect of being hazardous. The law requires us to review all current pesticide registrations in light of new data and new risk criteria. Then we are to reregister *only those* that meet the requirements and do not present unreasonable adverse effects when risks are weighed against benefits. As we review products for reregistration, some trigger a suspicion of risk and are referred for special assessment under the RPAR process. Our priority in reregistration review is to deal first with compounds that may cause unreasonable adverse effects.

When a pesticide is found to cause tumors or mutations in valid test systems, the EPA must initiate the RPAR process since there is no scientifically established threshold or safe level for such effects. For other health and environmental impacts, including birth defects, blood and nervous system disorders, and environmental impacts, it is presumed that a demonstrable no-effect level exists, and the relation of that level to exposure is considered in assessing that risk for RPAR purposes.

The important thing to remember about the RPAR process is that it is an intensive scientific review of the risks and the benefits of each of the triggered chemicals. We are involving registrants, user groups, environmental groups, and other Federal agencies in the process. The Department of Agriculture, for instance, has set up a group especially to provide benefits data for our RPAR reviews. As a matter of policy and practicality we will rely heavily on USDA to provide us with alternatives and their costs in assessing RPAR chemicals. The first step of the RPAR process is our assessment of risk. The risk criteria fall under these broad headings: acute toxicity, chronic toxicity, and lack of emergency treatment. Acute effects occur relatively soon after exposure to a substance, while chronic effects take much longer, even decades in some cases, to manfest themselves. Acute effects covered by the criteria include hazards to humans and domestic animals and hazards to wildlife.

Chronic effects covered by the criteria include: oncogencity—which indicates the potential to cause cancer; mutagencity—damage to the chromosomes which may cause inherited defects; other delayed toxic effects such as fetotoxicity—poisoning of the fetus; teratogenicity—birth defects; and reductions in populations of non-target plants or animals, particularly endangered species.

If we issue an RPAR notice based on risk criteria, the next stage of the process is begun. This is the rebuttal stage. Registrants, user groups, environmental groups, and any other interested persons may send the Agency data which either support or refute our presumption of risk. It is at this stage that many of you may want to become involved. After rebuttals have been submitted, we launch into the risk/benefit analysis stage. We began to accumulate date on efficacy, value of crops on which the RPAR'd pesticide is used, availability of alternative pest management techniques, exposure to man and the environment, and any history of adverse episodes. 'Use-benefit information, like risk information, is needed from outside sources.

A final decision on the registration status of any given RPAR'd chemical is made when all evidence has been analyzed by our Agency and after our proposed decision has been reviewed by the Department of Agriculture and the Science Advisory Panel, as required by 1975 amendments to the law. Examples of the types of decisions which might be made include (1) restriction of certain uses, (2) improved labeling, (3) cancellation of some uses, (4) cancellation of all uses, (5) other regulatory actions which would reduce risk, (6) suspension, or (7) simple reregistration.

Now, suppose that we do issue an RPAR on a forest herbicide. Suppose that all interested parties have submitted information both to support our risk assessment and to attest to the benefits of the compound. Now, what are our options? Must we cancel all uses? In many cases the answer will be yes, but also in many it will be no if the use of the compound is restricted.

This is where classification comes in. Classification is a way of reducing risks through restriction of use of some of our hazardous pesticides. Let me explain.

The 1972 amendments mandating classification make clear Congress's intent to provide alternatives to our old system of regulation. Up to this time we have had two options: we could ban pesticides entirely. Or we could allow their use by everyone regardless of training or competence. Classification of pesticides as "general use" or "restricted use" provides a much-needed alternative. We can now set aside certain hazardous pesticides for use by trained—certified—applicators only to avoid unreasonable risk.

The applicator certification program is now well underway. Many of you have had experience with the program, either in helping us develop it or by seeing that your people are certified. The first classification regulation, restricting the use of 23 currently registered pesticide chemicals, has just been published in the Federal Register. More chemicals will be added to this list soon. One herbicide which is used in forestry is on this list of 23. It is picloram—commonly associated with the trade name Tordon. All but one picloram product have been restricted because of the chemical's hazard to nontarget plants. The one excluded use is for a tree injection product.

So with this background material on our programs, let's talk specifically about forest-use herbicides. Several forest-use herbicides are under pre-RPAR review. Cacodylic acid and its salts are under review, along with monosodium methanearsenate (MSMA). These, as you know, are used for tree injection. Some of the phenoxy herbicides are also being reviewed—notably 2,4-D, 2,4,5-T, and related compounds. I know these are used to a significant extent in forest management programs. They are considered important in the conifer release program and are used widely in site preparation and vegetation management on rights-of-way.

There has not yet been an RPAR issued on a forest-use herbicide. We are now reviewing these chemicals to see if they indeed meet risk criteria which warrant issuance of an RPAR. 2,4-D is being reviewed because we have some evidence that it may be a tumor or cancer agent. We have not yet validated these studies raising this concern. 2,4,5-T is being studied because we feel that current studies show it may be a cancer agent and may cause birth defects due to its dioxin contamination. When our review of these chemicals is complete, we will decide whether or not to issue an RPAR on these phenoxy herbicides. Dioxins, one of the major focuses of our pre-RPAR review of 2,4,5-T, have been a concern of EPA and other groups for some time.

The regulatory history of one of these forest and vegetation management herbicides—2,4,5-T—has been long, scientifically complex, and administratively tortuous. Although others on this program will be discussing these matters in more detail as the Symposium progresses, I'll summarize the activities of EPA and others to put the time into perspective.

Action was taken in the early 1970's to suspend uses of 2,4,5-T in which direct human exposure could be expected: home uses, aquatic uses, recreation area use, and food crop use. These uses were cancelled—with the exception of uses on rice which was appealed to the courts by the registrant, Dow Chemical. The appeal resulted in an injunction against further regulatory action for over a year.

For the uses not cancelled as a result of the early 1970's actions, an Administrative Hearing was initiated in 1973 to assess the benefits and risks of continued use of 2,4,5-T. EPA withdrew from this hearing in 1974 since it had inadequate evidence of residues and exposure to the principal impurity of concern—tetradioxin (TCDD). The several parties to the hearing—EPA, Dow, USDA, and EDF—joined together to plan and carry out a cooperative program of sampling and monitoring to develop needed exposure data on these remaining uses of 2,4,5-T. This afternoon you will be hearing from members of my staff, Ms. Carolyn Offutt and Dr. Rick Kutz, about the dioxin monitoring program. This is a cooperative effort under the Dioxin Implementation Plan, which involves the EPA, the USDA, Dow Chemical, and the Environmental Defense Fund.

Exposure data are critical to establishing the degree of risk associated with the intrinsic hazards of TCDD. And exposure has been an elusive element in our evaluations to date.

The monitoring program worked for several years in the development of new chemical analytical methods capable of detecting dioxin at parts per trillion levels—the levels of concern for general population exposure. Samples of beef cattle have been analyzed using these sensitive techniques, as have a few environmental samples. Sampling human milk was begun last year in the Pacific Northwest to seek exposure evidence related to persons living in areas of 2,4,5-T use. Such samples will also be taken in Texas and Arkansas in the next months.

During these years of study the levels of TCDD in 2,4,5-T have been reduced drastically from several parts per million in the late 1960's to less than 0.1 parts per million today. At the same time citizen complaints and legal and political action at the Federal and especially the State level have multiplied.

And after several years of scientific study and the expenditure of hundreds of thousands of dollars, we are only beginning to piece together appropriate exposure data. It is clear that decisions cannot await completion of every study the benefits analyst or the risk scientist may wish to have. Yet we must have adequate legal and scientific basis for our regulatory actions.

You will hear more about all of these aspects as the Symposium proceeds today and tomorrow. We hope that EPA scientists will provide information useful to you as herbicide users, policymakers, and interested citizens. We, in turn, as regulators, hope to learn from you and to obtain a perspective on these pesticide uses that will better equip us to reach wise policy and regulatory choices regarding the use of forest and vegetation management herbicides in the near future. Thank you.

MR. KETCHAM: Thank you, Ed. As we have a little bit of time here at this point and knowing your interest in a rather unique meeting—unique in the sense that it was the first—there was a meeting yesterday of the Citizens Opposed to the Use of Herbicides in the National Forests. I would like to introduce DR. KENT D. SHIFFERD of the Coalition of Economic Alternatives from Ashland, Michigan, to give a report on this.

THE CITIZEN POSITION: AN OVERVIEW

Kent D. Shifferd

Good morning. I represent the citizens who asked for this Symposium. We are people who live and work in the National Forests. Most of us paid our own way here, either out of our own pockets, or in some cases, citizen groups and even city councils have sponsored us. We are here because what affects the forests affects us. We have different kinds of expertise, some by virtue of having lived through the experiences we describe.

We are not seeking confrontation, although we find ourselves confronted—at home, by the "economic poisons" the Forest Service is putting our environment, and here, by an agenda weighted in favor of the *status quo*.

We have but few slots on the panels and a mere 10 minutes to present our data and our critique of management by economic poisons. While 10 minutes might have been enough time for David to slay Goliath, David lived in simpler times. Speaking for people who live in the Forests, I will outline our six main concerns. Following this, our representatives will be in the room to detail each concern.

First, why is the use of phenoxy herbicides now in question, some 30 years after their introduction? There is an ancient maxim of Roman law on which our forefathers established this Republic. It goes, "That which touches all is the concern of all." The most fundamental right of a free people is the right to shape the world in which they live, especially when the issue is the pursuit of life, as well as liberty. Up until now the phenoxy herbicides have been assumed innocent until proven guilty. A recent EPA case study suggested, "One concern for the disappointing regulatory record (in cancelling dangerous pesticides) is that chemical products tend to have *de facto* due process rights." Do we really believe that nonliving chemical compounds which are potentially dangerous to human life should be protected by due process while there is, at the same time, no effective process to protect human beings from them? Our Constitution does not give rights to chemical compounds. Due process is a sacred privilege reserved to human beings.

If there has been but little evidence on which to indict the phenoxy herbicides up until now, it is partly because none was sought. Most medical doctors are not trained to make clinical diagnoses of herbicide-induced illness. Moreover, they do not have the sophisticated diagnostic equipment necessary to do so. Until almost yesterday the agencies were not looking either. Even now, EPA has no monitoring program for phenoxy herbicides in Lake Superior although they have been used in the Lake Superior watershed for 30 years. Our point is, one finds only if one seeks. And those who have sought most recently have found evidence which brings the innocence of phenoxy herbicides into serious question.

Our second concern, then, is toxicity and the related impacts on human health. We want this Symposium to seriously address the question: "Are the phenoxy herbicides safe or dangerous?" We want to discuss the carcinogenic, multagenic, and teratogenic effects. Cancer and birth defects are important issues to us. We want to discuss evidences of embryological toxicity, general sterility, respiratory effects, allergenic syndromes, and behavioral abnormalities that result from damaged nervous systems. We are especially interested in recent findings which indicate that exposure to the phenoxy herbicides reduces our immunity to a variety of diseases, increasing our overall susceptibilty to illness.

The evidence which makes these questions legitimate is now being demonstrated in laboratories and, tragically, in the farmyards of citizens who have been sprayed, and, worst yet, it is evidenced by the many cases of spontaneous abortions among women who have been sprayed. Some of those women are here now.

Human health is the issue, and we think it reasonable to act in a conservative manner to restrain threats to human health. It is not conservative to restrain our efforts to preserve human health.

Our thiird concern is that these materials cannot be used as directed. We have evidence that they are now so used and cannot be so used, which brings us to our fourth concern.

Is there another, better way to manage our forests without employing phenoxy herbicides? We want to discuss the word "better." It implies more than merely a short-term increase in timber yields. We believe that National Forests should, as their charter suggests, contribute to the general well-being and not be confined to the well-being of a specific industry and a single use. Their management must be judged in the light of all the components in the forest system, including humans, and in the light of the larger social system of which the forest is itself a component.

We believe that alternative methods are cost-effective. We have the data on that. Moreover, there are contradictions in the present management system. How much sense does it make that the USDA spends Federal dollars to provide food stamps for out-of-work people and, at the same time, argues that it has no dollars to put people to work in its forests? We are serious about our slogan "Hire people, not poisons." The use of phenoxy herbicides poisons our local economies. The Forest Service has the antidote if they will but use it.

Our fifth concern is with long-term economic health, and again we take a conservative approach. We want a secure economic future. But we do not know which forest resources will be needed in 80 to 100 years. Merely projecting current use patterns and growth rates does not constitute prediction. Changes in technology, in taste, in market conditions, productions costs, and even climate argue against designing our forests for a single product. (Think how quaint predictions made in 1878 look today.) The health of an economy based on forest products is protected by diversification every bit as much as is the economic health of a corporation. Let's not make all of our baskets out of one tree. A mixed forest is likely to offer a greater variety of the fiber and fuel products we will need in the twenty-first century.

Our sixth and final concern is expressed in ecological terms. A forest community characterized by diversity is more stable and, therefore, more likely to be there when we need it 100 years from now. We are concerned with long-term environmental health because we are concerned with long-term economic health, and even more because we are concerned with long-term human health.

We have come a long way to reopen this issue. We represent 16 States and Canada. People are here from Oregon (where dioxin is found in mother's milk), from Wisconsin, Pennsylvania, Illinois, California, Vermont, Arkansas, Arizona, Oklahoma, and elsewhere.

The issue is serious. We are serious. Dioxin is a deadly poison. In an article in *Science* Diane Courtney called it "one of the most toxic substances known. It kills animals and deforms their fetuses at lower levels than any chemical ever tested." It has been found in beef fat samples. It is in the food chain now. Football players in Florida are contaminated—2,4,5-T is in their urine, and PCP is in their semen. We are beginning to see the tip of the iceberg.

It is time to reopen the issue of the phenoxy herbicides. We citizens, who have now joined together in a national coalition, applaud Rupert Cutler's responsible decision to call this Symposium. But we are worried that all of you will talk only among yourselves and, learning nothing new, will conclude that there is nothing new. Talk with us instead. Thank you.

MR. KETCHAM: Before we break for coffee—and it is just about time for our break—I would like to ask our speakers and panelists, if they don't mind, to please meet right over here in this section. I think with that, let's break for coffee and start back at 10:30 on the button.

EXPLANATION OF LOGISTICS USED

Jan B. Wine

MS. WINE: My name is JAN WINE. I am an Assistant to the Director for the Office of Special Pesticide Reviews at EPA.

Before we begin our next session, I would like to discuss with you the logistics that we will be going through. You will see a number of EPA people in the aisles while the presentations are being made.

First of all, they will pass out to you 3x5 cards on which you can write your questions. Those questions will be organized into similar batches and brought up here to be presented not only to the person who has given a speech but to the panelists as well. If we run out of time for the questions, I remind you that we are meeting at 5:00 o'clock in room 207 in the hotel. It is quite a large room, and we can accommodate most of you.

The cards have been passed out to you. When you write the questions down—if you will pass them to either aisle—someone will come and pick them up.

If you do not have pencils or pens—if you could raise your hand and let us know—they will be supplied. A copy of today's proceedings will be mailed to everyone who has registered. You have registered by either filling out the last page of your brochure or filling out a card when you entered this morning. If you have not done either, please report to the registration desk at lunchtime and make sure you fill out a 3x5 card to ensure you get a copy of the proceedings.

We also ask speakers and panelists for this afternoon Mr. Witt, Mr. Cranmer, Mr. Freed, Ms. Offutt, and Mr. Kutz, particularly, to please come to the front of the stage at the luncheon break.

There is a change in today's Symposium. You will want to note that we have added a third speaker to this afternoon's presentation, Dr. Frederick Kutz, Acting Chief of the Ecological Monitoring Branch at EPA. He will speak to us this afternoon on EPA monitoring studies.

The problems associated with obtaining sound data required for registration of herbicides to assure that their usage be effective and not result in unreasonable adverse effects to man and the environment is our next topic.

INTRODUCTION OF PANELISTS

Our panelists are MAUREEN HINKLE, the Pesticide Monitor for the Environmental Defense Fund and the National Audubon Society. She has been actively involved in citizens groups for the majority of her career and co-authored a citizens' action guide to the pesticide law.

I might add that Maureen will be updating the citizens' guide with the new legislation and conference committee meetings going on on the Hill.

Our next panelist is DR. WILLIAM WELLS, Acting Director, Office of Special Pesticide Reviews in the Office of Pesticide Programs at EPA. Dr. Wells is responsible for managing the Rebuttable Presumption Against Registration process and the new generic standard development process for registration.

Next we have DR. CHESTER FOY, who is Professor and Head of the Department of Plant Pathology and Phsysiology at Virginia Polytechnic Institute and State University at Blacksburg. He is President of the Weed Science Society of America.

Next we have DR. JACK EARLY, President of the National Agricultural Chemical Association.

Our speaker is DR. ETCYL BLAIR, Director of Health and Environmental Research for the Dow Chemical Company. During his years of lab work with Dow he specialized in the synthesis of organic phosphate compounds leading to the development of important agricultural chemistry products.

DR. BLAIR: Thank you very much. It is indeed a pleasure to be here and to discuss with you a bit on what I have titled in my paper, "The Challenge of Developing Safe and Effective Chemicals for Creating a Productive Forest Environment."

One might really subtitle my talk, "From Test Tubes to Label." In fact, this is really what I am going to talk about—the requirements necessary to produce an agricultural chemical for use in today's society.

THE CHALLENGE OF DEVELOPING SAFE AND EFFECTIVE CHEMICALS FOR CREATING A PRODUCTIVE FOREST ENVIRONMENT

Etcyl H. Blair

Efficient forestry is essential to mankind and requires a multitude of management tools and skills. Among these is the proper use of chemicals to help create an environment favorable to a productive forest. Like beautiful stands of timber, effective chemical tools don't just appear instantly when needed. The problems in providing a variety of chemical tools for forest managers are complex.

During the past few years there have been numerous reports on the cost in time and dollars required for the discovery and development of agricultural chemicals[1-8]. These reports have noted concern about the decrease in the rate of development of new, effective pesticides needed to meet existing problems and to replace older existing products that are removed from the marketplace for various reasons, including government option and poor economics. New developments have decreased as industry has faced increased costs and reduced chances for success with the growth of bureaucratic harassment of any new candidate products.

I will devote my discussions to the chemical industry—that segment of the agricultural business charged with the responsibility of producing products which satisfy a need as expressed in the marketplace. It should be noted that only in the Western World do products originate by innovation, by supply and demand in the marketplace, and by the use of the free enterprise system. All other parts of the world—the Communist Block, the developing nations, and the awakening Third World—make use of Western technology and the products derived therefrom as they struggle to leave their primitive ways to improve their agricultural productivity.

RESEARCH PRIORITIES IN PERSPECTIVE

In 1974 we reported that one new pesticide emerged from industry for every 10,000 compounds tested; that the time from discovery to market ranged from 10 to 12 years; and that the cost would be in excess of $10 million[5]. We stated in those early reports that costs included research, development, technical service development, and pilot plant operations. Further, an important segment of these figures are associated with evaluation of health and environmental effects. And finally, the cost of the winners must include the cost of the losers —that is, commercial products must pay for those that required research but never made it. (The empty rooms of the motel must be covered by the revenues derived from those that were rented—if not, the establishment will eventually fail.)

Today the cost of developing a new commercial pesticide has increased to $15 million and the time required from research to full commercialization is 15 to 18 years[4].

In 1975 the industries of the Western World committed approximately $320 million in research and development of pesticides, of which $224 million was devoted to new product research[8]. For a number of years there has been a decline in the registration of new products. It is becoming apparent that the $224 million devoted to the development of new products is essentially an investment in failure. In time we can expect a redeployment of research dollars—either to support old and existing agricultural products or, more likely, a redevelopment to non-agricultural chemicals[4].

Goring's study identified $64 million per year committed to safety, health, and environmental evaluations and an additional $32 million spent to obtain registrations[4]. In other words, one-third of the total money identified in the health and environmental effects area is for the purpose of convincing the government to grant a permit to market the product. This appears to be an extraordinarily large amount of money identified to meet the bureaucratic requirements of the regulatory agencies.

Goring[4] has also noted that the number of new pesticides introduced each year has been falling. In 1966, 28 new agricultural pesticide products were registered; in 1974, 10 new products were identified, and in 1977, no new agricultural pesticides were registered by EPA nor introduced into the marketplace.

Modern science assures that a high proportion of the compounds coming from planned synthesis programs is biologically active. There appears to be no shortage of active and potentially useful compounds coming from our discovery laboratories. However, one of the major challenges to the agricultural chemical industry today is to identify and eliminate those products which are unduly hazardous to man or environment and which cannot provide sales large enough to cover development, production, and registration costs.

Industry must concentrate available resources on those products which have a higher reliability factor toward commercialization. The chance of commercial success will be higher for those agricultural chemicals which have a sales volume of $100 million potential or greater. The probability of discovering a new pesticide with potential sales in excess of $100 million is extremely low. Past histories would suggest that pesticides with large scale volumes will be herbicides and insecticides rather than fungicides, soil fumigants, defoliants, desiccants, or products for forest use. The record indicates that only one in four pesticides exceeds sales of $10 million. None of these have been developed in recent years. The ratio increases to about 1:15 for sales above $25 million, to 1:40 for sales above $50 million, and 1:80 for sales above $100 million. Twenty-five percent of the pesticides probably account for over 75 percent of the sales[4].

The consumption of pesticides is concentrated among relatively few crops. Approximately 63 percent of all pesticides is used on cotton, corn, rice, soybeans, and small grains, and 80 percent of the herbicides is used on these crops. Cotton, corn, rice, apples, and citrus crops account for about 68 percent of the insecticide market. Rice, small grains, apples, potatoes, and citrus crops account for approximately 49 percent of the fungicide market.

Forest management services cannot be called a major user of agricultural pesticides. This is certainly not to infer that the problems associated with forest management are not important but that the volume of use is small (less than $80 million) relative to that needed to support a new product. While the probability of success is low in working on a product with a $100 million potential, the cost of health and environmental effects remains essentially the same as for the product whose use is for a minor crop such as forest renovation. Obviously, the search for new products will not be directed toward the forest area.

DEVELOPMENT OF A NEW PRODUCT

The manner by which each company manages its research and development activities is probably quite similar because of government regulatory activities. The regulatory processes which require extensive evaluation of toxicity, environmental effects, and residue levels are more or less standardized. All chemicals must undergo an internal field evaluation program and then external field programs generally done in cooperation with public and private organizations.

Twenty percent of the total research and development costs for an agriculture chemical is associated with health and environmental effects such as metabolism, environmental residue studies, and toxicology. An additional 10 percent is associated with registration. The remaining 70 percent is distributed somewhat equally in procurement, field development, formulation, process study, and pilot plant.

A broad range of resources must be managed—dollars, professional skills (people), and facilities (analytical equipment, pilot plants, etc.). Industry makes use of planning tools—frequently, a modified critical path network system. The critical path is the shortest time it takes to do the required job. It sets the schedule for the many different individuals and functions involved. Funding and management of each of the factors impacts on all the others.

An indication of how costs flow against a project or product as it is being developed may be seen by examining the project at certain intervals of time. We at the Dow Chemical Company refer to these time intervals as stages. Four of the five stages involve the research and development cycle before commercialization.

Stage 1 is the exploratory stage. It is in Stage 1 that the scientists initiates effort on a problem where the solution will contribute an economic benefit that the user is able to identify and for which he is willing to pay. We are looking for new concepts—we're looking for potentially useful compounds, and we're exercising the processes of invention and innovation. In general the cost associated with this screening and exploratory stage is $500,000 and may involve a time span of up to 3 years. We will have synthesized and examined many hundreds of novel chemical substances. From this knowledge base we select a few compounds to examine in more detail in the next stage.

In Stage 2 the attempt will be made to identify the key limitations of the new discovery. The wise scientist will be attempting to place limiting values on his preconceptions and in turn examine them in the scientific manner. The value of the Stage 1 discovery must be somewhat quantified at Stage 2. It is at Stage 2 that we examine the health or the environmental considerations, the patent situation, the market potential, and the long-term economic situation. The purpose of the exercise in Stage 2 is to identify and remove the losers. The sooner that we can eliminate the loser the sooner we can apply our energies and resources to the winner. By the end of our Stage 2 study we will have invested an additional $1 million to $1.5 million.

Since the product must have a potential use in at least one of the major markets mentioned earlier, forestry uses would not be considered in Stage 2. If our research material has potential for other uses and becomes a commercial product, later development may determine that it has value as a forest product. Our company has been actively involved in the development of forestry management programs since the '50's, and our field people today devote effort to this area of technology. Yet, our interest for forest applications must be piggybacked on a product of primary interest.

To enter Stage 3, a project undergoes thorough review for assessment as a "go project" for we will be committing many people and big dollars to the study. Stage 3 will signal process work; design of manufacturing plants; additional research needs on the possible impact in air and water of raw materials: by-products; and the design of complete environmental, health, residue, and metabolism studies. It is at the Stage 3 level that we are involved in exhaustive tests relevant to ecology and toxicology.

If for some reason the project is dropped because of toxicology or ecology problems, or for any other reason, you can see that we have an expensive loser on our hands. There is no way that we can salvage value from a project that has become a loser for health or environmental reasons. The cost of the loser must be borne by the success of another product.

An even greater loss is realized if the project is abandoned at the end of Stage 4, when the costs have increased to $6 to $8 million. At Stage 4 we are engaged in cooperative research projects with private, university, State, and Federal agencies. Residue tolerances and product registration activities are now in full swing, pilot plants are being constructed, and the design of manufacturing plants is being finalized. At Stage 4 field demonstration scale research is in full swing.

Much attention is now being given to health and environmental studies on agricultural pesticides. During the last 25 years a rapid change has occurred in the minimum registration requirements (toxicology, metabolism, analytical chemistry, and ecology). In 1950 it was usual to conduct of 90-day study on rats and determine residues with an analytical method accurate to within one part per million. Today much consideration is given to teratology, carcinogenicity, and mutagenicity studies in rodents. Three generation reproduction studies are not uncommon, and we have developed analytical techniques sensitive to parts per billion and parts per trillion.

The environmental studies that we emphasize are associated with chemical stability, movement of the product in the ecosystem, the spectrum of biological activity, and the potential for bio-accumulation. If these factors are thoroughly understood in the early stages of development, we frequently can generate reliable predictions on the long-term potential for environmental damage and accordingly better focus our research programs.

It is obvious that the health and environmental aspects are one of the primary concerns of our research and development activities. However, the resources at the disposal of any function or any given organization are not infinite. As we deal with many projects at various stages of development, serious consideration is directed at force-ranking of priorities. As the economic viability of the product is identified and forced-ranked for agricultural use, a comparison must be made with the needs for similar studies on the large volume industrial chemicals. We must also look carefully at the many recurring requirements for additional data on existing products. New requirements from OSHA and EPA are forcing review of all of our industrial products.

It would be a bold organization which says: "With the limited resources that I have at my disposal, I will set aside the billion-pound-per-year polymer intermediate in order to carry out a health and environmental study on a herbicide used in forest management." While the decision might be bold, it may also be foolish. Today, corporations are examining, in critical detail, the use of their limited resources—for they now must prioritize the health and environmental data needs across their total business (plastics, fibers, industrial intermediates, and raw materials) and the many basic chemicals required by our society.

Stage 5 is normally regarded as the "sales" stage with much reduced research effort. Today we find that we must continue research simply to answer a variety of irrelevant and relevant questions from many directions. The recent Rebuttable Presumption Against Registration (PRAR) by EPA on dibromochloropropane (DBCP) and on ethylene dibromide (EDB) and the proposed OSHA workplace standard of one part per billion and one part per million, respectively, will probably force the industry to an early decision on these two agricultural products. We have neither the resources, the facilities, nor the professional manpower available to meet the new standards when faced with the many needs of our other products. We may, as a practical matter, be faced with possible shut-downs of our fumigant plants and be forced to abandon the business. Many in agriculture are concerned that the losses of these two products will not only bring about economic hardships to the farming community but may well, in fact, bring about the loss of citrus and pineapple business from California and Hawaii. Only time will tell.

OLD PRODUCTS MUST BE MAINTAINED

The FDA/EPA approach to the validation of existing data has raised a serious fundamental question. It is alway possible to question old data. If you repeat an old experiment using the latest techniques available, you may get somewhat different results. However, has the answer to the basic question been changed? There is constant change in our methods of experimentation. However, is it necessary and worthwhile to repeat the early work merely because there is a more refined technique currently available? Obviously, in a few cases, if you are concerned with real problems that have arisen and you need increased accuracy, clearly it should be done. However, most of the time it is unnecessary. It is a needless expenditure of resources which might better be applied to other projects such as problem-solving for the forest industry.

I think that the record clearly shows that the Dow Chemical Company has been concerned with safety—not only for man but also for the environment—and has directed a considerable amount of attention and resources to the generation of health and environmental data for decisionmaking purposes. This is also true with most companies producing agricultural products. Our reluctance to repeat old work with new techniques does not reflect a lack of concern but simply a search for reason.

CRITERIA FOR IMPACT ON THE FOREST ECOLOGY COMPARED TO CROPLAND

While product research for forest service applications in principle is little different from research on any other plant crop, there remains one fundamental difference. A tree is a long-lived perennial, whereas most crop plants are annuals. It may take 100 years for a Douglas-fir to grow to a size which has timber value. This has a very limiting effect on the frequency with which forest herbicides are used and the quantity that is introduced into the environment. Few people realize how little herbicides are actually used in forestry. Usually they are used only once or twice during a forest's long life cycle simple to create a reasonable environment for tree growth, for forest site preparation, and/or for release of the conifers from unwanted hardwood competition. Two applications of herbicides in 100 years, say for the Douglas-fir, is a very different situation than yearly applications in the case of corn. The timing and amount of chemical used to produce a timber crop is very different from other agronomic crops. It generally takes at least 10 years of growth before harvest for the fast-growing southern pines when used for pulp, and it takes a minimum of 20 years when used for timber.

Along with this time difference there is the size factor. Trees, even when young, are large plants. Except for nursery seedlings, plot size required for experimental work is much larger than for annual crops. It takes a much longer period of time to evaluate results. The amounts of chemical used, the time to apply and evaluate, the size of the plots—to mention but a few items—all mean that forest research is more expensive. It also means the challenge in forestry research is greater.

I am concerned that the agencies do not exhibit greater leadership in articulating the limited risks involved in use of pesticides in forests. Extensive data on toxicity to fish, quail, and mammals are available for almost every pesticide used in the forest. And environmental fate data are also available. It appears to me that, too often, the Federal Government has let pesticides become the whipping boy for local arguments and disputes involving land use and environmental esthetics. For example, EPA several years ago issued a special permit for the use of several hundred pounds of DDT in the Northwest. But this occurred only after extensive appeals for help and an unprecedented amount of environmental study. I know of no other developed country that would permit valuable timber resources to deteriorate while human resources and talents were drained into monumental projects of inconsequential proportions.

SOME SUGGESTIONS FOR REGULATORY POLICIES THAT ARE CONSISTENT WITH SOUND PUBLIC POLICY

I am surprised at how little practical recognition comes from the agencies in terms of how great a natural resource our forests are.

As a non-forester, I observe that the costs of lumber have skyrocketed and that our whole housing industry has diminished its reliance on lumber. I also observe that enlightened research and development directors are seriously looking to trees as a part of the answer to the national energy conversion that must take place. The Swedish Government is already evaluating what they call energy plantations. The point is that needs and opportunities for effcient development of timber are unprecedented. It is most alarming to me that all of the Federal Government is not looking for new ways to double the efficiency of timber production. It is a tragedy that our bureaucratic system sabotages and eliminates efforts by the private sector toward efficiency.

Regulatory agencies should give serious thought before withdrawing registration of current, useful herbicides for agricultural use or for forest application. They may think that, if in time they recognize the mistake they may have made, they merely have to reverse their decision and that the chemical plant will be there ready to produce the product once again. I can assure you that this is a major misconception. An idle plant is an expensive item; and as soon as a product is out of production, the plant will be dismantled or retooled to produce a different chemical for another product opportunity.

It is an economic fact that we in this country are making a serious mistake in the manner in which we abandon products. Not only are we abandoning products, we are forcing a change in research and in the number of pesticide producers. We are beginning to see a change in the location of the pesticide producers. Among the 16 major manufactutrers the largest two have sales between $500 million and a $1 billion—and they are foreign-based companies. The next eight have sales of $250 million to $500 million, and three of these eight are foreign.

In addition to the lack of new products being developed, there is a disproportionate share of the manufacturing, research, and development functions shifting to Europe and Japan, as has occurred in the drug industry. In time these products will work their way into the United States, but the lost research and development technology will no longer be available as a prime driving force for the Nation.

We in industry have a serious problem and are concerned about the interpretation of health and environmental data and its increasing cost. The requirements of our laws are becoming so demanding and so difficult that many in industry are seriously questioning the long-term viability of agricultural pesticide production. This becomes a problem for the citizens and producers in our country who will no longer have this technology available.

The charge has been made that the use of chemicals has been unduly pushed upon the farmer. This allegation is completely unfounded. The farmer is a most pragmatic individual. At today's farm prices he has to be efficient, or he will be forced out of business. The farmer is now and always has been most interested in obtaining the lowest cost pest control consistent with maximum benefit. The farmer, the forester, any agriculturist, will immediately adopt any program that is economical, that works, and that is safe. That is as it should be.

I hope you have recognized that we at Dow are very much interested in environmental safety as well as the efficacy of chemical herbicides for use in forestry. As a matter of long-standing, we have been concerned with the safety of chemicals—both to man and the environment. However, we do not live in a total risk-free world. Even doing nothing has risk. In fact, this might result in one of the greatest risks of all. There is no one method of pest control. The most economical and safest methods that will work will be readily adopted.

Needless to say, there will be much priority-setting in the future. I ask you to give careful and comprehensive thought before removing a pesticide from agricultural use. The wisdom, or lack of wisdom, resulting from such decisions will be visible for many years to come.

To summarize, our future in the testing of chemicals is complex. But I believe we can make progress if we do not bog down and become enmeshed with the inconsequential. We must focus on priorities, the leadership that industry can provide, and the decision that you in government are charged with making.

As a final comment I wish to highlight the need for cooperation and trust in policy formulation. There are in industry a large number of interdisciplinary scientists, seasoned managers, and expert practitioners in agriculture. Our industries have great strengths in the areas of setting priorities, generating sound toxicological and environmental data, and in solving technological problems. EPA and USDA have the major role of reviewing for the Nation the pesticides used in the forest and in agriculture. We must establish mature trust between industry, university, and government. This, coupled with reasoned scientific challenge, will in time earn the trust of the public—which is so sorely needed. Only by establishing this trust can we avoid the legal and bureaucratic entanglements which have become so much a part of pesticide regulation.

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PANEL DISCUSSION

MS. WINE: Thank you, Dr. Blair. If you have questions, you can write them down on your 3x5 card, and a monitor will pick them up in the aisle.

To begin our panel discussion, I would like to ask Dr. Wells if he feels that the generic standard approach to registration will reduce the cost that chemical companies incur in registering their products?

DR. WELLS: The answer to that question is yes. By going to the generic standard approach in registration, we will be attempting to gear all the supporting data for an active ingredient into one package. It would be expanded to include standard labels and all the information pertaining to registration of that pesticide.

Someone wishing to register a formulation with that active ingredient would then only have to establish by providing chemistry information that the product did, in fact, fit into that standard for the active ingredient. We envision some day one might not have to submit a label if it was proven to us that the formulation fit the standard and the uses on the label would fit the uses on the standard labels in the package.

The resolution of the issues pertaining to compensation for the data would be established outside the agency, between the companies, where we feel it belongs. So the time and cost of securing a registration of a formulation should be greatly reduced.

MS. HINKLE: I would like Dr. Blair to comment on the role of corporate responsibility in the research and development of pesticide products, and, as an example, I would like to say that in May of 1976 Ciba-Geigy halted production of chlordimeform, took the products off the market, and recompensated the farmers and producers who had chlordimeform on stock. They also did not go into high production. They did not start production in their brand-new plant in Louisiana that cost $25 million to construct, solely for this promising new compound which was to be used on cotton. They did this action as a result of a preliminary test that they had conducted on mice, voluntarily. It was not actually required of them at the time. But they were worried enough about the results in these rodents that they decided they had to take some precipitous action.

As Dr. Blair pointed out to us today with documentation and in great detail, it is very obvious that Ciba-Geigy went to great cost and a great deal of time in order to research and develop this product, so I would like him to comment on the role of corporate responsibility and the various avenues of action which are available to the chemical companies.

DR. BLAIR: All right. I do not specifically know the example you have used. I believe that most of the corporations in this country, if they produce information or they learn of information which is valid—that indeed shows that there is a high risk or risk beyond that which is accepted for the return of the benefits—that the corporate responsibility of essentially all companies would be to not put that product on the market.

In fact, I as a research director stopped one of the developments of a specific herbicide—not because of any cancer problem or mutagenic problem but because of a combination of factors. The product was Daxtron. Many of the people in the field development areas may know of this product. The combination of water solubility—the product was water soluble. It photodegraded in light, but was placed under the soil, which meant it would not get sunlight. It had the property of producing damage to the eyes of rodents and also acted as an anticoagulant in blood, so we withdrew all work of that product and pulled it out of all experiment stations around the world.

I believe that most of your industries represented in this Nation do have a corporate responsibility and that they are responsible public citizens.

DR. EARLY: I would like to respond also, Maureen. I am generally familiar with the situation that you have just talked about. I believe the reason you are surprised at the situation is because, unfortunately for Ciba-Geigy, they had gone quite a way in development of the product and had a significant amount of money invested. However, it is the kind of decision made every month every year, among all companies. The reason that this caused so much attention is because they were so far down the line before they discovered the toxicology situation. I know from personal experience in talking with our companies on a monthly, yearly basis, they are dropping products out of commercialization because they have discovered an abnormality of some situation to toxicology.

I am not surprised, but it was unfortunate for them it was so far down the line.

MS. HINKLE: In yesterday's *Washington Post*, Dr. Blair was quoted as saying that Dow only undertakes research that you have an interest in, and not only do you undertake this research on compounds you have an interest in and you have a commitment to once it is on the market, you want to get back the investment that you already put into it, which we know is several million dollars. You get money in order to undertake research on these compounds that are already on the market, and we know that; we also know that as long as there is not enough data to determine whether or not the compound is safe, the compound remains on the market—yet Senator Kennedy in January 1977 issued a report in which he said that data submitted for the 1200 compounds you allow on the market are either missing, inadequate, or misleading. Because of that allegation it would probably take up to 20 years for these 1200 compounds. What assurance do we—does society have—that these compounds are safe?

DR. BLAIR: The reference you made to a quotation in the *Washington Post* yesterday really had to do with a specific contract. In general, Dow does not enter into contract research. Our organization is sufficiently large, and we have such a need for health and environmental evaluation studies, that we need most of our facilities and our capabilities to deal with our own problems.

The only reason that we attempted to enter into a contract basis was on this particular chlorinated solvent. I don't remember whether it was trichlorethylene—is that what it was? The quotation picked up from me was that we had lots of information available, and it sort of left the idea that we didn't make this available.

The industry was being asked to produce information on trichlorethylene. We have an enormous amount of information on trichlorethylene. It is a product which we manufacture; and having developed that product, we would be able to couple our own historical data that we have on trichlorethylene with new studies.

An organization totally unacquainted with trichlorethylene would go through a great learning experience in learning just how to deal with that particular substance, so that was the reason that we considered bidding on this contract. But, in general, we do not bid on contracts.

As far as answering the second question you had, I believe that in many cases where Senator Kennedy and others have talked about information being inadequate, this is an exaggeration to quite a degree. As I mentioned earlier, we are talking about formulations.

When you talk about 1500 chemical substances, if you had an update on one particular compound, you might cover 150 or 500 formulations. It depends upon what the product is. I don't believe that there are enough scientists in the world to answer every single question that some individual may raise. Most of the products that are available in the marketplace, if used according to the label, are not going to cause a problem.

One of the problems, however, we do have is: we all tend to lightly glance at labels, and one of the problems we struggle with in the industry is how to inform, how to train people not just in pesticides but in general use of many materials.

It could get down to driving your automobile. The speed limit says 55; look at how many of us drive at 65. But as a whole, in most cases, we are reasonable in our use and understanding of what we are dealing with. The companies are concerned about the use of their products, and they are constantly investing in more studies to learn more about the products.

It is having to do it over and over again to try to convince an agency that is really chewing up our resources. For the products we are not studying, we need to get on with and not be reinventing the wheel on well-established, well-known products where we have histories without much of a problem.

DR. WELLS: I have a little difficulty in understanding exactly what you are talking about when you say doing things over and over again. The slide you showed us earlier indicated very strongly that there was a different set of requirements in the '50's, and that probably in large part was due to a very different state-of-the-art and science.

Do you mean to imply that we should deny ourselves the advances that have been taking place in science in assessing chemicals and the possible risks and that we should not be going back and asking for information to fill gaps, which is what we have been doing? We are not asking you to do things again if done adequately the first time.

DR. BLAIR: I will answer the question in two ways: Let's take the cases of phenoxy herbicide or dibromopropane (DBCP). Both of those materials have been used for many, many years. There have been isolated cases where some harm has been done. To prioritize that against an opportunity which may exist for a product, as I mentioned, that will go into corn, and today we are facing an opportunity to develop a product for, say, corn rootworm, and there are only a finite number of toxicologists and resources available in this country or anywhere in the world, so basically government as well as industry is going to have to sit down and look at what we are going to be doing.

We will probably abandon the old product, because there is no way to go back and apply all of our modern technology and redo all the testing, say it is going to cost \$15 million for a product of which there is only \$2 or \$3 million sales on. It is just as simple as that.

DR. WELLS: To talk a moment about the example you cited, DBCP, that is a good point to illustrate what I was trying to say. The state-of-the-art in 1961 and the late '50's indicated that there was no problem with DBCP, but rodents would lead us to be more concerned about that chemical, and EPA demonstrated its concern by taking regulatory action. I think that particular example you used reinforces the point I was trying to make.

DR. BLAIR: That is not quite correct. What really is the action of OSHA on DBCP is to go to one part per billion, and that is not the problem with that. It has nothing to do with the setting of a TLV. The problem is more likely to be consistent contact or close contamination, not a threshold-limit value. When the agency sets a level of one part per billion, that means in the total workplace there can be no level greater than the part per billion.

The event you are talking about is similar to the fact that the speed limit is 55 miles an hour, but there is a bad turn 20 miles down the road. So you set the speed limit for the whole distance at 35 miles an hour so that you need not deal with the bend in the road.

We need to deal with where the problem of exposure came from. The solution on a certain set of operations may be that one needs to be in a different kind of clothes, has to go through a different kind of cleaning process, procedure, or something. We haven't been able to get at that.

MS. HINKLE: Had you had the exposure set at a level which protected the workers, you might not have had to shut your plant down.

DR. BLAIR. I grant that. There is no argument. There was an event there which we are not happy with at all, and we are doing all we can to deal with that problem. The point that I am trying to make is that having identified a problem area, we need to examine in detail what really was the problem; and once we identify the problem, to find the solution to that problem and not just suddenly to come out with a study which says "we will now go to one part per billion."

MS. HINKLE: You were aware of that problem in 1958?

DR. BLAIR: We were aware of many problems in 1958. The problem you are talking about is sterility, one in which at that time we examined the health effects on people, more dealing with kidney and liver, and the studies were really conducted at five parts per million, and the standard was set for operating at below one part per million. We recognized that even a number of years ago.

DR. WELLS: Before we leave this particular point on validating all the studies, Dr. Blair, you may not know this, but we are also undertaking at EPA a laboratory audit program, and I can assure you that the validation of all data has been made necessary not only because of advances in the state-of-the-art and not only because of the necessity to fill data gaps of information that simply weren't required in the past—and I am very sorry to say this, but it is true—it has also been necessitated by what we have found in our laboratory audit program.

In a number of cases sufficient to give us great concern, we have found that data have been misrepresented. There may even be some possibilities of fraudulent practices. I am not permitted to go into any details regarding those situations, but I can say that some criminal investigations are underway. There are not necessarily industry laboratories. These are independent testing laboratories at this stage, and I might hasten to add that I suspect that a number of the industries are also quite surprised at what they are finding went on in testing done by independent labs. So there are a number of reasons that we are revalidating the older studies.

DR. BLAIR: I have no problems with what you call revalidating. In fact, I personally believe that there should be inspections, examinations of all labs, not only industry testing labs but, I believe, university—and let's don't let government get off, while we are at it.

DR. WELLS: We haven't.

DR. EARLY: Let me jump in here a little bit. You were raising the question about the Kennedy report and about it not being safe because it has not been properly validated—the product. When a product was registered 10, 20, 30, 40 years ago, at that particular time when those products were registered, they were registered based on the data gathered, based on the latest technology at that time, and the products were judged to be safe at that time.

Any period of time you jump ahead in history is going to improve technology. This is why we went to the reregistration process. Certainly our industry does not object to it.

As far as we are concerned in the industry, the total reason to suspect or point any fingers at products on the market today is because they have not had all the recent technology cranked into them that they are not safe products.

I don't think you are implying that at all. You want greater assurance that under the new technology we have explored the other areas of technology, which is what EPA is doing now. We are going to be raising these same questions 10 years down the line because there will be new technology and we will be looking at it again. I think at the time registered, the product was safe. As far as I am concerned, the product is still safe.

One other quick question. Bill talked about the validation of laboratories, and I am not going to get into that with him at all here. I am sure that Bill did not mean to imply that because they have found some isolated situations where data may have been fraudulent or something to that extent, all data submitted to EPA files are fraudulent data. I don't think you mean to imply that at all.

Most of the data are very valid data. I think you should find out which is questionable.

MS. WINE: Dr. Foy, you have been active in both fundamental and applied research. Can you comment on the development of new herbicides for the use in forest management? Dr. Blair indicated there were not that many herbicides available for forestry.

DR. FOY: Maybe I am here under false pretenses. I am here because I am identified with the Weed Science Society of America and have worked with pesticides for quite a long time. I am not a specialist in herbicides used in forestry situations.

I think one point that could be made, though, in connection with those already made, is the fact that these herbicides have not come on the scene simply by accident. They have come on the scene because necessity has been the mother of invention.

We know the tremendous economics involved now in the development of any new herbicides. I had some data that I was going to share from Hart Brinkley—and Jack Early would back up—only slightly different from those given by Dr. Blair.

The point is, though, that there has been a need, and I think one of the biggest deterrents to our obtaining sound data, not only in forestry situations but also in food production situations, is the matter of attitudes and perspectives and setting priorities and this sort of thing.

If I may, I'll elaborate on that. The fact that we simply have advocate/adversary relationship roles prescribed for EPA and USDA—is not EPA also interested in the benefits package? Should not also USDA be interested in the risk package? I think we will certainly agree that both is the case. We talk about man and his environment. Is not man part of the environment and, in fact, the most important part of the environment because he is the decider of issues such as these?

Pollution versus contamination: every agricultural chemical that is deliberately introduced into the biosphere is a contaminant. We know that. But is it a pollutant? It is a matter of perspective.

When we talk about whether there should be a curtailment in the development of pesticides, it may be an academic question. It is only a small portion of the total now in there. The economics may preclude it. The fact that we now cause losses approximating $11 billion, exceeding the losses of any other group of agriculture, shouldn't go unnoticed, and the occasional use of herbicides in forest situations to establish the forest once or twice or three times in many years is inconsequential compared with the repeated annual use of multiple use in low crop situations, which we are content to live with because we are dependent on those things we eat. What I am really saying is a reexamination of the word "pesticide" might be in order. We place too much emphasis on the side part—the fact that they are designed to kill or impair growth.

The idea that they are doing it for a lark: necessity has been the mother of invention to produce these things as agricultural aids or human aids, and it was because the pests occurred in the first place that these things were so designed.

To simply ban pesticides categorically would be analogous to an automobile that is going down the street and slams into a telephone pole or into a tree. You don't ban all Ford automobiles. You certainly don't ban all automobiles or automobile traffic. You don't even revoke the license of anyone except the driver, and I think we might take this example to heart when we think about generalizing over the entire field of pesticides.

Someone in this group already has used the term "pesticides and herbicides." Are weeds undesired vegetation not pests, or herbicides not pesticides? We need to sharpen up our terminology and our perspectives and get our priorities together so we are talking about the same language. We talk about integrated pest management. Worldwide integrated pest control is used. We manage people and resources and assets. We control pests because they are pests. We kill or control pests because they are pests. There was reference made in an earlier talk about those herbicides which will drift. Any herbicides will drift under the right circumstances. Are we not aware of that? Watermelons and bowling balls will drift if you take them high enough and put a strong enough wind on them.

We spoke of 10 minutes being adequate perhaps for David to slay Goliath. Are we really slaying Goliath here, or are we biting the hand that feeds us?

Generalizing can be very dangerous is my point. Picloram has been determined that most of the uses in forestry situations—with one exception—should be in the restricted use category. Well and good. That was carefully thought out. It was a panel of people who were involved in this advice, and this seems to be a firm decision, but each one of these should be taken up on its own merit rather than categorically generalizing across herbicides or across pesticides.

I rambled a great deal, but the sum and substance is that herbicide use in forestry is a drop in the bucket. We are dealing with broaded issues here in terms of attitude and priorities and the things that deter us.

From the experimental standpoint the ideal sized plot would be every acre treated with a phenoxy herbicide. That is ideal. That is the whole population. So then you are faced with compromising all the way down. There are inadequate resources, whether manpower, facilities, equipment, or operating budgets, or whatever, to test all of those things adequately and technically on a long-term crop like a tree. So there are constraints on what can be done, and you simply can't have everything.

Knowledge is produced that he has learned so much. Wisdom is humble that he knows no more. If we have the answers, we haven't asked all the questions.

Shall that deter us in making the progress we have made in feeding the world's population—producing food and fiber and shelter? This is cause for a careful analysis of the cost or risk versus benefits of each situation.

MS. WINE: A lot of questions that we are getting from the audience address the broad generalities that you are making reference to. I would like to address the questions that are coming from the floor to the panelists as well as Dr. Blair.

QUESTION: Society has not established a zero-risk policy for crime, traffic safety, human health, or war. Do you believe that society should adopt a zero-risk policy for pesticides? Would you ban the use of any substance where there was a risk to human health?

DR. WELLS: The EPA has not established a zero-risk policy for pesticides; and if you look at the regulatory decisions the agency has taken, you will see that they do not reflect zero risk, and in the rebuttal presumption process the risk will be weighed against the benefits; and I am sure that even in the case of a carcinogen that you will not find a zero-risk policy advocated or utilized in the case of pesticides.

MS. HINKLE: Neither the Environmental Defense Fund nor the National Audubon Society, which I represent, ask for a totally riskless society. We don't ask for the impossible.

QUESTION: Can we be assured that chemicals registered by EPA are both effective and safe? Does EPA have the authority to stop the use of unsafe pesticides? If yes, then those allowed to be used are safe, aren't they? Which goes back to our zero risk. How can we assure that they are safe and effective, Bill?

DR. WELLS: I think that the talk that Dr. Blair gave this morning gave a pretty good outline of the kinds of testing that we require to be done on pesticides today. That series of tests, those requirements, reflect what we feel is the utilization of the best tools available today to answer that question—that the pesticide, when registered, will be safe when used according to the directions on the label.

Now, we have already talked about some of the problems with the fulfillment of data gaps, since the requirements have changed to reflect the changes in the state-of-the-art; so if we feel there are concerns, we are trying to go back and satisfy those concerns to give you some high degree of reliability that when you use a pesticide as directed for use on the label that it will result in safety to humans and to the environment.

QUESTION: On the cost figures that you have given, how do your financial losses from chemicals that are never marketed, which were $10 million, I believe, compare to your company profits?

DR. BLAIR: How do they—I don't think I can answer that. The question is what, now?

QUESTION: How do your financial losses compare with your company profits? You stil make a profit, right?

DR. BLAIR: Well, the company does; and obviously the agricultural product department is making some kind of a profit or it wouldn't still be there, so what really we are dealing with, again within the operation of a particular organization, is a balance of investments into those areas where obviously we would like to have more useful products for the benefit of society, and I believe it is part of the whole process that we go through, which is to eliminate and remove those products which really don't belong there, and that is really what it is, and so when I talk about losses, I am talking about really the amount of research investment of cost, and it can be toxicology or anything else. Whenever a chemist synthesizes a molecule, it immediately goes to the toxicology laboratory. We get a quick determination of what the effect may be on some rodents and other kinds of animals, and that is relayed back to the chemist.

We don't consider that a loss. That helps the chemist guide himself to handle the material, and that becomes part of the total data bank we build up.

I am talking about losses where we get into, like Ciba-Geigy, where we put in $5 or $10 million, and we have to abandon the product. That is a nonrecoverable kind of a loss. We haven't generated much data we can use toward something else.

QUESTION: With regard to the $2 million out of $70 million that went to product failures, what percentage of that was directly a result of step four?

DR. BLAIR: I would say the bulk of that at some point—I am going to use a figure of 50 percent. I can't really break that down at this time. It is a very good question. I should do that. Obviously, there are some noncompetitive products that may have gotten out and didn't belong there because we couldn't produce them at a price.

One of them, I know, was Zectran. Secretary of Interior Udall sent us a letter praising us for the development of Zectran, considered the ideal insecticide. It was not effective from an economic basis. It cost us so much to produce when we sold it in the marketplace, nobody could buy it—yet it was the one identified by Interior as one which all industry ought to strive for, but the economic reality of the world whipped us. When the Forest Service went to purchase insecticides, they didn't buy Zectran.

VOICE: You produce what is profitable but not necessarily useful?

DR. BLAIR: We try to do both. Somehow we have to pay the people who are doing the work, and we have to somehow pay the workers working in the factories, and we have to somehow pay the stockholders.

QUESTION: Have the increased costs of research and development been caused by inflation rather than increased testing? I imagine Jack Early can help you on that.

DR. EARLY: Are you saying that the question apparently implies that most of the increase in R&D is related to inflation?

MS. WINE: Yes.

DR. EARLY: That is the implication there. Certainly some parts of it are due to inflation. Like everything else, we are all caught up in inflation. I know that some of the statistics from our annual survey that we do with our member companies has shown a definite increase in the number of dollars being spent on research, and when I say this, I think primarily in the area of defensive research, and the reason for this, I believe, is obvious to most of us here, is that you have old products on the market where you are having to try to keep these products on the market and so you enter a defensive research posture.

So we are seeing more and more dollars being sent into that defensive area rather than innovative research to keep a product on the market today. That has increased some in recent years.

I suspect as we see some of these old products coming under the new requirements and the new guidelines or new studies that we are going to see this amount of defensive research go up even more in the next several years. Whether we are going to see it go up to half the research dollars or 60 percent or 40, I don't think we know that. It is going to have to increase if these products are going to stay on the market.

When you increase the expenditure in the area of defensive research, something has to give. Innovative research is going to suffer as a result. I don't know whether that is responsive to the issue or not. Maybe so.

QUESTION: What does it cost EPA to register a pesticide? Do we have figures?

DR. WELLS: No.

QUESTION: Dr. Blair, how do costs of testing for environmental and health effects compare with the dollars spent on advertising and promotion?

DR. BLAIR: We do not spend a lot on advertising and promotion. We are not like the toothpaste company. There they spend probably more in advertising than they do in research and development. In the Dow Chemical Company our research and development budget is in excess of $200 million a year, and I am sure that our advertising budget doesn't approach that at all. It is a minor, small part of any of those kinds of costs.

If we talk about a consumer-oriented industry which is really selling close and that kind of thing, that is a different thing.

QUESTION: Also directed to Dr. Blair: your statements indicate that the present knowledge of the economic and environmental cost of biocides may indicate a need to change directions and study other management tools in place of chemical biocides. Is Dow considering such a reorientation to new avenues of research?

DR. BLAIR: Well, obviously, we are always looking at new ways of doing research, and there are many things we need to get on with.

One is the computerization of data, the ability to transmit technical information from, say, the industry to EPA. Doing it by tape or by computer is a lot better than these massive volumes of paper that have to be typed and that type of thing and, in turn, have to be read.

I think there are many innovative ways of getting on into the future. One of the points I was trying to get across, at that particular period in time, is that when one talks about health and environmental research, I become somewhat concerned that of the figures that I showed there, I think $60-some million that went in over a certain period of time, roughly $50 million was working in the interface between, say, a company and the government.

I recognize the extremely difficult situation that government is in, because if there is really a problem you turn to government first. I would like to see us find a way to get more value of that $30-some mission we are talking about and part of it—I think some were addressed by the panel this morning, a better way of getting a return for our dollar for what we are putting into that kind of effort and put more over into the technology of actually carrying on tests.

Actually, I think we need to find even better testing tools to look at cancer and mutagenicity problems. The classic way to carry out cancer tests today is to use rodents. One needs 2000 rodents to have a statistical number. A cancer study would take 2 years of the animal and it takes about 6 months to design and set the experiment up, and 6 months to work the data, so we are talking about 3 years of study and in a company such as Dow, which has one of the largest toxicological facilities in the world, we probably cannot carry out more than a dozen at the most of those kind of studies, and each of those studies run a cost of something from one-half million to $1 million. So there is a finite number of studies that can be done, and we need to look at faster ways of doing studies and have them mean something and not just be an indicator we get excited about.

QUESTION: Someone in the audience would like to know whether or not there are grants available from Dow to do these kinds of environmental studies that you are talking about?

DR. BLAIR: I think in general not. We do not. We do put grants out for special reasons, but actually there is so much that we learn when we do studies. Let's say we make a class of compounds, you might say the phenoxins are a class, I have silvex and you have 2,4,5-T. As you work on these two different compounds, you are actually learning a lot. If one organization was working on 2,4,5-T and one was working on silvex, their opportunity to bring that data together and have that gain in learning experience is not nearly as great.

We have, in addition, our own long-term, in-house backgrounds. As I mentioned, every material which is synthesized and made in our company goes through preliminary tests, and there is actually an enormous body of information on literally hundreds and hundreds of compounds.

In many cases it is only fragmentary, but it is data on which can be added another piece of information—and another piece. So we, and I think many companies, like to be able to expand, and in some cases there are grants that are put out—but that is really not our common way of doing things.

A point I might state here is that I believe that the USDA does have programs where there are minor uses for products where the opportunity there isn't great enough for the companies to be involved, that they do have grants on research programs.

I don't know what exactly they call that program, but those are available. For instance, there are special kinds of agriculture in the U.S. where it is a special kind of crop, very indigenous to a certain region of the country, and if they don't have a certain type of chemical, they couldn't grow that crop. The government provides that USDA works in those areas to benefit those regions of the country using various companies' products.

QUESTION: Generics has not worked for the drug system, FDA. The tendency has also been for more efficacy data, not less. Why does EPA wish to repeat the drug mistakes? Also in regard to efficacy, what are your company's concerns regarding EPA's contentions to de-emphasize efficacy data? Maybe both of you can talk briefly about our emphasis or deemphasis on efficacy data and how it affects the manufacturer.

DR. WELLS: I think I may skirt around that first question a little bit. The Agency has decided that we have expended far, far too many hours in doing the classical efficacy reviews. We feel very strongly that because of the very heavy involvement by industry in this area, as Dr. Blair's presentation indicated, and the fact that this industry involvement brings in State institutions and in some cases Federal institutions and screening for the efficacy of pesticides, and in particular herbicides, that there are ways to assure that the product is efficacious without this vast expenditure of resources on the part of the Agency, and this is what Mr. Johnson was referring to this morning in saying that we should be able to accept the word of the experts in the field as to the efficaciousness of the product.

It also is extremely unlikely any company is going to market a product long if it is not efficacious. This is true in the case of a herbicide when you quickly see whether it is efficacious or not. That is the Agency's viewpoint.

Jack, you might want to respond about how the industry feels about it.

DR. EARLY: I might add that obviously whether a product is successful or not rests in the marketplace. As Bill said, if a product is efficacious, it will sell. If it isn't, it won't sell.

So that is the obvious place for it to be. Some of our member companies do have some concern that EPA maybe should not back away too far from getting some efficacy data. There should be some requirement to show that a product is efficacious.

Again, I think our association and our industry has supported EPA in this direction, saying the marketplace is the place to determine whether or not a product is efficacious.

MS. HINKLE: I think once you let the marketplace determine the efficacy, that means that the farmers and the consumers find out whether the product works or not, and I guess one could ask if that is the proper place for testing whether or not a product works, particularly in the case for consumers as in the case of a disinfectant.

DR. WELLS: In the case of disinfectants, the efficacy requirement is not being diminished.

MS. WINE: We have a number of questions concerning 2,4,5-T, 2,4-D, and TCDD. We have questions about the rebuttable presumption process. I would like to lump them together.

QUESTION: What is the status of 2,4,5-T and 2,4-D in RPAR? When there is hard evidence that a chemical compound may endanger human health or life, what relative values are assigned to human life, forest products, and economic solvency in the process of making a distinction regarding the continued use of the chemicals in question? How much of a problem do we have with dioxins and 2,4,5-T and PCP, and when did Dow first become aware of the existence of TCDD in 2,4,5-T?

DR. WELLS: I guess I should take the first couple there.

As regards the status of 2,4,5-T and 2,4-D, 2,4,5-T is a candidate chemical for RPAR for the RPAR decision. All uses have been under review. We anticipate that we will reach a decision point on 2,4,5-T in late March or early April. I cannot tell you at this time whether that decision will be that a presumption will be issued or not, because we haven't finished our review.

2,4-D has been referred to the Office of Special Pesticide Reviews to be evaluated for candidacy to enter the RPAR process. Due to a lack of resources we haven't looked at 2,4-D yet. It is in a filing cabinet along with other referrals. We don't have anyone to put on that chemical. So at this point, 2,4-D is not a candidate for RPAR. It has been referred to our office; and until we have looked at the reasons for the referral and established their validity or invalidity, I cannot tell you whether it will be a candidate for RPAR or not.

The rebuttable presumption process involves first an examination of the studies that indicate that there are certain criteria with regard to chronic or acute effects or effects on nontarget populations, wildlife—an examination of those criteria to see if the scientific reasons are in fact valid and indicating that those criteria have been exceeded—if we find that is the case, we then would issue a notice, an Agency position that the risk of this chemical gives us enough concern that we want to invite public comment on that chemical.

Dr. Foy indicated this morning that EPA should get interested in benefits. I can assure him that we are very much interested in benefits and we do, in fact, work very closely with the USDA to ensure the collection of information on the benefits of the pesticide. The assessment team which collects that information is a joint assessment team, and USDA and EPA work closely on that rebuttable process.

I want you to understand that this is an open process with full participation by the public, by the industry, by the environmental interests, by anyone that wishes to make a comment. We want people to supply information with regard to risk and with regard to the benefits of the pesticides.

We want to do this in an informal process, not in a court. That is the whole purpose for the process. So we invite everyone who has an interest to participate. We want to have the complete story on risk and the complete story on benefits so that we can balance them one against the other and make reasonable decisions.

In the decisionmaking process that we have been involved in over the last year, we have found that once we begin to weigh the risks and the benefits in attempting to exercise regulatory options, we find a decided lack of data in one particular area; and since this panel is supposed to be talking about problems with regard to data, I want to emphasize this point so that many of you who are researchers can be aware of it. The kind of data that we need so desperately to exercise regulatory options and make regulatory decisions are exposure data, and we have very, very little exposure data.

I think most reasonable people would acknowledge the fact that risk by itself is meaningless, unless someone is exposed to it; and in many cases when we don't know what the exposure picture is, the Agency is forced to make a decision on the side of safety—and this gives rise to comments about zero-risk policy and what-not.

If we have good exposure data, we can make much more reasonable decisions. I just want to point that out. I think there was a question in there some place about the dollar value on human life or something. Do you want to restate that?

MS. WINE: I think they were concerned about how you equated the regulatory options with the dollar values of continuing to produce food and fiber, what relative values are assigned to human life, the products that are produced in the forests and economic solvency in the process of making a decision. We do consider economic benefits.

DR. WELLS: We do, and we assign dollar values to crops and the production of food and fiber. It is a little stricter when you start talking about dollar value on a human life. I find that a distasteful equation. I don't like the idea of assigning dollar values to human life. I can't give you a nice answer or a nice formula for making a risk-benefit decision, and I don't want to see one.

You have to put the cards on the table, and you have to make some pretty hard decisions. After we have made a number of decisions, a pattern may evolve. At this point I can't tell you whether we are going to allow five cancers in a population of a million—or whether it will be zero cancers—or 20. I don't know. We just have to look at each situation now and maybe after we have made a number of these decisions, there will be some patterns; we will know what ballpark we are playing in, and I can answer a question like that.

MS. WINE: Dioxins are going to be addressed this afternoon so this won't be the only time you have a chance to address questions. The other questions are directed to Dr. Blair.

QUESTION: Specifically, when did Dow first become aware of the TCDD in 2,4,5-T?

DR. BLAIR: By the early '50's Dow had developed a biological test which was really using rabbit ears for monitoring purposes of some of the by-products from 2,4,5-Trichlorophenol. One of the things that you may not all be aware of is that the TCDD problem is not one so much associated with the herbicide 2,4,5-T, nor is it made—when the herbicide is made, it is one which may exist in there from the trichlorophenol, a raw material which is used to make 2,4,5-T. So having been a producer for some time, a manufacturer of trichlorophenol which has other uses than just 2,4,5-T, we had developed a monitoring technique in the early '50's to monitor by-products to make certain that we were in control of all of the situations surrounding making the 2,4,5-T.

When we came into making it—by the early '60's—the analytical techniques were becoming sophisticated enough to begin to identify what the specific isomer was. Again, we use the term dioxins and there are 60 or 70 isomers, if you are talking about chlorinated dioxins.

I think we are really dealing with one specific isomer, the 2,3,7,8-dioxin. I would say in the late '60's, mid-'60's, the concentrations were around a part per million. Today they are less than a tenth of a part per million. So there has been a constant effort to bring the product out with lower and lower levels.

One of the things I am sure that will be decided this afternoon is some of the physical properties, especially the chemical properties, of the material.

As I mentioned, the specifics are running around a tenth of a part per million. It is a light sensitive material. It is rapidly photodegraded. That is one of the reasons we have difficulty finding it in the environment. If we do, in many cases it has been very heavily applied. The bionetics material which was used in the test in the '60's really contained 28 parts per million, and it was a laboratory sample on a shelf. It wasn't a production out of the Dow Chemical Company or Monsanto. It was a production of a company which went out of business.

MS. WINE: The other questions that we have are requests for clarification on the generic standard approach to registration and questions about trade secrecy as it relates to FIFRA.

Dr. Blair will be here this evening from 5:00 to 7:00 as well as a number of EPA people, and many of us will be remaining here during the lunch period; so if we have not considered your questions on the forum, feel free to come up and meet with us later on.

I would like to break for lunch now. We will see you back here at 1:15, and thank you, panelists and speakers.

(Whereupon, at 12:10 p.m. the meeting was recessed to reconvene at 1:15 p.m. of the same day.)

POST-SYMPOSIUM RESPONSE TO QUESTION SUBMITTED TO WILLIAM WELLS

QUESTION: I've heard of a proposal that EPA would require the retention of all "raw data" used to support a registration of a pesticide—university, government labs, private, commercial, etc.,—which would be subject to inspection for the life of the registration on penalty of having data invalidated by EPA. What are the facts? How could this be? Who would foot the bill? Repercussions?

ANSWER: As a result of EPA's Data Auditing Program there is cause for concern regarding the validity of test results submitted in support of pesticide registrations and tolerances. Due to the fact that invalid test results could have a significant impact on human health and the environment, EPA is requiring registrants to retain all raw data supporting the tests results that they submit to EPA.

POST-SYMPOSIUM RESPONSES TO QUESTIONS SUBMITTED TO ETCYL BLAIR

QUESTION: When obtaining efficacy data for registering a herbicide for forestry uses (site preparation), how many acres are required for each test, and how many test sites are required? How many replications are needed? How many years data are required?

ANSWER: Normally, several years of exploratory experimentation precedes the establishment of plots for registration purposes. These exploratory tests help define the dosage rate and the selectivity and provide the basis for the protocols of the later experiments. When the final tests for registrations are undertaken, the requirements are not clearly outlined; however, in general, they entail four to five forestry regions with two to three tests in each region. The surface area depends on the type of environment and species but ranges in amounts of 3 to 5 acres minimum with two to three replications. Testing normally takes at least 3 years.

QUESTION: Your statements indicate that the present knowledge of economic and environmental costs of biocides may indicate a need to change directions and substitute other management tools in place of herbicides. Is Dow considering such a reorientation to new avenues of research?

ANSWER: Chemical tools are only one of the many tools that a forester may use depending upon which is most appropriate and economical for a given problem. Current safe and effective products presumably will continue to be selected if they have a role which gives them performance and economic preference over other practices. Dow will continue to seek ways of using the various tools in conjunction with each other; and when new pesticides are developed for other purposes, their possibilities in the forest management area will be explored.

QUESTION: If Dow wants the trust of the public, why won't you share the data and results of your research as to toxicological effects of phenoxy herbicides? (Why is this information considered trade secrets?)

ANSWER: Work of Dow toxicologists on phenoxy herbicides has been published extensively in scientific journals available to anyone. The full details (notebooks, etc.) have been available for professional toxicologists to review. Since it has become a matter of public record, it is also available to anyone who wants to take the time to study it objectively and who has the technical background to make appropriate interpretations of the data.

QUESTION: Please name one area where research successes do not have to pay for research failures. Ag-chemicals is no exception.

ANSWER: Our discussions today dealt with the many problems of developing a new pesticide for forestry uses. In a review of these problems, many of these mentioned were not particularly unique to forest research but are general problems which must be considered in the development of any herbicide. Certainly the cost of failures applies in any field of research; however, the point has been emphasized so that the layman who may not recognize all of the costs that must be recovered in the price of a product has a more complete understanding of the overall costing and pricing process.

QUESTION: I am appalled that in your new chemical development (Stage 2) you consider marketing and patenting questions at the same time you consider health. How can you explain that health is not number one priority?

ANSWER: In the selection of a potential new product, I'm sure you'll agree, the first criterion must be that it is active for the purpose intended. There would be no point in even considering health implications until this criterion has been met. Once this activity is defined, then it is important to immediately test the compound for fit and acceptability on many other things, health and environmental considerations being of paramount importance. It would neither be sensible nor feasible to run toxicological studies on all chemicals if almost all of them have no potential as pesticides. Therefore, our discussion deals with the sequential consideration of the various questions in a new product development which follows an orderly progression and does not reflect any specific priority relative to importance to society, the company, or the user.

QUESTION: Can herbicides that are registered for non-cropland (i.e., powerline rights-of-way) be used as labeled for forest lands through which the rights-of-way pass? (Even if forest practices are not mentioned on the label, and if not, why not?) (What differences are there between rights-of-way and adjacent forest lands?)

ANSWER: As a practical matter herbicides which are used on powerline rights-of-way will often find utility in forests. These must be selected carefully, however, since sometimes it is important to have materials which are selective on conifers, for example, and this is not required in powerline rights-of-way where most tall-growing woody species are undesirable. However, the regulatory establishment requires that these compounds cannot be used interchangeably unless data are submitted to support the use specifically and until registration of a label specifically recommending this use has been obtained.

QUESTION: When do you predict additional or new pesticides will be manufactured since none was manufactured in 1977?

ANSWER: There are numerous compounds in the research systems of industry today which represent technological advances and which could contribute measurably to forest and food production. In the present scheme of things there is no way of predicting when these will be available to society, and if in fact the manufacturers will persevere and try to bring them through the regulatory maze to useful development.

QUESTION: One feels Dow wants FEA and EPA to just go away. Would they prefer this? If not, how would they cope with public and consumer safety with environmental damage? Or would they just look for profits which was Dow's main theme?

ANSWER: There are a number of ingredients required to bring along a new product to the point where it can be successfully used to benefit society. Among these, of course, are safety, economics, etc.; and while much attention is focused on these, one other ingredient in success is profits. This combines with all of the others to make a successful product. It does not stand alone as the only requirement; however, in the present emotional environment of the media the factors of safety and environmental aspects are highlighted constantly to the public while the need for profit are rarely mentioned, much less explained. It is imperative that any discussion of the concerns in new product development also includes this for the understanding of all people such as the audience here today who have indicated an interest in all aspects of product development. The Dow Chemical Company recognizes that there is reasonable need for a governmental regulatory role in many aspects of our society including that of pesticide use. It does not accept the widely propagandized view that corporations are interested only in profits to the exclusion of consumer safety and environmental damage. Corporations balance all aspects of products they bring to the marketplace in as reasonable a manner as possible. There is, however, reason to feel that the technological future of our country has been unnecessarily subordinated to the growth of a ponderous regulatory establishment which attempts to solve all problems by substituting arbitrary rules for good judgment and which has developed skills in the political arena exceeding their professionalism or dedication to the advancement of the country as a whole. Dow would like to see regulatory organizations assume a more professional role in which they become a part of solving all of the various problems for the country rather than to maintain one-dimensional adversarial roles opposed to everything except the rapid proliferation of regulation.

QUESTION: You stated that there are only (usually) two sprayings per hundred years on a section of converted land to decrease tree competition of hardwoods.

This might be a textbook figure but does not take into account many factors that can and do frequently increase the number of sprayings, such as drift caused by other than ideal spraying conditions. The contracted sprayers don't always spray only during ideal conditions resistant hardwoods that take more than two or three sprayings.

How can you flatly state that it is sprayed so seldom when in reality it is sprayed more often and has more of a chance in causing a toxic effect?

ANSWER: In the normal course of events a forester will only use a minimum number of herbicide treatments sufficient to modify the competitive environment enough (i.e., reduce competition but not eliminate it) to shift the balance toward the production of conifers, for example, as opposed to hardwoods. In a classical commercial use today this does not involve more than something like two applications. This is ordinarily enough to give the conifers the assistance they need, and if it is not accomplished with these minimum numbers of treatments, it usually becomes uneconomical in the course of producing a long-term crop to make more applications. Spraying must therefore be done intelligently with sound knowledge of the technology involved in the undertaking in the hands of the professional forester. Resistant species can be handled in many ways. Sometimes this can be prevented by the proper selection and application of a herbicide, or, secondarily, sometimes small areas can be treated an additional time on a very localized basis. Frequently while not killed, they may be suppressed adequately enough to permit the conifers to continue to grow, and the fact that they were not completely eliminated is unimportant. The important thing is not to kill a maximum of "weed" plants, but rather ot create an environment in which the desirable plants can thrive. Certainly there have been instances of spray drift, and there are always instances of a typical situation in any kind of undertaking. However, these are minor problems of the total overall forest management program and normally occur in such a way that they do not have any significant environmental impact.

QUESTION: Why should a research-and-development-oriented company divert funds to fill data gaps or update data files for an unpatented compound when EPA desires to operate a generic registration? Funds and support of these old products would not be well invested in products that lack patent protection. The first registrant to satisfy the requirements would have higher costs to recover from sale of the product.

ANSWER: Any company which undertakes to do all of the research and provide the staff for negotiations with the Federal Government . . . (necessary for reregistration of older products) devotes a considerable amount of his resources for this purpose at the sacrifice of new product development. Other companies or organizations who do not participate in this process and do not have these expenditures normally are of the kind who are not expending money on making advances in technology but will simply wait until all of the work and negotiating is completed and then ride on the coattails of the industrial leaders doing the research. In these circumstances there is no way that the company doing the research can recover its investment. In addition, there is the possibility that if for some reason registration is not obtained, whether it be logical or not, that no one will recover any funds. There is no way that a company can do this and continue to stay in business.

QUESTION: How can the chemical industry rightly claim that toxicological information gained during research is an industry trade secret? Does this not limit the debate that citizens can participate in?

ANSWER: This information is developed to more fully understand and support the toxicology picture on a compound which a manufacturer is making or proposes to make. This information is submitted to governmental authorities for professional review and is fully opened to those who have regulatory responsibility and can make professional toxicological judgments. A company making this kind of commitment of resources cannot allow itself to become the "little red hen" of the industry that does everything while others only eat the bread. A company must protect its investment in studies needed for registration so competition does not obtain this information for nothing.

QUESTION: Unique new chemicals for exclusive forest use is unlikely because of the small margin. Can the chemical industry bear the cost of registering ag products for forestry? Will USDA have to assume some of this work if registrations are to be obtained?

ANSWER: Industry can certainly bear the cost of registering products for forestry which already have other agricultural uses if the registration requirements are reasonable. Registration, on the other hand, is only a part of the total cost of developing a new, unique chemical for forestry use. It is unlikely that any coalition of activities would improve the chances of developing such a compound.

QUESTION: With a reduction in productivity from increased weed competition (from less use of herbicides) to meet the demand for wood, would forestry practices become more intensive or extensive?

ANSWER: Certainly larger acreages will be required to produce the same amount of wood product if forests are less intensively managed. To this extent the practice would become more extensive. However, in either case the net result will be that wood products will become more expensive, and a renewable resource which our country can provide for its citizens will be seriously restricted and economically unavailable for many purposes.

QUESTION: It seems that the cost of producing and convincing the Agency to grant registration is so expensive that your company would welcome the opportunity to review old work with new techniques.

ANSWER: Industry is most anxious to use "old work" to support registration of products and to, in a sense, avoid reinventing the wheel. The problem that I have attempted to highlight is not a lack of interest in using old data but rather an arbitrary and non-scientific approach on regulation which in effect declares that research findings on old products which have been around for many years are obsolete, not because the product has been any more or less safe, but simply because the research has not been done according to new arbitrary rules and regulations which are constantly being modified and which have no substantial bearing on the outcome of the experiment and the significance of the data issuing from the experiment.

QUESTION: What do you have against the use of people (human labor for vegetation management)?

ANSWER: The cost of producing wood is very great, and forestry management people use various kinds of machinery, chemicals, and any other tool that they can to produce it most efficiently and keep the cost from being prohibitive. People should and, I am sure, will be employed wherever their contribution is economically sound and where they provide a necessary service at a cost that is more economical than other alternative ways of accomplishing the same goal.

QUESTION: Why shouldn't our communities and the public take over the chemical industry and produce what is needed, not what is marketable or what will sell?

ANSWER: The end user is the final determining factor regarding whether something is produced. If the potential user does not have a need for the product, he will not part with his money for it; it will not be made. This puts the decision where it reasonably ought to be, and I am sure that none of us would like to see the materials that are available in our stores determined by some mythical body that thinks it knows more about what we want than we do and, therefore, makes many things which we would be willing to purchase unavailable to us.

QUESTION: If value of forest management chemical products is estimated at $80 million and marketplace cost is $15 million, why is this unprofitable? My assumption here is that the new product will be safer than what is presently available.

Many different chemicals are used in the forest products industry none in large amounts and certainly none at the $25-$50 million per year which is the size of market required to support the development of a new product, specifically for the forest product industry.

ANSWER: It is currently estimated that approximately $8 million are spent by the forest industry for pesticides per year. It is not a million dollars per year. Of this total amount of money a high amount of the cost is involved in manufacture, shipping, warehousing, and other costs. The costs of research must then also be deducted from any difference that remains between the selling price and all of these other costs so that such a small amount is left that basically there is no return on investment, either the $15 million in research costs or the capital required to produce.

QUESTION: Would you please discuss the impact of spraying on local economies in timber-producing areas?

ANSWER: Basically, spraying or any other practice which helps to make the production of timber in any given area more economically competitive with the rest of the world helps to develop and/or preserve an industry in that local area which employs people. As we mentioned before, people will be employed wherever their contribution is economically viable and where the contribution that they can make is essential. If there is no technology available to help make local forest production efficient, there will not be a forest industry, and there will not be anybody employed in that area in wood production.

QUESTION: Why has no testing been done with animals with combinations of chemicals with carriers instead of each separately as a basis for your no-effect judgment in forest use on the health and environment?

ANSWER: The emphasis of toxicological research is on developing and understanding of the toxicology picture of any given chemical. Once this is obtained, and once the product is approaching the commercial use stage, various combinations which might ultimately be used are tested for their total toxicology picture and for their effect on the environment. The basic information on the toxicity of the individual components does, however, provide a good basis for trained scientists to effect reasonable judgments without duplicating everything in its entirety.

QUESTION: If Dow is concerned with environmental damages, are grants available from Dow to do environmental studies which can be shared with EPA?

ANSWER: Dow maintains a program of grant-in-aid to research to qualified organizations where work can be done under contract to fulfill environmental research needs for products which it is developing.

QUESTION: When DDT was permited to be used, were follow-up studies in the field done? If so, where do we find the data compiled as a result of the testing that should have been done in connection with such a study?

ANSWER: Dow was not involved in the application of DDT referred to. However, the EPA, of course, was very much involved and is in a position to provide you with information on those studies and on the follow-up.

QUESTION: Since DDT was found to be environmentally harmful, why wasn't manufacture discontinued?

ANSWER: DDT was also found to be enormously useful. Thus, the decision to use or not to use DDT is a risk/benefit balancing proposition. DDT is not a product of the Dow Chemical Company; however, it is our understanding that because of the continued need for such a compound to meet human health needs in various countries of the world, this product is still used, and it is, in fact, manufactured in some instances by governmentally owned plants to ensure its availability so as to improve the life of its people.

QUESTION: Are you aware of conifer damage done by use of herbicides?

ANSWER: Our company has been involved in research in the field of forestry since 1946. We have seen many herbicides which when used improperly can and will injure conifers. We have, on the other hand, seen thousands of acres of conifers treated in the proper way with excellent results and significantly improved growth of conifers.

QUESTION: When did Dow first become aware of the TCDD in 2,4,5-T? Please give background.

ANSWER: Since 1950 The Dow Chemical Company has been aware of the possibility of a highly toxic impurity being formed in the production of 2,4,5-trichlorophenol, a precursor of the herbicide 2,4,5-T. The most sensitive toxic reaction observed in humans to this impurity was a response termed chloracne, a skin disorder. By exercising appropriate manufacturing controls, this impurity can be kept at a minimum in tricholorophenol and consequently in 2,4,5-T.

In 1957 Schulz and Kimmig of Germany disclosed that 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) was formed in the manufacture of 2,4,5-trichlorophenol and was the cause of chloracne in workmen making the chemical.

In late 1964 several Dow workers developed chloracne and the rabbit-ear bioassay program showed that the skin reaction potential of the waste oil from the 2,4,5-trichlorophenol process was the source. Exposure of this waste oil, not exposure to trichlorophenol or the herbicide 2,4,5-T, was the cause of the acne in the workmen. After this occurrence the 2,4,5-trichlorophenol plant was rebuilt incorporating improvements to avoid a recurrence of the problem. At that time a specification was established that permitted no TCDD in 2,4,5-T when assayed by a method sensitive to 1 ppm. In 1970 the specification was lowered to none detectable by an assay method sensitive to 0.5 ppm TCDD. In 1971 the specification was again lowered to 0.1 ppm TCDD.

It should be emphasized that the reports of chloracne in workers have resulted from exposure to products related to the manufacturing of 2,4,5-trichlorophenol, not the herbicide 2,4,5-T.

QUESTION: How much of a problem do we have with dioxins in 2,4,5-T and PCP?

ANSWER: It should be realized that theoretically there are a possible 60 or 70 different dioxins. The dioxin contaminants currently recognized of greatest concern are:

(1) 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in products made from 2,4,5-trichlorophenol.

(2) Hexachlorodibenzo-p-dioxins (HCDD) occurring in pentachlorophenol. Octachlorodibenzo-p-dioxin is also present. TCDD has not been found in U.S.-produced pentachlorophenol.

The manufacturers of the herbicide 2,4,5-T are producing a product containing less than 0.1 ppm TCDD. This level was recommended by the Advisory Committee on 2,4,5-T to the Administrator of the Environmental Protection Agency in 1971.

Currently the Environmental Protection Agency is reviewing the possibility of making recommendations on the maximum allowable dioxin content in pentachlorophenol.

QUESTION: Why do you say that products shifted to Europe and Japan by U.S. environmental restrictions will work their way back into the U.S.? What evidence is there for this?

ANSWER: Japan, and especially Europe, have, at least up to now, taken a more reasonable attitude on testing of agricultural chemicals (and drugs) than has the U.S., and it simply takes less time to put a new product on the market in these areas of the world than in the U.S. As a consequence, new-product development is increasingly taking place—first in these and other areas of the world, and last (if ever), in the U.S. This puts these countries ahead of the U.S. on a technology basis, and the gap keeps widening.

QUESTION: You have spoken about costs. Can you estmate the profits which Dow has realized on agricultural, pesticides and the degree of governmental grants, subsidies, and research support?

ANSWER: The agricultural chemical business in Dow has been for a long time, and still is, one of its less profitable businesses. Nevertheless, our management recognizes that there is a great need worldwide for better and safer agricultural chemicals and has been willing to continue to constructively invest into business in the hope that it will eventually turn around. A similar kind of commitmnet on the part of the U.S. Government would be most helpful.

Dow receives very little from the government in the way of grants, subsidies, and research support. As a matter of fact, we subsidize the government through the taxes we pay and the taxes our employees pay. We also support a substantial grant program to public sector organizations, particularly Land-Grant colleges.

QUESTION: How do your financial losses from chemicals that are never marketed compare to company profits?

ANSWER: Profits of the Dow Chemical Company before taxes are approximately 16–20 percent of sales, and after taxes about 8–10 percent of sales. Twenty-five to 50 percent of the profits after taxes are distributed in dividends. The remainder is used to build new production plants and replace obsolete and inefficient production plants with newer, more pollution-free plants.

Losses as a result of potential products that never make it to the marketplace or products that are unsuccessful in the marketplace are substantial—running into the tens of millions of dollars each year. This is an unavoidable risk in the development of new products which the company strives to keep to a minimum, since the cost of unsuccessful products must be applied to the selling price of successful products. There are limits beyond which this cannot be accomplished in the mraketplace because of price competition in the marketplace. Thus, if there are too many unsuccessful products, the entire business will founder.

QUESTION: How does the amount of money spent on health and environmental effects of a chemical compare to the amount spent on advertising and promoting a new chemical?

ANSWER: The cost of health and environmental testing is usually substantially greater than the initial costs of advertising and promotion for a new product. However, the former is a one-time cost, while the latter continues throughout the life of the product and eventually would be substantially greater than the former.

Advertising and promotion are as necessary a cost to the development and sales of a new agricultural chemical as health and environmental research. It is simply the cost of communication and in considerable measure involves communication of the results of health and environmental research. The pesticide industry is not nearly as dependent on advertising as, for example, certain consumer industries since its products are sold on the basis of technical performance, not consumer appeal. Nevertheless, it must reach hundreds of thousands of farmers by advertising and promtion if it is to sell the product at all.

QUESTION: In what period of time must a chemical reach $100 million in sales in order to be practical? Are potentially usable chemicals often branded as "losers" because they fail to meet this qualification?

ANSWER: A pesticide chemical does not have to reach $100 million in sales in order to be practical, but it does have to provide an equivalent profit to a bank investment 15–20 years after the start of the R&D investment—and 5–10 years after initial sales. After 20 years it should be substantially more profitable than a bank's investment in order to justify the risks initially involved. This requires annual sales at maturity of at least $25–50 million and a selling price at least 2½ times the manufacturing cost. The expiration of patents and the entrance of competitors into the business after 20 years will will usually drive the selling price/cost ratio substantially below 2½.

By definiton no chemical is potentially usable unless it does meet these requirements since it will have to compete in the marketplace with other chemicals that do. Furthermore, the nature of private corporations requires that they make a profit in order to survive. Continued monetary losses from the sale of a pesticide (no matter how useful its biological activity might seem to be) will necessitate termination of sale since the losses constitute undesirable evidence that the marketplace does not value the product sufficiently to make it profitable.

QUESTION: Do your cost figures for R&D on new pesticides reflect not only increased emphasis on environmental effects but also increased resistance among targets and also the opportunity costs of the monies initially invested?

ANSWER: The cost figures for R&D represent (1) the increased cost associated with government regulation for every phase of pesticide discovery and development, (2) inflation, and (3) the greater probability of failure due to the increased government restrictions and reduced numbers of markets of sufficient size.

QUESTION: Between 1956 and 1969 your cost of developing agricultural chemicals increased at 8½ percent per year and between 1971 and 1977 at 7 percent a year. This is probably reflective of inflationary pressure. The big jump was 1969–1971 and probably reflects increased focus on the chronic health effects and carcinogenicity. Do you feel that these health studies are unnecessary? Do you feel it is reasonable to expect development costs to be constant instead of reflecting inflation?

ANSWER: Our total R&D costs in the agricultural chemical business are generally related to the growth of sales. If business is good, we spend more on research, and if business is bad, we spend less on research regardless of inflationary trend.

The pattern of research has been changing due to government regulation. During the last 10 years we have reduced our manpower devoted to discovery to 40 percent of what it used to be. This manpower, and more, has been shifted into activities ,designed to meet the demands of governmental regulation. We do not feel that all of these new health and environmental studies are unnecessary, but we do feel that many are and that the whole philosophy of government requirements is being poorly handled. Since these tests are a cost of doing business which must be applied to the selling price of products, it is in the interest of the consumer that we do only those tests that are necessary to make good judgments and that we do them efficiently. The government continues to force new and frequently unnecessary and unjustifiable tests on the industry as fast as the tests are invented and does a very poor job of making use of the information coming from these tests to constructively register safe products for use in agriculture.

QUESTION: How much of the increase in R&D is due to inflation? How much of it is due to the increase in cost and availability of raw materials? How will the decrease of the value of the dollar affect the sale of pesticides by foreign companies in the U.S.?

ANSWER: Inflation of costs (people and raw materials) is a substantial part of the growing cost of R&D. However, regulation is an even more important cost because (1) it is causing shift from discovery research to defensive and development research, (2) it reduces the number of products that can be developed per year, and (3) it greatly lengthens the time required for development.

The decrease in the value of the dollar is unlikely to affect the sale of pesticides by foreign companies in the U.S. since these companies are multinational and have their own research and manufacturing facilities located in the U.S.

QUESTION: Have the increased costs in R&D been caused by inflation rather than increased testing?

ANSWER: The answer is both. Inflation is certainly a part of the increased costs. But the major increase in cost is due to increased testing requirements at every level, long delays in the registration of products, increased numbers of personnel simply to deal with the EPA, and the more stringent requirements relative to developing pollution-free processes. Confontration with bureaucracy at every level on a day-to-day basis has greatly eroded productivity and vastly increased the costs of discovering, developing, registering, manufacturing, and selling pesticides.

QUESTION: What do you think would be the best way the government could protect people and the environment from pesticide misuse?

ANSWER: A better goal would be to help people protect themselves and the environment from pesticide misuse. In my own experience the most successful safety programs involve a personal commitment on the part of the individual to his safety and the safety of others rather than on a slavish dependency on the government to do all the thinking for the individual. This is not to say that the government cannot and should not play a major role. Specifically, the government should:

1. Require a scientifically valid and sufficiently comprehensive program of experimentation to determine the potential hazards of a pesticide. (The current program is excessive but at the same time does not meet the above stated goal.)

2. Develop in conjunction with other public institutions and manufacturers recommended programs to avoid pesticide misuse (product stewardship). Some of the best safety programs in or out of government have been created and implemented by major chemical manufacturers.

3. Develop an educational program in conjunction with other public institutions and manufacturers designed to increase awareness of how to handle pesticides safely at every level of use. This program should be accurate and realistic. Continually "crying wolf" about pesticides does not help to develop trust, understanding, and perspective in the user.

QUESTION: If the manufacturer of a product says it is safe if used according to instructions, should not the manufacturer be willing to pay for health damages if any incurred when the product is used that way?

ANSWER: The manufacturer strives to develop recommendations for the use of a product that will ensure its safety if the recommendations are followed. If a health problem (objectively measureable) occurs even though these recommendations are followed, the manufacturer is liable for damages.

QUESTION: After Stage 4 Dow has invested millions of dollars in the new product, and at that point it certainly is difficult to swallow any loss. Is there not a basic contradiction in having the manufacturer prove its products safe to the government? How is a lack of bias demonstrated?

ANSWER: The implication of the question is that because companies invent, manufacture, and sell products, their research personnel are either incapable or not desirous of doing unbiased research work on the safety of their products. Apparently, their mortality is not to be trusted because in addition to developing safe products and efficacious products they are also required to develop profitable products.

I believe that any unbiased evaluation of the integrity and capability of industrial scientists will reveal the stand second to no one, including government and academic scientists, in the pesticide field. In addition, they have certain "incentives" to perform that government and academia scientists are not burdened with.

For example, if the product does not perform, the company can be sued. If the product is dangerous to human health, life, and the environment, the product could be banned and the company find or sued. If a researcher falsifies data, he is certain to be fired and will probably go to jail.

Companies recognize that developing new pesticides is a high-risk business and that a pesticide can fail to meet the necessary qualifications at any stage along the way. In almost all instances the failure is not in the health and environmental area since their limitations are usually identified at a very early stage. The most serious limitation is the cost of manufacture/pesticide-efficacy relationship. Many pesticides are dropped because they simply cannot be manufactured and sold at a price that will generate a reasonable profit.

QUESTION: When there is hard evidence that a chemical compound may endanger human health or life, what relative values are assigned to human life, forest products, and economic solvency in the process of making a decision regarding the continued use of the chemical in question? Does a human life have a dollar value?

ANSWER: There is nothing in the environment that does not constitute some potential danger to human health or life including sunshine, bees, birds, wildlife, automobiles, hammers, sassafras tea, and, of course, chemicals. There are no intrinsic characteristics of any chemical, man-made or natural, that preclude its being managed in such a way as to *not* constitute a hazard to human health or life. It is true that there may be chemicals so toxic that the precautions needed to permit their use could make the effort not worthwhile from an economic or use standpoint, but this is usually a very rare situation. It is possible to properly manage *all* chemicals so that they do *not* constitute a hazard to human health or life.

This is not to say that chemicals of one sort or another will never turn out to be hazardous. Human frailty of one sort or another and "acts of God" will most certainly create situations from time to time that will turn out to be hazardous to human health and life. The same is true of guns, automobiles, skateboards, sidewalks, bathtubs, etc. It is not constructive to blame our own frailty or accidents of chance on inanimate objects or inanimate chemicals.

QUESTION: What benefits to the environment, to pesticide users, and to the efficiency of the EPA regulatory process can be realized by deemphasis of efficacy?

ANSWER: There is no intention to deemphasize efficacy data—only the role of EPA in the process. Good efficacy data is of paramount importance to the manufacturer, who must stand behind the product he sells legally, and the important public service groups such as the U.S.D.P., the Land-Grant Universities, the experiment stations, and the Extension Service, who advise the farmer. These groups are the most capable for generating efficacy data and providing suitable recommendations for use. The EPA's primary role is safety of the pesticide to humans and the environment, and it should use the resources it has to improve the ways in which it approaches these goals.

QUESTION: What are the company's concerns regarding EPA's contentions to deemphasize efficacy data requirements?

ANSWER: We subscribe to the deemphasis of efficacy data requirements by the EPA. The USDA, the Land-Grant Universities, the experiment stations, and the Extension Service have traditionally played the strongest role in evaluating the usefulness of pesticides and developing recommendations for farmers. Their role should be strengthened. The EPA is too far removed from the practical aspects of day-to-day farming to be able to pursue this role in a sufficiently flexible and responsive manner to meet the needs of farmers and agriculture.

QUESTION: How will EPA's proposed deemphasis of efficacy influence reliability and consistency in pesticide produce labeling (claims, use directions, limitations, restrictions)?

ANSWER: The decreased role of EPA with regard to efficacy data should in no way decrease consistency of pesticide product labeling (claims, use directions, limitations, restrictions, etc.). The EPA will certainly be exercising its prerogative to limiting labeling to uses, methods of application, rates, etc., that are safe to humans and the environment. Within that framework the public institutions that advise the farmers will in cooperation with the manufacturers devise the best possible labeling for optimum efficacy. The constituency that they save, namely, the farmers, will make sure that happens in the marketplace by their decisions to buy or not to buy specific pesticides for specific uses.

QUESTION: (1) You showed that $10 million out of $70 million went towards product failures. What percentage of that (or how many millions of dollars) was directly a result of Step 4 health effects?

(2) How does this compare to gross and net profit in 1977 dollars?

(3) How does this compare to chemical industry-wide product development losses?

(4) Why were no new, novel products placed on the market in 1977?

(5) What percent of R&D dollars are spent on chemical product development versus crop immunity or resistant strains?

ANSWER: (1) In the last 10 years we have lost at least two products at the Stage 4 or Stage 5 level due to potential health and environmental effects. A number of other products were eventually discarded for economic reasons—that is, they were unable to compete in the marketplace.

(2) The cost of product losses in the last 10 years far exceeded gross and net profit in our agricultural business in 1977. The agricultural chemical business in Dow has on the average not been nearly as profitable as the rest of Dow's business. The company is striving to correct this situation so that it can continue to support the agricultural chemical business.

(3) We do not have information on chemical industrywide product development losses.

(4) Presumably because the Environmental Protection Agency chose not to register any new products.

(5) Chemical companies do research on agricultural chemicals, not crop breeding nor genetics, since this is what they know best. However, some of the chemical companies have purchased seed companies which do crop breeding research. According to the Agricultural Research Institute research survey, 26 companies reporting spent a total of $33.7 million on plant-breeding research.

QUESTION: (1) How much money (gross) is Dow making from selling pesticides?

(2) Which and how many "products" have been abandoned?

ANSWER: (1) Dow does not publicly break-out the profitability of its agricultural chemical business from its total bioproducts business (agricultural and human health). However, the 1977 annual report shows the profitability (profit margins) of these two businesses were substantially smaller than for the rest of Dow's business making it difficult for them to compete within Dow for investment funds. What is true for the total of the agricultural and human health business was equally true for the agricultural business alone.

(2) The following products have been abandoned in the last 10 years in Dow's agricultural chemical business:

NORBAK particulating agent
Trichloroacetic acid (TCA) herbicide
DAXTRON herbicide
ZECTRAN insecticide
LORVEK fungicide
KEDLOR feed additives
NELLITE nematicide
TAVRON herbicide
ZYTRON herbicide
Fospirate insecticide
Chloine Chloride
ERBON herbicide
EDB soil and grain fumigant

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MS. WINE: For our next two speakers, James Witt and Morris Cranmer, we don't have panels because we felt we were covering areas that were rather familiar, but we wanted you to have the background information so that the proceedings were well rounded.

DR. JAMES WITT is the extension chemist and professor in the Department of Agricultural Chemistry at Oregon State University. He is involved in working on problems in the areas of chemistry and the behavior of pesticides, the registration of pesticides, the toxicology of pesticides in industrial chemicals, and the behavior of pesticides and industrial chemicals in the environment.

DR. WITT.

CLASSIFICATION OF SILVICULTURAL HERBICIDES

James M. Witt

The issue before this Symposium is whether herbicides ought to be used in forest pest management. There are many facets to such an issue. The opponents to the use of herbicides have not made it clear whether their principal concern is toxicological, ecological, sociological, or economic. Certainly, there appear to be elements of each of these present in the concerns as they are variously expressed. The element most often presented as a basis for garnering broadly based public support for opposition to the use of herbicides is the toxicology of the herbicides. Nevertheless, even in that context it is not clear whether the opponents are objecting to the presence of dioxin, the use of only the phenoxy herbicides, or the use of any or all herbicides. Unfortunately, when objections are raised on the basis of the properties and toxicology of one or two chemicals, the public perception is that this applies to all herbicides for they tend to think of herbicides as a single type of chemical entity rather than a diverse group with widely different characteristics. For this reason it is important that we review the chemical classification of herbicides used in the forest. This will identify the chemicals involved in this controversy, clearly illuminate the fact that there are several different groups of chemicals involved, provide a basis for actually seeing that they are different kinds of chemicals, and in effect define the terms used in this controversy.

Any classification system used for any purpose groups "like-for-like," so that common properties can more easily be associated with groups and can also be used as a basis for prediction of behavior or properties of other members of the group. In the classification of pesticides we generally use both chemical structure and function or purpose as a basis for classification. The initial segregation is the obvious and familiar grouping according to purpose:

PESTICIDES
- HERBICIDES
- INSECTICIDES
- FUNGICIDES
- NEMATICIDES
- RODENTICIDES
- PISCICIDES
- AUICIDES
- Etc.

There are two points which need to be made about this type of initial classification. We commonly see persons using the phrase "herbicides and pesticides." I think they tend to use the word pesticide as an equivalent for insecticide, and the phrase "herbicide and insecticides" would be correct, but it can be seen that the phrase "herbicides and pesticides" should never be used. Any functional classification of pesticides such as this can be as long as you wish to make it, simply by identifying the pest name and combining it with the suffix "-cide," a latin word meaning "to kill."

The chemicals used as insecticides can be classified into three or four families which comprise about 90 percent of the insecticides used. Unfortunately the herbicides are a much more diverse group. Within a functional grouping, such as herbicides, we can classify the chemicals according to structure. For herbicides the number of chemical families is long and somewhat confusing. Some of the more important families and a few samples of herbicides are:

HERBICIDES

PHENOLS	:	PCP, DNOC, Nitrofen, Dinoseb
PHENOXIES	:	2,4-D, 2,4,5,-T, 2,4-DP, Silvex
BENZOICS	:	Dicamba, Amiben, Fenac, Dacthal
ANILINES	:	Benfin, Trifluralin, Nitralin
AMIDES	:	CDAA, Kerb, Ramrod, Alachlor
CARBAMATES	:	Chlorpropham, IPC, Tandex
THIO-CARBAMATES	:	EPTC, Diallate, Vernolate
PHOSPHO/AMINO	:	Glyphosate, Krenite
UREA	:	Monuron, Diuron, Linuron, Methazole
TRIAZINE	:	Atrazine, Simazine, Terbutryne
URACIL	:	Terbacil, Bromacil, Bentazon
ORGANO-ARSENICAL	:	Cacodylic acid, MSMA, DSMA

Although this partial presentation of herbicides and herbicide classification can be somewhat confusing, the problem is considerably simplified when we eliminate those not used in forestry.

HERBICIDES

PHENOLS	:	DNOC
PHENOXIES	:	2,4-D, 2,4,5-T, 2,4-DP, Silvex
BENZOICS	:	Dicamba
ANALINES	:	
AMIDES	:	
CAR-BAMATES	:	
THIO-CARBAMATES	:	
PHOSPHO/AMINO	:	Glyphosate, Krenite
UREA	:	
TRIAZINE	:	Atrazine
URACIL	:	
ORGANO-ARSENICAL	:	Cacodylic acid, MSMA

This simplifies the problem of understanding the herbicides, but the listing is incomplete. A complete identification of the herbicides used in forestry is as follows:

FOREST HERBICIDES

CHLORO ALIPHATIC ACIDS	:	Dalapon
NITRO PHENOLS	:	Dinoseb
PHENOXIES	:	2,4-D, 2,4-DP, 2,4,5-T, Silvex
BENZOICS	:	Dicamba
PYRIDINES	:	Picloram
TRIAZINES	:	Atrazine, Simazine
PHOSPHO/AMINO	:	Glyphosate, Krenite
ORGANIC ARSENICALS	:	Cacodylic Acid, MSMA
OTHER	:	Paraquat, Diphenamide

The nature of these herbicides and their groups is best shown using chemical structures to illustrate the basis for a category or family and examples of those categories. This is not intended to be a complete listing of the herbicides nor to completely instruct anyone in reading the notations of organic chemistry which we call chemical structures. The purpose of examining the structures of a few of the examples of a few chemical families of herbicides is to illustrate the basic structure common to members of a group, **the logical** progression of structural changes between **homologues** within a group, or between analogues between **groups.** The important thing is to know that these **relationships** exist, to know that some properties of a few **members of** a group are common to other members of the **group,** and to begin to think of the properties of **groups or** families. This approach of perceiving herbicides **and** their properties as groups is much simpler than **thinking** in terms of individual chemicals.

We *illustrate* this approach with those **herbicides** for which more than 100 pounds were used by the U.S. Forest Service on a nationwide basis in FY-76.

So few herbicides are used in forestry that it is difficult to illustrate how changing just one atom in a molecule produces a series of analogues, or very closely related herbicides. This is best shown in the phenoxy acid group. It can be easily seen that adding just one chlorine atom (Cl-) to 2,4-D results in 2,4,5-T and adding just one methyl group Ch_3-1 to 2,4-D results in 2,4-DP or dichlorprop. Adding either of these atoms decrease the rate at which a plant can metabolize the herbicide, thus increasing its persistence. This is why 2,4,5-T and 2,4-DP are more effective in controlling woody brush tha n2,4,-D. The addition of a Cl- is more effective in this regard than a CH_3-; however, if both modifications are carried out, the result is 2,4,5-TP, or silvex. The important thing to note is the group shown as characteristic of the chemical family and how various atoms are hung on it to produce a series of related herbicides.

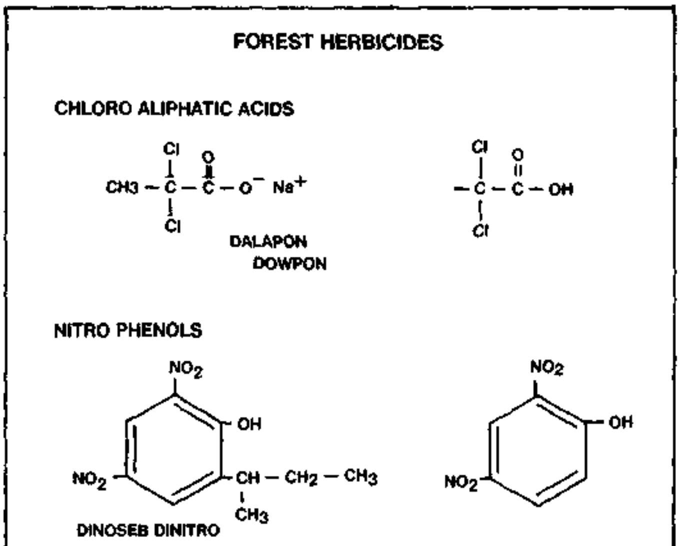

FIGURE 1.

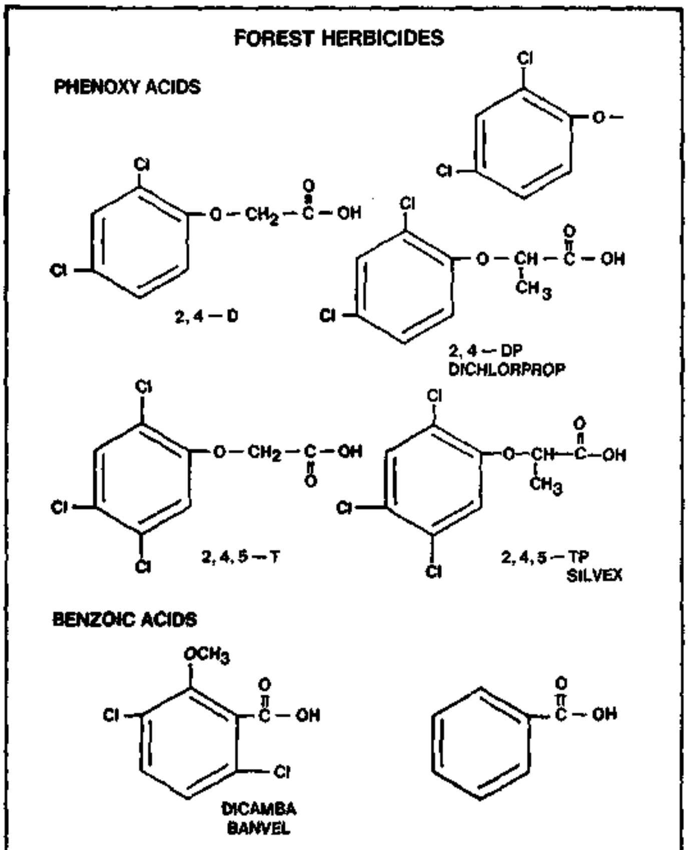

FIGURE 2.

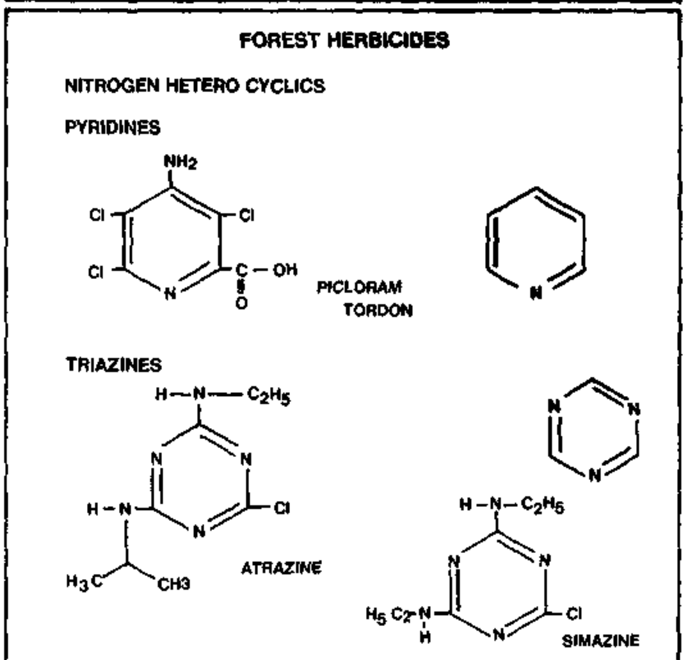

FIGURE 3.

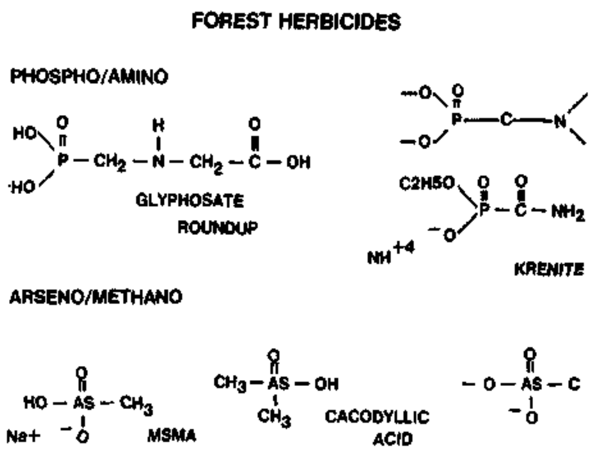

FIGURE 4.

We narrowed a large list of common herbicides down to just a dozen or 15 which are commonly used in forestry. The next questions to consider are which of these are used in the greatest amounts, and how are they used. We do not have reliable data for the forest Industry, but we do for the U.S. Forest Service and shall use their figures. The 10 most commonly used herbicides are as follows:

USFS USE OF HERBICIDES
FY 76 (7–75 to 9–76)

Herbicide	*Pounds used*	*Percent of use*
1. 2,4-D	232,395	55.4
2. 2,4,5-T	86,023	20.5
3. picloram	61,958	14.8
4. MSMA	11,268	2.7
5. dalapon	7,424	1.8
6. simazine	7,292	1.7
7. atrazine	4,815	1.1
8. silvex	3,755	0.9
9. 2,4-DP	2,354	0.6
10. dicamba	2,288	0.5

In addition to these, 1754 lbs of cacdylic acid, 929 lbs of amitrole, and 113 lbs of glyphosate were used. No other herbicides were used in amounts greater than 100 pounds.

The purpose for which these herbicides were used by the Forest Service is as follows:

USFS USE OF HERBICIDES FY 76
Kinds of Uses

Description	*Percent of use*
Release	59.3
Site Preparation	12.8
Right-of-Way	11.8
Range Rehabilitation	5.5
Thinning	3.6
Aquatic	2.2
Fuel Breaks	1.6
Noxious Weeds	1.3
General Weeds	1.0
Wildlife Management	0.9

It is of interest to note that the use of herbicides in forests is not massive—only a little over 400,000 pounds were used in 15 months. Over 90 percent of the herbicides used were 2,4-D, 2,4,5-T, and picloram—only three herbicides. Thus the task of comprehending the important forest herbicides is now greatly simplified. Eighty-four percent of the herbicides was put to only three uses—release of conifers from a brush overstory, preparation of brushy site for planting conifer seedlings, and maintenance of rights-of-way. These herbicides are mostly applied by air or ground machines. There is some spot spraying and injection application.

Some consideration of formulation is necessary to appreciate the behavior of pesticides. The purity of a pesticide is of some concern. Proprietary companies are required to identify impurities in their product down to the level of 0.1 percent or 1000 ppm. This is ordinarily quite sensitive enough to avoid unexpected problems. A case such as 2,4,5-T with TCDD as an important impurity at less than 0.1 ppm is an exceptional case. However, if toxicity studies are carried out with (1) the purified material, (2) the technical grade material, and (3) the formulated material, as they should be, even exceptions such as the TCDD problem will be identified.

Pesticides are most often formulated in the form of Emulsifiable Concentrates, Dusts (which are used in agriculture but not in forestry), Wettable Powders, granular, slurry, and soluble (i.e., water soluble) preparations. The most commonly used formulation is the Emulsifiable Concentrate which contains the (1) active ingredient, (2) solvent, and a (3) surfactant. There may be more than one solvent and surfactant in a EC formulation. One important aspect of the terminology is that the "formulation" and "active ingredient" and "chemical" are not interchangeable terms. One often sees the EPA refer to the problems of regulating 30 or 40,000 pesticides with the implication that these are separate chemicals or active ingredients, when in fact they are referring to formulations of about 600 or so pesticides.

There can be different derivatives of a single pesticide when it has an acid group in its structure such as do the phenoxy acids, dicamba, or Tordon. 2,4-D acid can form either ester or salt derivatives. The esters can be either low molecular weight, high volatile esters or high molecular weight, low volatile esters. Their salts can be either organic, usually amine salts or metallic, usually sodium, salts. The amine salts are very nearly non-volatile, and sodium salts are completely non-volatile.

The modes of action of herbicides on their target pest, the weeds, are limited to those which interfere with the biochemical processes unigue to plants, i.e., which do not occur in animals. Most of these can be categorized as follows:

MODES OF ACTION OF HERBICIDES

- Plant hormone—like action
  - cell growth
  - cell division
  - tropic responses
  - growth abnormalities
- Inhibition of photosynthesis
  - respiration
  - mitochondrial electron transport
  - Hill reaction
  - nucleic acid metabolism
  - protein systhesis
  - chloroplast development

The first category of effects, plant hormone-like action, is caused by the phenoxy acids, benzoics, and picloram. The second category of effects, inhibition of photosynthesis, is caused by the triazines, ureas, uracils, and carbamates.

There are other modes of action on animals, and these will be covered by other speakers. Nearly all herbicides have a selective toxicity towards plants, i.e., they are far more toxic to plants than to animals so that, at the rates they are used, they will kill weeds but not animals. They also have a selective toxicity towards different kinds of plants. This can come about because of differences in the sensitivity of the site of action, the rate of metabolism of the herbicide by the plant, or from physical characteristics of the plant such as nature and shape of its surface, depth of roots, etc. Selectivity can be imposed by how it is used, i.e., foliar-active herbicides can be used selectively through appropriate timing and soil-active herbicides can be used selectively through placement, incorporation, pre-plant, pre-emergence, and post-emergence use. However, even though a herbicide such as 2,4-D can be used on conifers to kill the brush over-story, higher doses of 2,4-D will severely damage conifers. Selectivity is seldom absolutely selective but is a function of dose.

Finally, a word should be said about the hazard evaluation process. We are constantly confronted with allegations that confuse the toxicity of a chemical with its hazard. Toxicity is an inherent property of a molecule, and hazard is a function of how much is used, how it is used, what processes degrade the chemical, and what dose finally reaches a non-target organism. It is easy for anyone to recite a catalogue of symptoms for any chemical but very difficult to establish whether a chemical can actually reach an effective dose under actual use conditions. It should always be remembered that any chemical, no matter how "safe," can cause death, and any chemical, no matter how "toxic," can be used safely at some dose level. We cannot divide the world of chemicals into "safe" or "poisonous" chemicals without also specifying the dose and route of administration. It is distressing that in the process of hazard evaluation people have divided up into sides with one group depending heavily on anecdotal information of illnesses with no dose or cause/effect relationship established and the other countering with demands for a body count.

A proper hazard evaluation process will contain the following three steps:

1. Identification of the no-detectable-effect dose.
2. Identification of the operational or environmental dose for (a) occupational exposure, (b) consumer exposure, and (c) environmental exposure.
3. Calculate the safety margin.

After this has been established, a risk/benefit evaluation must be conducted for both the primary control method and for alternatives being considered. At this point it is necessary to identify the socially acceptable risk. This is, of course, a subjective social and political process involving what is reasonable—or what risk the public is willing to accept for that benefit. Fundamental to this is that we must clarify whether we are talking about a measurable or identifiable risk or insisting on a "zero" risk.

One process which is not acceptable is the "Didjaknow" process. This is where someone claims that use of a chemical carries an unacceptable high risk by stating "did you know that . . ." and proceeds to catalogue a list of symptoms or an array of anecdotal stories.

POST-SYMPOSIUM RESPONSES TO QUESTIONS SUBMITTED TO JAMES WITT

QUESTION: Don't the herbicides cut photosynthesis in evergreens as well as the broadleaf plants? Considering the growing air pollution can we afford to use substances in such large quantities which reduce the production of oxygen by plants?

ANSWER: I stated that the mechanism of action of certain herbicides was to inhibit the photosynthesis process thus killing the plant, but this has nothing to do with whether the oxygen supply on earth is increased or decreased. That is determined by what plants replace those which are killed. It is likely that replacing brush with fir increases the O_2 output of that patch of ground. The forest ecologist would have to tell us that.

QUESTION: What do you consider to be a "socially acceptable risk?"

ANSWER: In discussing hazard evaluation, I stated that after the safety margin was determined and a risk/benefit evaluation completed, the socially acceptable risk would have to be determined. The "socially acceptable risk" is what "society" tells us they are willing to accept. They tell us this in many ways: what risks they accept now in relation to many other kinds of activities, legislation, and protest groups. The law presently states that pesticides shall not create an "unreasonable adverse effect," therefore they are telling us that the socially acceptable risk is a "not unreasonable adverse effect."

QUESTION: Is the term "pesticide" not really less accurate than "biocide?" The organisms classified as pests today may well be found to be of value in 20 or 30 years. Pesticides kill more than pests.

The term "biocide" is not a definition—it is a polemical statement. Its intended use is to conjure up a spectre of horror rather than to clarify or segregate one group of chemicals from another. One could easily argue that all chemicals could be included in the category of biocidal; therefore, it is not a useful category.

The fact that a pest of today may be of value tomorrow is certainly true, but what has that got to do with getting the weeds out of the garden? Controlling a pest does not eliminate it as a species. They are far too hardy for that. When the existence of a species is threatened, or appears to be threatened, from a pesticide or any other technology of man, it is never the *pest* species.

QUESTION: Why did you not mention insecticides in forestry?

ANSWER: Because the subject of the Symposium was on the Use of Herbicides in Forestry. However, since you asked, for the 30-year period between 1945 and 1974, 99 percent of the insecticides applied to USFS lands were DDT, Sevin, Zectran, Malathion, and Dylox. Ninety-five percent of the insecticides applied were for the control of the western budworm, gypsy moth, spruce budworm, and Douglas-fir tussock moth.

QUESTION: Since ignorance breeds fear, would you recommend that all who are concerned about the use of herbicides be required to take courses in chemistry and economics in addition to ecology and law?

ANSWER: Require is a pretty strong word. I wouldn't require that a citizen interested in or concerned about herbicides take chemistry courses. I would recommend that they take chemistry and toxicology too. I would recommend the same, whether the person involved was interested in supporting the use of herbicides or was opposed to it. I wish I could require that persons who make decisions about the use of pesticides take courses in chemistry and toxicology, whether they be in the EPA, USFS, or private industry.

QUESTION: Do you know of a "no-effect dose" for 2,4,5-T or TCDD in rats or mice or monkeys?

ANSWER: Yes, in rats. The appropriate experiments have not yet been done on all species. The no-detected-effect level (NDEL) for rats exposed to TCDD is 0.065 ng/Kg (sum of all daily doses, or total dose) and for 2,4,5-T is 10 mg/Kg per day. The exposure studies on monkeys are not as complete as for rats, but chronic exposure studies indicate that the cumulative dose results in a very low LD_{50} value of about 3 ng/Kg. One is tempted to calculate an NDEL of 0.005 ng/Kg from this; but since it is only a calculation, it is a speculation. There is some concern about whether TCDD is carcinogenic. If it is, the on-set of tumors occurs in about 15,400 ng/Kg (total dose) in rats.

QUESTION: At present assuming that benefit/risk equation equals 1 and if EPA deemphasizes the requirement for efficacy data, could you predict the benefit/risk value of 5 and 10 years from now?

ANSWER: No. I cannot even calculate a true benefit/risk value now. I have never seen one. As near as I can tell, everybody talks about the "benefit/risk ratio," but nobody calculates one; and if they did, it would probably be meaningless because the units of risk are different than the units of benefits. I prefer the term "risk/benefit evaluation," which implies a certain subjectivity is present in the process to the term "risk/benefit ratio" which implies a numerical answer. Notice that I placed risk rather than benefit in the numerator.

I did this so that for those situations where the benefit is zero, any attempt at calculating a risk/benefit ratio will result in a risk value of infinity if there is any measurable risk. If EPA diminishes there requirements for benefits data in the future for only a few limited situations, it will probably help the regulatory process, but if they begin to omit requirements for benefits data in a broad or general way that is in most pest control situations, they will destroy the concept of risk/benefit evaluation, wreak havoc in the pest control process, and jeopardize the existence of the Office of Pesticide Programs.

QUESTION: Is the use of the herbicides 2,4,5-T and 2,4-D in agricultural food and fiber crops being studied and challenged with an emphasis equal to the challenges against their use in forestry? If not, why not? Why so much concentration on forestry which would appear to be the least hazardous to humans?

ANSWER: 2,4,5-T is under much stronger challenges to its use than 2,4-D because the toxicology of TCDD is a difficult question to resolve, while the toxicological basis for a challenge against the use of 2,4-D is rather weak. 2,4,5-T is not used on very many agricultural crops because the weed problems in cultivated lands do not usually involve woody plants. To the best of my recollection, in a study on over 5000 samples of food analyzed for 2,4-D and 2,4,5-T, there were only three samples which had positive values. Therefore it is not believed that these chemicals are entering the food supply in significant quantities. 2,4-D is used on wheat and a number of other cultivated crops, but the major uses of 2,4,5-T in agriculture are on rice and permanent pasture and rangeland. I fully expect the uses on permanent pasture to be challenged as severely as the uses in forestry. That they have not been to date is probably because they are not being used in agriculture by a Federal agency which is more vulnerable to challenge by citizens groups that are private companies. The use of these chemicals by private companies would have to be challenged through the EPA registration process.

QUESTION: There are re-entry guidelines for the entry of cattle onto chemically treated rangelands, why are there no re-entry guidelines for forestry workers (tree planters and thinners) who often must enter recently treated sites?

ANSWER: When pesticides first came under regulation, it was primarily under the same kind of regulations that govern feeds and fertilizers which was to ensure that the buyer got full measure. It was not until the 1920's that it was perceived that there needed to be some limit on the residues of pesticides on foods to protect the consumer. For 40 years all the requirements for registration were directed at making certain the treated food was safe for consumers and the product was efficacious. It was during the period in which the concern was directed in this way that most of the registrations for 2,4,5-T were developed, which is why the need for a waiting period for cattle was studied. Food chain accumulation and dermal penetration of chemicals was only dimly perceived at that time (the late 1940's to the mid-1950's). By the 1960's it became apparent that requirements to assure wildlife and environmental safety would have to be put in place along with requirements to protect the consumer. It had always been perceived that people would have to be protected while spraying, but it was not until the 1970's that it began to become clear that people entering treated areas after the cessation of spraying may also have to be protected. This was late in being perceived because reports of adverse effects were rare, episodic, and seemed to bear no relation to a cause. The potential for adverse effects on workers entering fields after pesticide treatment appears at present to be a minimal risk situation and present only when there is direct and continued contact between a worker and treated foliage, certain organophosphate insecticides were used, the treated plant surface is dusty, and there is some belief that the critical variable may be the presence of high levels of ozone and PAN from photochemical smog. For these reasons it has been most difficult to develop re-entry guidelines which make any kind of sense. If you believe that you are aware of a re-entry situation for forest workers which poses a hazard to human health, please bring this to the attention of the EPA so that they and we can make plans to evaluate the problem and make plans to have it carefully studied.

QUESTION: You spoke of the general safety of the substituted urea herbicides and called them relatively safe. Some monuron products were voluntarily canceled after studies indicated that it was oncogenic in mice. Would you still call monuron safe?

ANSWER: I did not know that monuron was withdrawn by the proprietary company because of oncogenicity. To fully respond to your question, I would have to see the research reporting that monuron causes tumors. I would like to know how many tumors; what kind of tumors; whether they are considered to be malignant, pre-malignant, or benign; what was the dose level; and how does that compare to consumer, environmental, and occupational exposure level? I do not hold the position that one research report finding oncogenecity is automatically and without further question a basis for designating a chemical as highly hazardous.

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MS. WINE: We will have our four people picking up questions if you have them. A number of you have expressed concern about the fact that your questions did not get answered and you felt they would not be in the record. I remind you that you can write down questions, opposing statements, pro statements, and submit them to our stenographer in the front to have them included in the record.

VOICE: How long will the record be held open?

MS. WINE: Until the end of the week at least.

QUESTION: In one of your tables is control of hardwoods classified under the category of release?

DR. WITT: Yes.

MS. WINE: Are there any other questions coming down? Please pass your cards.

QUESTION: Why haven't the granular forms of substitute urea herbicides been more used in site release and preparation?

DR. WITT: I made a disclaimer about getting too deep into some of these subjects. Why don't we ask Ron Stewart or Mike Newton? One of them could very well answer this.

MS. WINE: We can have that question redirected to them tomorrow, then.

ONCE AGAIN, the dioxin questions will come up later. Some of the questions are really not totally related to your topic, and I don't want to go into them if they aren't.

QUESTION: Why should citizen groups identify their zero-risk bias if they possess one?

MS. WINE: I don't understand the question; I am sorry.

DR. WITT: I think I do. I will give it a try.

MS. WINE: Okay.

DR. WITT: If you are asking for zero risk, that is if you identify a toxicity for a particular chemical and you are concerned about it and you say, "I think this chemical should not be used because it has this kind of toxicity when we do this or that experiment," if one then is essentially through that statement—you wouldn't always, but in some cases you could be asking for what I call zero risk, that is a risk which is, you know, one can legally kind of construct a pattern which if everything happened in the right order, some small dose might reach an individual, and then if everything happened in the right order, an injury, a biochemical injury, possibly leathal, could result from that. That examination tells you it is possible, but highly improbable. Then in effect you are asking for zero risk. I am saying if you do ask for zero risk, you need to tell people what kind of risk you are asking for, because I don't think everybody necessarily wants to agree with you that they want a zero-risk society.

You know, take this thing on dioxin. I will give you a little example. It is occurring in 20 parts per billion in 2,4,5-T. That number struck me because that is the same level aflatoxin is permitted in peanut butter. That is one of the most powerful carcinogens known to man. You are spraying one out, and you have to follow the sequence and speculate exactly how that will get to people and hurt them. With peanut butter you have practically 100 percent exposure. People are willing to accept the one kind of risk, and maybe they are and maybe not the other, but you want to be sure you know whether they are asking for a finite risk or absence of all risks because people are willing to accept some risks.

VOICE: That was my question, and that was not the question, really. I suppose you couldn't read the handwriting; but the question was, why should the environmentalists identify their zero-risk bias when the industry group assumes a high permissible value and says there is no risk when these decisions are made in a political arena nowadays? We are playing a political game.

DR. WITT: I think both sides should identify the risk level they are willing to accept. If the chemical company has a weak carcinogen they want to use as a herbicide, they should project out, playing games with numbers—you have to try, it is better than not trying at all. They come up with a prediction. They say we get a tenth of the cancer per year in somebody. They should ask the people, "are you willing to accept this risk or not for this use." That should be part of the package. I agree, it cuts both ways.

MS. WINE: Do you know of a "no-effect" dose for TCDD or 2,4,5-T in rats or monkeys?

DR. WITT: Yes, I do, but I would rather leave that to Morris Cranmer; and after he is through, if he wants to compare numbers, we can.

MS. WINE: Some of these questions are toxicological in nature, and we will hold them.

Thank you, Jim.

Our next speaker is DR. MORRIS CRANMER. Dr. Cranmer is the Director of the National Center for Toxicological Research. The Center is charged with the responsibility for determining the effects of exposure to chemical toxicants and developing better evaluation limits with regard to the safe use of toxic chemicals.

TOXICOLOGY OF FAMILIES OF CHEMICALS USED AS HERBICIDES IN FORESTRY

Morris Cranmer

The production and use of herbicides has increased markedly during the last 2 decades. Because plants differ markedly from animals in physiology, biochemistry, and hormonal activity, herbicides usually present little hazard of chemical toxicity to man and other vertebrates. Indeed, some compounds have very low toxicity in mammals, but even among herbicides as a family of chemicals structural class is quite variable, and there are representative highly toxic chemicals, some of which have caused fatal posionings and others which represent at least theoretical risks of cancer, birth defects, and genetic and reproductive defects.

The compounds, 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) as their salts and esters are the most prominent herbicides used in forest management. 2,3,7,8-tetrachlorodibenzo dioxin, a trace contaminent of 2,4,5-T, exhibits unusual toxicity and has created a great controversy over theoretical birth defect risks. A comparison of teratogenic risks from 2,4,5-T and dioxin is presented as part of a risk-estimation model.

The laboratory toxicity of a compound is relatively useless unless presented in the proper context of interaction with the species at potential risk. Estimates of route, rate, and duration of exposure and other environmental effects impacting on the distribution of sensitivities in a population must all be considered before estimates of risks of toxicity become meaningful.

Toxicity of herbicides must be considered in the totality of the forest environment. In every forest there are a large number of other organisms including man, wildlife, insects, microorganisms, shrubs, and annual and perennial plants living in intimate ecological relationships with trees. Each is an integral part of the natural forests, and any substantial natural or man-induced change in the population of one organism is likely to have ecologically significant effects on one or more of the others. These changes can be reflected as alterations in the toxicological response.

The families of chemicals used in the various plant pest management tasks include, but are not limited to, chlorophenoxy compounds (2,4-D, 2,4,5-T), dinitrophenols (DNOC), bipyridyls (paraquat and diquat), carbamates (propham), substituted ureas (monuron and diuron), triazines (simazine), and amides (propanil). The toxic effects produced by these compounds in experimental animals include cancer; birth defects; mutagenesis; interactions with organophosphate pesticides; uncoupling of oxidative phosphorylation; CNS; and liver, kidney, and lung pathology. The risk to man from the use of herbicides is mainly to the applicator and through accidental poisonings.

INTRODUCTION

What is the role of herbicides in fulfilling the need and improving the quality of our forest resources? The "products" provided by a forest depend upon the objectives of the managers and users of the land. In this sense forests do not provide us with only one well-defined product—nor is there any single set of plants or any one organism that is undesirable in all forest situations. Also, the future of a forest with even a brief rotation from seedlings to mature or harvestable trees cannot be decided the year it is planted if only because of shifting and unpredictable future values of its potential products.

Thus, the existence of many different objectives for different forest lands, or for a single forest over time, creates a situation in which it is important that managers avoid irreversible control decisions that might have unwanted toxicological effects in the future. This philosophy also suggests that control should not be aimed solely at killing pest plants and should be undertaken only when the activity of a pest plant can be clearly shown to interfere significantly with management objectives. This also suggests the need for careful cost/benefit analyses that ensure that those objectives will be served without undue cost or loss of other important benefits.

One out of every 3 acres in the United States is classified as forest land. The 750 million acres in forests would cover the United States east of the Mississippi River with enough left over to carpet Texas and part of California. In addition, forest trees are important features of many urban and suburban areas that are not classified as forest land. There are about 585 separate species of trees native to the United States, and, in addition, more than 90 foreign species have become naturalized here (Little, 1949). American forests are thus both of vast extent and great biological variety.

In every forest there are a large number of other organisms—animals (including insects), microorganisms, shrubs, and annual and perennial herbs—living in intimate ecological relationship with the trees. These relationships may be favorable, inimical, or essentially neutral to the survival and growth of the trees, depending on the specific forest situations. From the biological point of view all of these organisms—trees, mammals, birds, insects, microbes, and secondary vegetation—fulfill characteristic ecological roles. Each is an integral part of the natural forests, and any substantial natural or man-induced change in the population of one organism is likely to have ecologically significant effects on one or more of the others.

About 165 of the native and introduced tree species are recognized as having major actual or potential importance to man—as sources of wood products, food, or medicine; as aesthetic features of the landscape; or as essential protective cover. As for the associated organisms some may contribute directly to human welfare: game animals, flowering shrubs, birds, and bees are obvious examples.

Pests are organisms that diminish the value of resources in which man is interested. An organism can be classed as a forest plant pest only on the basis of a recognized set of forest management objectives and a clear understanding of the organism's functions as an element in the particular ecosystem of which it happens to be a part. Trees may be "pests" if they obscure a cherished view, contribute unduly to fire or windstorm hazards to human habitation, draw excessive quantities of moisture from a critical watershed, or decrease potential yield.

This view of the forest pest problem differs in major degree, if not in kind, from the view of pests that is characteristic in crop agriculture and public health. In both those areas of concern man's objectives are usally more single-minded than is the case in forestry. On public forest land, for example, the simultaneous existence of more than one valid objective for a single area is specifically recognized by the Multiple-Use Sustained Yield Act of 1960. On any forest site the question of what management objectives are appropriate to the particular area becomes a central feature of any discussion of the forest pest situation.

Any discussion of the toxicological potential of a given use of a given herbicide must be constrained by the conditions of use. Forest land owned by private industry, which accounts for only 13.5 percent of the commercial forest land, is managed primarily for the profitable production of timber as a commodity for conversion into wood products. In National Forests and other forests owned by the public, however, such commodity production is usually only one of a number of explicit forest management objectives embraced within the broad concept of "multiple use." Here the relative priority of production of timber commodities and other forest uses, such as providing sites for outdoor recreation or protecting watersheds, is not clearly established on large portions of the area involved. On the "other private" category of ownership (almost 60 percent of the forest land) we know that management objectives vary greatly among the 3 or 4 million individual owners, but there is little information that would permit us to identify ownership objectives on any one particular property.

This diversity of objectives makes it virtually impossible to characterize any species categorically as a forest plant pest. Instead it forces us to consider forest plant pest problems within some explicit forest management framework, where the objectives of management are known, the significant ecological variables can be quantified, and management capabilities can be evaluated in relation to possible alternative pest control strategies.

FOREST AREA

From early in the century to early in the 1950's forests appeared to increase modestly. That trend has now been reversed; total forest area in 1970 was about 1.7 percent less than it had been in 1962.

This relatively fixed total forest base, however, is under steadily increasing human pressure. Burgeoning public interest in recreation is resulting in steady enlargement of the forest area reserved for recreation and park purposes.

MAJOR FOREST LAND USES

The major uses of forest land include provision of habitat for wildlife, provision of an environment for diverse kinds of outdoor recreation, production of range forage for domestic livestock, protection of soil, protection and improvement of watersheds, growing and harvesting of timber, and preservation of rare or unique natural ecological or scenic features. Preservation of unique features and provision of environment for outdoor recreation were the uses first recognized by Federal policy, with passage of the Yellowstone Park Act (1872). Subsequently, recognition was given to timber production and watershed protection as the basis for reservation of National Forests (1897). Since 1905 the importance of all the forest uses enumerated above has been recognized in a wide variety of Federal and State legislation.

Forests have an unusual capability to accommodate use for several of the above purposes at the same time (e.g., soil and watershed protection, preservation of scenic features, and provision of wildlife habitat on a single forest area—or timber growing and certain types of recreation on the same area, at least during most of the timber growth cycle). This "multiple use" capability is recognized as the appropriate means for achieving management goals on much publicly owned land, and to some degree it is a feature of all forest management. Thus, it is essentially impossible to segregate forest areas by dominant type of use.

WILDLIFE HABITAT

Virtually all forest land provides wildlife habitat, and many species, including the principal big game animals, are found primarily in forested areas. Use of forest land for hunting, fishing, and observation of wildlife has steadily increased. As in the case of soil and watershed protection most organisms commonly regarded as forest pests appear to have only minor effects on wildlife habitat, because of the forest's ecological diversity.

OUTDOOR RECREATION

Recreational use of forest land includes a great number of quite dissimilar activities. These range from the group viewing the cliffs of the Yosemite Valley from the veranda of a luxury hotel to the mountaineering party in the Brooks Range, and from the motorized family complete with camper, trailbikes, and portable televisions, all installed in the forest campground with hot showers and electricity, to the solitary cross-country hiker.

The amount of forest land used for these varied purposes is even less well known than is the amount used for the timber growing, in part because much recreational service is provided by forests that are also used for other purposes. Certain forms of outdoor recreation are either dominant or codominant uses in units of the National and State park systems, national recreation areas, and the wilderness system. Some 600 million acres of land have been formally assigned to these units. In addition, recreation is a dominant use on portions of the National Forests outside wilderness areas and is a permitted use on most multi-use areas of the Forests.

The trend in recreational use of forests has been almost explosively upward throughout most of the past 40 years. Except for the period of World War II attendance rates at National and State parks and National Forests have at least doubled during each successive decade.

The very diversity of forest recreation activities makes it difficult to generalize on herbicides that are used. The situation in campgrounds, picnic areas, and other sites designed for visitor occupancy may be quite different from the situation in the recreational forest, which simply forms the backdrop for hiking, riding, climbing, or viewing. In the latter sort of area, where recreational use is widely dispersed, the main goal of forest protection is to maintain aesthetic quality. Levels of production management impact which would be considered seriously damaging to a campground or heavily used lakeshore may, in this case, be entirely acceptable.

In campgrounds and other occupancy sites on recreation areas problems are likely to be much more localized but more numerous. At the same time the relatively high value per acre of such sites may justify quite intensive methods of control. Local elimination of plants poisonous to human beings may be required. Dead and dying trees, in addition to possible unsightliness, increase the hazard to users from both fire and winds—hazards that must be kept at a minimum. Due to the high value, high accessibility, and close surveillance that characterize such areas, intensive and discriminating methods of control will usually be feasible.

FORAGE PRODUCTION

Forage for domestic livestock is among the by-products of the outputs from forest land. There are, of course, large areas of true grassland within the administrative jurisdiction of such agencies as the USFS. But in addition several important forest types (e.g., most hardwood types, pine types in the South and West) produce grass and herb ground covers of substantial forage value. Management of these forest types to increase nutritious forage may involve use of selective herbicides and, unless properly controlled, could create pesticide residue problems.

SUBURBAN AND URBAN FOREST USE

Forests located within urban and suburban areas represent conditions where control must be considered in its intensive form. The values are high and are often assignable on a tree-by-tree basis. Side effects of any control measures are likely to be more critical than elsewhere, and the methods of control may be severely limited because of the close proximity of the human population. The problems are often multiplied by the presence of large numbers of exotic species and by cultivation practices such as irrigation and soil manipulation.

Although the circumstances of urban and suburban forestry have, until now, been radically different from those surrounding more conventional forms of forest management, it is becoming increasingly evident that the differences are mainly of degree. As time goes on, and as the intensiveness of forest management increases, the problems of control in the commercial and recreational forests will approach comparability with those of suburban forestry, in magnitude of the values at stake, in the need to localize impacts.

PLANT PESTS

What are the plant pests and sites to be selectively controlled by herbicides? Various vegetation types are sometimes "pests" in relation to management objectives. Central to this subject is the concept that successful achievement of management objectives by itself has a major environmental impact. This must be kept distinct from the impacts of the specific control practices used to achieve them. Thus, the establishment of a Douglas-fir forest or a stable shrub community has an effect that may last for centuries, encompassing all life systems, regardless of the method used to establish such a community.

Management objectives determine whether a plant is a pest on a particular site. Commodity-dominated management depends on replacement of stable brush or noncommercial trees with valuable species that may also be stable; the same stability of brushfields is regarded as a virtue in preventing the establishment of trees on rights-of-way. Although the objectives of management differ, the concepts of vegetation management are common to a wide variety of objectives.

PLANT PESTS IN PRODUCTION FORESTS

In special-use situations, such as seed orchards and tree nurseries, weeds are regarded as critically limiting on production. On the much larger acreage of commercial forest land where trees are grown for timber, however, weed species are only beginning to receive attention commensurate with their impact on productivity.

In production forests weeds may include trees of the same species as the crop tree or of different species, various shrubs, or herbaceous cover. The unwanted plants interfere either by preventing the regeneration of the desired species or by competing for site resources after a stand is already established.

Weeds That Prevent Regeneration

Prompt replanting of cutover lands is an effective and widely used means of ensuring regeneration in the presence of weed species. Where the land is cleared without reforestation, whether because of wildfires or lack of funds or interest on the part of the landowner, shrubs and grasses often increase in coverage or invade fairly rapidly. Sometimes acreage that has never been managed constructively will be overgrown with noncommercial species. Subsequent management for timber production will require removing or controlling the unwanted vegetation by mechanical or chemical means. The degree of control and the herbicide required varies with the species to be planted.

Weeds That Compete for Site Resources

Low-grade tree or shrub species compete with more valuable species to some extent on nearly all of our forested lands. The reasons for weed dominance vary from place to place. Many stocking problems are a result of man's activities. These include logging without reforestation; disruption through mining, railroad, and grazing activities; and selected harvesting of high-grade trees. The last practice, which causes a gradual deterioration in quality, if not quantity, of production, has been of particular importance. Over a span of up to 300 years man has continually removed from forests the trees that he finds most valuable. This has left an increasing proportion of trees of submarginal value, including those not well adopted to manufacturing, those that are too small to be usable. A low-value forest remains in many areas.

Not all weed problems are man-made. Extensive fires have allowed the invasion of brush in some areas. In other areas the natural vegetational trend results in tree species that are less desirable from the land manager's point of view. In parts of the South, for example, pine species may be replaced by a variety of hardwood species if the successional trends are left unchecked. Where the forest is managed for maximum timber production, the softwood species are often more desirable because of their faster growth rates and because there is a ready market for them. Management for softwoods in those areas requires periodic destruction of invading hardwoods or management to minimize their intrusion. Herbicide use substitutes for wildfires, on which natural pine stands usually depend, but which are unacceptable by present-day standards.

The impact of undesirable vegetation on lands managed for timber production is undoubtedly substantial, although it is difficult to measure. Walker (1973) estimated the total acreage of commercial forest land supporting important amounts of undesirable vegetation at some 300 million acres. The trees on this very large acreage all suffer some loss of potential annual growth increment, a loss that may be as high as 55 percent. (This figure is based on an estimated average productivity of 25 percent, with 80 percent of potential assumed to be a realistic production goal in native species.)

PLANT PESTS OF NONTIMBER FOREST AREAS

Rangelands

About 630 million acres of rangelands are grazed in the United States, much of it in the Rocky Mountain region. On some of this acreage forest management for timber competes with management for grazing and (on public land) for wildlife forage. In general, however, the grazing resource has been considered of primary importance. The scattered trees, then, along with a diversity of shrubs, are the "weeds," and grasses and forbs are the "crop." The problem of persistence of the parent herbicide or contaminants or metabolites has been considered by some to represent a potential food chain problem for humans, for example with TCDD.

Recreation Areas

Where land is managed primarily for recreation, no specific plant is undesirable in its own right, except perhaps one that is poisonous to man. Vegetation in such areas is sometimes manipulated to provide a better wildlife habitat; such treatments may or may not act in direct opposition to the production of timber. Where a recreational facility is heavily used, it is sometimes necessary to clear out dead or dying trees that create hazards of fire or windfall. Sometimes relatively mature stands of timber are cut in order to provide ski slopes. In general, however, it has been unnecessary and economically impractical to attempt to change the species composition of a forested recreation area.

In the West many of the lands designated as recreation areas have never been deforested, and change would be unnecessary even if the land were managed for timber production. In the populous areas of the East, however, much of the forest land was once cleared for agriculture and is now dominated by what would be weed trees in a production forest. Today, a large part of that wooded land is valued primarily for recreation or residential use so commercial forest productivity is not its major value.

APPROACHES TO CONTROL

Plant pests, in general, have a regional nature. Western areas with dry summers can stabilize in either grass or shrubs. Humid regions may stabilize in shrubs but generally not in herbs. In the absence of such a shrub cover a stand of trees, especially shade-tolerant species, can form a relatively stable vegetation type in both areas. These concepts are helpful in reaching management objectives for either rights-of-way or timber management.

Nearly all vegetation control in forests has been carried out in intensively managed production forests or along rights-of-way. The control methods used on these two land areas are tactically similar although the objectives, as described above, are quite different. Control of plant pests, unlike control of other pests, is only one part of an overall attempt to promote the development of a certain type of stand. Thus, in commercial forestry the objective is the promotion of a stable forest of valuable trees; along a right-of-way the objective is to create a stable cover of shrubs or herbs. In both cases unwanted vegetation must be controlled to release site resources for the establishment or enhancement of the desired cover. Following are some of the methods used in plant pest control.

Site Preparation

Broadcast application of herbicides from aircraft has gained in importance. This method generally involves the use of phenoxy herbicides, especially 2,4,5-T, which provides fairly selective control of deciduous plants with minimal injury to conifers. Single aerial applications of 2,4,5-T are less effective in killing vegetation than even moderately intensive mechanical preparation, but the chemical method is also less costly and has no physical impact. Herbicides leave the soil intact and fail to reach or to damage seriously most ground cover under the brush canopy. Animal habitat generally sustains minimal disruption. Thus, even repeated application of short-lived herbicides or such herbicides combined with minimal mechanical treatment creates less drastic surface disturbance than full-scale mechanical preparation.

Even after good site preparation many planted areas need treatment in their second year, and some require further treatment after several years. Selective herbicides are used on conifers.

Removal of Competing Tree Species

The enormous volume of cull tree material that could be harvested in weed control operations in mature forests must be considered a resource. Most of it can be used as pulpwood with present-day technology, and other end uses are under development. Its present low value is due to the availability of other sources of higher quality wood fiber with lower labor requirements.

In the absence of increased demand for low-value wood, which would allow economic harvest of thinned material, forest weed control involves several chemical methods including tree injection, basal spraying, and aerial spraying. All are more or less effective means of diverting resources to high-quality trees, but each has a different environmental impact.

Injection of individual trees is effective and low in cost and may be accomplished with nonpersistent herbicides. Several hundred acres, primarily in the South, are treated in this way each year. Basal spraying is also effective but may be more costly; its impact is similar to that of injection. Its use is primarily confined to rights-of-way. Aerial spraying with rapidly degrading herbicides may be used effectively on shrubs, but it is not successful for large cull trees. Aerial sprays of currently registered herbicides have a general effect on ecosystem structure. As most of the herbicides are of short life and low toxicity, effects on wildlife are primarily related to habitat change. Prescribed fire may be used at frequent intervals to prevent or remove the understory of shrubs and hardwood trees that commonly develops in pine stands. This treatment is effective under some conditions, especially in the South, and it is also finding some use in the Pacific Northwest where herbicides are used to prepare fuel by desiccation.

The forest weed problem is more likely to require man's intervention than other pest problems. Once dominant desirable trees are established, however, they tend to remain dominant, so that continued trouble with weeds is unlikely. Therefore, a management plan that includes the harvesting or killing of low-value trees and provides for the establishment and culture of valuable species eliminates the weed problem (Newton, 1973).

The use of chemicals involves crew training and discipline; and although these have proven very difficult to overcome, there has been a recent increase in thinning operations using injection of low-toxicity organic arsenical herbicides. The chemical method involves less physical impact than manual thinning and provides protection against insects and diseases.

Right-of-Way Management for Vegetation Control

Herbicides have been widely used in right-of-way management for vegetation control in this country. In 1969 almost half of the 2,4,5-T uses in the United States was applied to over 2 million acres of rights-of-way (USDA, 1971). (This figure does not include rights-of-way treated by Federal agencies.) Other herbicides as well as 2,4-D have also been widely used—almost always as blanket sprays.

The use of blanket sprays, with heavy dependence on the phenoxy herbicides, is often ineffective in terms of the ultimate objective which is essentially the control of tree growth. With the most widely used phenoxy herbicide, a 2,4-D/2,4,5-T mixture, a grassland is often the resulting cover after repeated applications. In most forested regions with moist summers this vegetation type is readily invaded by tree seedlings from the contiguous forest, especially if the grassy cover is discontinuous. The result, then, is a cover type that tends to perpetuate the problem that one is attempting to solve.

A technique that would result in the least disturbance to the existing vegetation and in the process create a shrub cover that would tend to arrest tree reproduction would be preferable. This is the opposite of brush control in forest plantings. In forest management it is well documented that dense shrub covers often necessitate the use of herbicides in order to open site conditions for forest regeneration. It is desirable to avoid tree regeneration along rights-of-way.

Although it has been argued that selective techniques are less economical than broadcast sprays, the relative economy depends upon whether one's point of view is short-term or long-term. Single blanket spray applications may be less costly than selective sprays, but repeated blanket spraying is required to obtain adequate control. If unwanted trees are root-killed by selective stump or basal techniques and a plant cover is created that tends to inhibit further tree establishment, the need for future spraying is minimized.

The fact that certain utilities, such as those in Connecticut, have essentially converted to the selective approach indicates that it is commercially feasible (Crain, 1969). Public pressure has played a role in changing vegetation manipulation practices (Goodwin and Niering, 1959, 1962; Niering and Goodwin, 1974) and will continue to be important in the future as citizens become more aware of the value of the right-of-way resource.

The maintenance principles discussed for right-of-way management are also applicable to vegetation management along forest roads within State, National, and commercial forests. The two major management tools that have been used to maintain sight lines along forest roads are mechanical cutting and herbicides. The use of broadcast foliar sprays may destroy desirable herbaceous cover and by drift may also affect adjacent nontarget vegetation.

Along firebreaks cutting or selective spray techniques can also be used. Blanket sprays often result in a grassy cover that accentuates the first hazard. An open mixture of broadleaved herbaceous plants and low-growing shrubs may constitute a much more desirable plant cover in certain regions. The regional vegetational pattern will tend to dictate the most appropriate techniques.

LABORATORY TOXICOLOGY AND EPIDEMIOLOGY

The production and use of chemicals for destruction of forest plant pests have increased markedly during the last decade. Because plants differ markedly from animals in their morphology and physiology, it might be expected that herbicides would present little hazard of chemical toxicity to vertebrates. Indeed some compounds have very low toxicity in mammals, but even among the herbicides there are highly toxic chemicals, and a number of these have caused fatal poisonings in man.

Chlorophenoxy Compounds

The compounds 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) as their salts and esters are probably the most familiar chemicals used as herbicides for control of broadleaf weeds and forest woody plants along highways and utilities rights-of-way as well as large scale respeciation. They exert their herbicidal action by acting as growth hormones in plants. They have no hormonal action in animals, but their mechanism of toxic action is poorly understood. Animals killed by massive doses of 2,4-D are believed to die of ventricular fibrillation. At lower doses, when death is delayed, various signs of muscular involvement are seen including stiffness of the extremities, ataxia, paralysis, and eventually coma. Sublethal doses, singly or repeated, lead to a general unkempt appearance without specific signs except a tenseness and muscular weakness. Feeding studies in animals indicate that repeated exposures to doses just slightly smaller than the single toxic dose are tolerated, indicating little cumulative effect. In a case of suicide an oral dose of not less than 6500 mg led to death. It has been estimated that the oral dose required to produce symptoms in man is probably about 3 to 4 g. Profound muscular weakness was noted in a patient recovering from an episode of acute poisoning by 2,4-D. Peripheral neuritis was reported

TYPE OF OCCUPATIONAL DISEASE REPORTED CAUSED BY PESTICIDES AND OTHER AGRICULTURAL CHEMICALS IN CALIFORNIA IN 1969*

Type of Chemical	Type of Disease				
	Systemic Poisoning	Respiratory Condition	Skin Condition	Other and Unspecified	Total All Types
Organic phosphate pesticides	140	4	12	75	231
Halogenated hydrocarbon pesticides	9	7	19	22	57
Herbicides	3	9	50	14	76
Fertilizers	—	8	28	7	43
Fungicides	2	3	21	1	27
Phenolic compounds	2	1	10	2	15
Sulfur	1	2	25	3	31
Organo-mercury compounds	1	—	—	1	2
Lead or arsenic	2	—	2	5	9
Miscell.-specified	5	1	15	7	28
Unspecified	9	12	162	21	204
Total	175	47	345	160	727

* From California Dept. of Public Health: *Occupational Diseases in California Attributed to Pesticides & Other Agricultural Chemicals, 1969.* Bureau of Occupational Health & Environment Epidemiology, Sacramento, 1969.

REPORTS OF OCCUPATIONAL DISEASE ATTRIBUTED TO PESTICIDES AND OTHER AGRICULTURAL CHEMICALS IN CALIFORNIA IN 1969*

	Type of Industry								
Type of Chemical	Agriculture	Manufacturing	Construction	Transportation Communication, Utilities	Trade	Structural Pest Control	State and Local Government	Other	Total All
Organic phosphate pesticides	162	40	1	12	1	1	11	3	231
Halogenated hydrocarbon pesticides	19	15	2	6	2	3	8	2	57
Herbicidies	44	4	1	5	—	—	18	4	76
Fertilizers	23	7	1	—	2	—	3	7	43
Fungicidies	18	3	1	—	2	—	1	2	27
Phenolic compounds	5	5	3	1	—	—	1	—	15
Sulfur	28	1	1	—	—	—	1	—	31
Organo-mercury compounds	—	—	—	—	—	—	1	1	2
Lead or arsenic	4	1	1	1	—	—	1	1	2
Carbamates	1	2	—	—	—	—	—	1	4
Miscell.-specified	13	5	1	1	1	1	4	2	28
Unspecified	137	19	1	7	12	3	15	10	204
Total	454	102	13	33	20	8	64	33	727

*Abstracted from California Dept. of Public Health: *Occupational Diseases in California Attributed to Pesticides and Other Agricultural Chemicals*. 1969. Bureau of Occupational Health and Environmental Epidemiology, Sacramento, 1969.

for three men who had recent heavy occupational exposure to 2,4-D. Pathologic changes in experimental animals killed by the chlorophenoxy compounds are generally nonspecific with irritation of the stomach and some liver and kidney injury (Hayes, 1963).

The chlorophenoxy herbicides have produced contact dermatitis in man, and, as mentioned earlier, a rather severe type of dermatitis, chloracne, has been observed in workmen involved in the manufacture of 2,4,5-T (Poland et al., 1971). This effect appears to be due primarily to the action of a contaminant, 2,3,7,8-tetrachlorodibenzo-ρ-dioxin.

Courtney et al. (1970) reported that technical 2,4,5-T containing 30 ppm 2,3,7,8-tetrachlorodibenzo-ρ-dioxin (TCDD) caused an increase in the incidence of cleft palate and cystic kidney in C57BL/6 and ARK mice. Since then there has been considerable concern about whether 2,4,5-T is a human teratogen. Only minimal or no teratogenic or fetotoxic effect of 2,4,5-T in rats has been reported (Courtney and Moore, 1971; Emerson *et al.*, 1971; Sparschu *et al.*, 1971; and Khera and McKinley, 1972). The compound was not teratogenic in rabbits given 10 to 40 mg/kg/day on days 6 through 18 of pregnancy (Emerson *et al.*, 1971) or in sheep given 100 mg/kg/day on days 14 to 36 of gestation (Binns *et al.*, 1971). Collins and Williams (1971) reported an increase in fetal mortality, incidence of hemmorhage in live born, and the number of malformations (primarily of the head region) in hamsters given 100 mg/kg/day of 2,4,5-T containing no detectable TCDD. No cleft palate was produced.

Following the report of Courtney *et al.*, 1970, several papers have been published reporting a significant increase in cleft palate in several strains of mice given multiple doses of 2,4,5,-T by the oral or subcutaneous routes (Courtney and Moore, 1971; Roll, 1971; Hart and Valerio, 1972; Neubert and Dillman, 1972; and Bage, *et al.*, 1973). Courtney and Moore (1971) reported that analytical grade 2,4,5-T containing less than 0.05 ppm TCDD given by gavage on days 6 through 15 produced cleft palate and kidney anomalies in CD–1, C57BL/6J, and DBA/2J mice. Roll (1971) observed a significant increase in fetal cleft palate and reduction in fetal weight in NMRI mice given 35 to 130 mg/kg/day of technical 2,4,5-T containing less than 0.1 or 0.05 ppm TCDD orally on days 6 to 15 of pregnancy. A dose level of 20 mg/kg/day was established as the teratogenic "no-effect" level. Neubert and Dillman (1972) reported a frequency of cleft palate exceeding that in the controls with doses of 2,4,5-T higher then 20 mg/kg. They treated relatively large numbers of NMRI mice by gavage on days 6 to 15 of pregnancy with dosage levels of 8 to 120 mg/kg of 2,4,5-T containing less than 0.02 ppm TCDD. Reduction in fetal weight was observed with doses as low as 10 to 15 mg/kg, but there was no clear-cut dose-response relationship for fetal weight. They did not report any kidney malformations.

In 1973 a study designed to correct some of the deficiencies in existing information on the teratogenicity of 2,4,5,-T was initiated at the National Center for Toxicological Research. The deficiencies were considered to be:

1. Inadequate numbers of test animals.
2. Inadequate or non-existent replications of tests.
3. Inadequate testing at doses below 100 mg/kg—needed for more valid dose-response studies.
4. Need for testing in different strains or stocks of mice.
5. Inadequate investigation of fetal kidney development to properly evaluate the reported "cystic kidney" effects.

This paper, one of a series reporting the results of the complete study, will deal with dose-response studies conducted with technical 2,4,5-T in four inbred strains of mice, one random-bred stock, and a dihybrid stock developed from the four inbred strains. The endpoints considered are the incidence of cleft palate, embryolethality, and fetal weight reduction.

Studies of the teratogenicity of 2,4,5-T were conducted in the four inbred strains of mice, C57BL/6, C3H/He, A/JAX, BALB/c, the random-bred CD–1, and a dihybrid cross of the inbred strains. All of the inbred strains were obtained from Jackson Laboratories, Bar Harbor, Maine, and the CD–1 from Charles River Breeding Laboratories, Wilmington, Massachusetts,. The dihybrid cross was developed at the National Center for Toxicological Research, Animal Husbandry Division (NCTR), according to the following design:

Female C57BL/6 (B) X A/JAX (A)
↓
B · A (F_1)
Female BA (F_1) X Male HC (F_1)
↓
BA · HC (F_2)
(Dihybrid Cross)

Female C3H/He (H) X BALB/c (C)
↓
H · C (F_1)
Female HC (F_1) X Male BA (F_1)
↓
HC · BA (F_2)
(Dihybrid Cross)

X
↓
BAHC (F_3) fetuses

The dihybrid cross was developed and tested because this outbred population was considered as offering the following advantages over the use of a "random-bred" population: (1) the dihybrid cross is reproducible and its gene pool is controllable, (2) belief that the dihybrid would be less susceptible to extraneous sources of environmental variability and that their fetuses, because of their hybrid vigor, would be less sensitive to the embryotoxic actions of 2,4,5-T, (3) a diversity of genotypes in which segregation patterns may more closely resemble the human population than inbred or "random-bred" animals. The inbred strains used were chosen because of their general availability, frequent use in other teratogenicity studies, and background information on their general characteristics including spontaneous and induced malformation rates. It is also known that these strains exhibit a wide range of cleft palate incidences as a consequence of treatment with cortisone.

Technical grade 2,4,5-T of 97.9 ± 0.4 percent purity containing 0.06 ppm dioxin supplied by Dow Chemical Company, Midland, Michigan, was formulated so that appropriate dose levels (mg/kg) could be given in 0.2 cc of the vehicle per mouse. The vehicle consisted of 1 part acetone to 9 parts corn oil (volume/volume basis). The amount of 2,4,5,-T in the vehicle was adjusted for 5 gm weight ranges, e.g., mice weighing 21 to 25 gm, and those weighing 26 to 30 gm were dosed from different formulations to give the same dose levels in mg/kg. The appropriate amount of 2,4,5-T was dissolved in the acetone to give the concentration needed for treatment after further dilution of the solution in corn oil. A sample of each of the formulations was saved by the Chemistry Division for chemical analysis to verify 2,4,5-T concentration. No one formulation was used longer than for the 9-day treatment period.

For breeding, the female mice were individually caged overnight with a male. Females with vaginal plugs the next morning (day 0) were designated as pregnant for purposes of treatment. Pregnant mice were housed in a 12 by 12-foot laminar air flow tent. The mice were distributed by random assignment into treatment groups with four mice per cage in shoe-box type plastic cages and supplied with food and water. Within a cage the mice were identified by ear clip.

Each test for a mouse strain or stock was designed to establish a dose-response curve for the teratogenic and embryo-toxic effect of 2,4,5-T. The tests were replicated from 4 to 8 times in each strain or stock with 28 to 204 litters in each replicate. The tests for establishing dose response curves in the CD-1 using five dose levels of 2,4,5-T were replicated 8 times. However, the entire study was designed to test 2,4,5-T at two or three dose levels in CD-1, concurrently with each replication for all other strains and/or stocks of mice, using the CD-1 as a "positive" control, since this stock was known to be quite susceptible to cleft palate induction with cortisone. This accounts for the large number of litters that are included for some dose levels in presenting some of the results for the CD-1.

The order of treatment of the different groups of mice within a replicate was done in a random manner. The mice were dosed daily by gavage between 8:00 a.m. and 12:00 noon on days 6 to 14 of pregnancy. The control mice were given 0.2 cc per mouse of the acetone-corn oil vehicle. The animals were weighed just before dosing on days 6, 9, and 12 of pregnancy. This allowed adjustment of the 2,4,5-T formulations for maternal mice which had gone from one 5 gm weight range category to another.

Any mice that were found dead or observed in a moribund state during or following treatment with 2,4,5-T before the date of scheduled sacrifice were sent to the Pathology Division for complete gross and microscopic histopathology examination. On day 17 of pregnancy the maternal mice were sacrificed and the uteri opened and examined for dead, resorbed, and viable fetuses. The viable fetuses were examined externally, weighed, and placed in individual containers of Bouin's solution. At the time of sacrifice and removal of the uteri of each replicate of animals, five maternal carcasses each from the control group and the highest dose group from each strain were delivered immediately to Pathology for complete gross and microscopic histopathology examination. Using aseptic technique, the entire intestinal tract was taken by the Diagnostics Division from each of four maternal control mice and four mice given the highest dose level of 2,4,5-T. Total bacterial counts, both aerobic and anaerobic, were determined for the intestinal contents to see if 2,4,5-T had any effect on the intestinal flora.

After about 48 hours storage in the Bouin's solution the fetuses were examined for cleft palate and other external malformations. They were then sent to Pathology for detailed examination of the kidneys. All fetuses were sexed internally when the kidneys were removed.

The teratogenic endpoints analyzed were incidence of cleft palate, resorptions, and fetal weight reduction.

Probit analysis was done for percent of litters with cleft palate and percent of litters with at least one resorbed fetus pooled over all replicates for each dose level using Abbot's formula (Finney, 1971) to adjust for incidence of cleft palate or resorptions in the control mice.

For each strain or stock of mice linear regression analyses were done for average percent fetuses per litter with cleft palate, average percent fetuses resorbed per litter, and for fetal weight reduction. These analyses were performed on values averaged over all replications for each dose level after extracting out the control values averaged over all replicates. Then an analysis of covariance was performed so as to adjust all means to a common dose level using the method described by Snedecor and Cochran (1967).

The gavaging of the mice was rotated among five technicians. To test whether or not there was any influence on the results because of variation in the technicians, a two-way analysis of variance was performed on all strains or stocks of mice. There was no indication that embryolethality, fetal viability, or incidence of cleft palate in the mice was influenced by difference in technique of treatment by the different technicians.

The widespread use of the herbicide 2,4,5-T which contains even a small amount of the chemical impurity 2,3,7,8-Tetrachloro-dibenzo-ρ-dioxin (TCDD) in Southeast Asia gave rise to a great deal of concern. Let me discuss briefly my opinion as to the relative risks both to man and the environment due to 2,4,5-T with less than 0.1 ppm 2,3,7,8-tetrachloro-dibenzo-ρ-dioxin (TCDD) and a comparison with TDCC from other routes of entry.

TCDD of course, is very toxic to all species studied. TCDD and other dioxins contaminate many chlorinated phenols and related products (e.g. 2,4,5-T), in addition to other materials of much wider application (at least in the past) like hexachlorophene. Why then do we worry about TCDD in 2,4,5-T? Indeed, how did we come to realize that a compound as difficult to analyze as TCDD was present in such small quantities in a commercial product which contains many other contaminants in much greater quantities?

The commercial production of 2,4,5-T was hampered in the synthetic process. Toxic effects were many, including hepatoporphyrin, vascular lesions, chloracne, and photosensitivity. The process was improved from an industrial hygiene standpoint and production continued. Courtney (1970) at NIEHS studied 2,4,5-T with 27 ppm to TCDD and observed cleft palate and cystic kidney which substantially was described as hydronephrosis. Several other workers (e.g., Moore at NIEHS (1973)) observed the teratogenicity of TCDD in the μg/kg range. There were several groups, notably DOW Chemical, that considered presence of the dioxin as the causative agent in technical grade 2,4,5-T which contained varying amounts of TCDD, but it remained for Neubert (1972) to demonstrate that it required concentrations approaching 100 ppm of TCDD to produce a clear additive effect. Even so, the controversy raged on. At the NCTR we proved, I believe, as previously documented, that the currently available 2,4,5-T is teratogenic in several dose response studies, that the effect is not due to a generalized non-specific effect on the maternal animal, and the TCDD plays no discernible role at the current levels found in 2,4,5-T.

Gehring et al. (1973) showed that the half-life of a sample of 15 mg/kg dose was approximately 1 day and would be expected to plateau on repeated treatments after 3 days. This is not terribly different than what is found for rats, and was shorter than found for dogs.

Kearney et al., in 1972 (1972) estimated for example that the half-life of TCDD in soil is about 1 year. There is a possibility that under certain conditions the ecological half-life could be longer (conjecture only). It seems to me that there are two concerns from TCDD: (a) environmental half-life; and (b) biomagnification in grazing animals. Let's take on the ecological half-life problem first and make some assumptions (recognizing that they represent oversimplification of the problem): a probable ecological half-life of 1 year and an outside possibility of 10 years; 10 year's use of a product at a mean TCDD concentration of 25 ppm; and a subsequent 10-year period of use with a mean TCDD concentration of 0.1 ppm. Then, if we accept that:

$$\ln \frac{X}{X_0} = -k_1 t$$

$$\ln \frac{X}{X_0} = -(0.07) \text{ (first year)}$$

$$\frac{25 \text{ ppm}}{X_1} = \text{antiln of } 0.07 = 1.073$$

$$X_1 = \frac{25}{1.073} = 23.3 \text{ ppm}$$

What I will now do is calculate an estimate of the ecological burden over the 20-year time period.

EXAMPLE OF ECOLOGICAL BURDEN OF TCDD (OVER 20 YEARS)

Year	t½ = 10 Years (ppm)	t½ = 1 Year (ppm)
	a. Exposure at 25 ppm/Yr.	
1	23.3	12.5
3	23.3 + 042.0 = 065.3	12.5 + 09.4 = 21.9
6	23.3 + 094.8 = 118.1	12.5 + 12.1 = 24.6
10	23.3 + 150.1 = 173.4	12.5 + 12.5 = 25.0
	b. Exposure Continues at 0.1 ppm/Yr.	
11	0.09 + 161.7 = 161.8	0.05 + 12.50 = 12.55
13	0.09 + 140.8 = 140.9	0.05 + 03.15 = 03.20
16	0.09 + 114.4 = 114.5	0.05 + 00.44 = 00.49
20	0.09 + 086.9 = 087.0	0.05 + 00.07 = 00.12

Several observations need to be highlighted:

First, at t–½ = 1 year, 99 percent equilibrium occurs at 7 years at about the yearly exposure level. In other words, there will never be more TCDD remaining than is in the formulation being applied. Rephrased, if you wish to predict the level of TCDD, you would take the amount of 2,4,5-T applied and multiply by ppm TCDD contaminate. If this exposure continued, equilibrium would be reached at approximately the end of the seventh year. However at t–½ = 10 years, the TCDD concentration is increased to about 7 times the applied concentration after 10 years and has yet to reach equilibrium.

Now, considering a continued exposure at the lower TCDD contamination level (i.e., 0.1 ppm), the rate of decrease in the improvement of the environment would only be detectable after 8 years of use if a t–½ = 1 year and would only be detectable after 70 years, if an ecological half-life of 10 years is correct.

Also, the percentage contribution of 0.1 ppm TCDD would never be more than 1 percent of the residue which results in a single year of 25 ppm application. Application of a single year of 25 ppm TCDD would require 8 years to decrease to the level obtainable after continued use of 0.1 ppm TCDD. The situation of a 10-year half-life is worse in terms of what we have already done to the environment but demonstrates a smaller relative contribution of 0.1 ppm TCDD than the t–½ = 1 year at 25 ppm.

How about the toxicological significance of the effect of the two 10-year periods? Although the significance would vary greatly for each species, its place in the food chain, etc., again, let's consider a simplified version of possible numbers for the sake of discussion. Total the ppm x numbers of years at a ppm for a 1- and a 10-year half-life and you get 225 ppm-years for 1–10 years and 26 ppm-years for 11–20 years with t–½ = 1 year, and 1053 ppm-years for 1–10-year period, and 1209 for 11–20-year period for t–½ = 10.

If one compares using linear extrapolation of the damage which has occurred in a 10-year application of 25 ppm TCDD with t–½ = 1 year, it would take 2250 years of use of 0.1 ppm TCDD to produce the same "damage" as would have already been done or with a t–½ = 10 over 10,000 years of use.

If one used an extrapolation procedure, which I believe is more reasonable, of probit analysis and experimentally produced slopes, one approaches a million years before an equivalent toxic accumulation could be accomplished. I personally believe as far as damage to the environment is concerned, this becomes even more ridiculous when we know the use of 2,4,5-T will never approach past levels and most 2,4,5-T used had more than 25 ppm TCDD as compared to the 0.1 ppm used today.

Does this mean that I am not concerned about biomagnification? It does not. Again, however, I must point out that TCDD, as an example, does have a half-life in animals as well as in the environment, and that the variance of each "system" considered is great and, in fact, frequently less than the numbers I have selected for illustrative purposes. Also, we would expect the biomagnification to be on the decline for at least 10 years utilizing the examples previously described.

I believe that dioxins in the environment are important, but I feel that pesticides will contribute little, if untoward conrol over the qualiy of production is maintained. The problem lies not with the pesticide but with industrial chemicals escaping into the environment. As an example, let me draw on data from a May 1975 article by Carter et al. (1975). Between February and October of 1971 waste oil residues of a hexachlorophene production plant in Missouri amounting to about 50,000 kg contaminated with 350 ppm TCDD were sprayed to control dust. To equal this, one would have to use at least 400 million pounds of currently available 2,4,5-T. This abuse of industrial waste disposal is not isolated and must be stopped.

Along the same line, and emphasizing the need for careful adherence to safety in chemical manufacturing, is the recent explosion in Seveso, Italy. An explosion at a Swiss subsidiary of Hoffman La Roche caused a 500-gallon vat of trichlorophenol to explode releasing approximately 4.4 pounds of TCDD. The chlorophenol is used in the production of hexachlorophene. Here it must also be remembered that in chemical reactions involving high temperatures or pressures where chlorinated phenols are precursors, the potential for forming a chlorinated dioxin exists, but not even all the tetrachlorinated dioxins possess similar levels of toxicity, i.e., the 2,3,7,8-TCDD isomer is by far more toxic than the other isomers.

Let me finish this note with one more thought. The ED_{06} for cleft palate for TCDD is approximately 1 μg/kg/day. The ED_{06} for cleft palate is approximately 10 μg/kg/day for 2,4,5-T. Simply stated, the concentration of TCDD would have to bioaccumulate to at least 1000 times the concentration of bioaccumulated 2,4,5-T before the effect due to TCDD was equal to 2,4,5-T. This, of course, has to be superimposed on the probability of 2,4,5-T being able to bioaccumulate to an effective dose level. Some good work needs to be done on the pharmacokinetics of TCDD in food stuff likely to be consumed by man and modeling of man's biological half-life.

After we have combined animal toxicology and human exposure data, we must determine if levels of contaminants actually exist in food. Great strides have been made in the last 20 years. Gas chromatography has become a common laboratory workhorse with sensitivities proceeding from 1950's thermal conductivity (10^{-6}g), to 1955's flame ionization (10^{-9}g), to 1960's electron capture (10^{-12}g), to gas chromatography mass spectrometry (10^{-15}g).

$$\frac{ED_{06}\ 2,4,5\text{-T}}{ED_{06}\ TCDD} = \frac{10\ mg}{1\ \mu g} = K_{[e]} = 10{,}000$$

TCDD is 10,000 times more teratogenic than 2,4,5-T.

$$\frac{[2,4,5\text{-T}] + [TCDD]}{TCDD} = \frac{1}{1 \times 10^{-7}} = K_{[c]} = 10{,}000{,}000$$

There is 10,000,000 times less TCDD than 2,4,5-T.

$$\frac{K_{[c]}}{K_{[e]}} = 1{,}000$$

After we have determined the potential for toxicity and the presence of a residue, we are usually still faced with the necessity of extrapolating the toxic results from high doses to observed human exposure levels. This, in my opinion, is, and will remain, the greatest challenge of all.

DINITROPHENOLS

Several substituted dinitrophenols alone or as salts of aliphatic amines or alkalies are used in weed control. Several human poisonings by dinitro orthocresol (DNOC) have been reported (Bidstrup and Payne, 1951). Signs and symptoms of acute poisoning in man include nausea, gastric upset, restlessness, sensation of heat, flushed skin, sweating, rapid respiration, tachycardia, fever, cyanosis, and finally collapse and coma. The illness runs a rapid course with death or recovery generally within 24 to 48 hours. These signs and symptoms reflect an increased metabolic rate which may exceed several times normal values and is dose-dependent. If heat production exceeds the capacity for heat loss, fatal hyperthermia may result. Chronic exposure to dinitro-orthocresol may also produce fatigue, restlessness, anxiety, excessive sweating, unusual thirst, and loss of weight. A yellow staining of the conjunctiva has been noted, and cataract formation is another possible sequela of chronic dinitro-orthocresol exposure. Blood levels of DNOC below 10 ppm are considered of trivial importance; levels of 11 to 20 ppm indicate appreciable absorption; and above these blood levels toxic manifestations are likely. Levels greater than 50 ppm are critically dangerous. After removal of the poison from the skin or gastrointestinal tract, treatment consists of ice baths to reduce fever and administration of oxygen to assure maximal oxygenation of the blood. Fluid and electrolyte therapy may be necessary to replace loss by sweating. Atropine sulfate is absolutely contraindicated in cases of poisoning by dinitrophenolic compounds, and therefore care should be taken to avoid a misdiagnosis of organophosphate poisoning. Symptoms of poisoning and their severity are enhanced when the environmental temperature is high. In very cool weather blood levels as high as 50 ppm have been tolerated without symptoms. The oral LD_{50} of DNOC in rats is approximately 30 mg/kg (Hayes, 1963, 1971).

It will be noted that the nitrocresol compounds produce symptoms of toxicity similar to those produced by dinitrophenol and therefore probably act by uncoupling of oxidative phosphorylation as has been proposed for dinitrophenol. Compounds that produce uncoupling of oxidative phosphorylation also have the peculiar property of rapidly producing rigor mortis after death. Studies on the toxicology of substituted nitrophenols used in agriculture may be found in a report by Spencer and coworkers (1948).

BIPYRIDYL COMPOUNDS

Paraquat and diquat are the best known compounds of this class of herbicides, which are increasing in use. Cases of accidental or suicidal fatalities resulting from paraquat poisoning have been reported (Campbell, 1968). Pathologic changes observed at autopsy in all of these fatal human poisonings showed evidence of lung, liver, and kidney damage. Some cases had myocarditis, and one case showed transient neurologic signs. The most striking pathologic change was a widespread cellular proliferation in the lungs. This pathology was also evident in a suicide case in which the paraquat was injected subcutaneously. In this case the victim died in respiratory distress, and the main pathologic findings at autopsy were in the lungs. Hence, paraquat produces lung damage even when administered by routes in which exposure of the lung is secondary. Although ingestion of paraquat results in gastrointestinal upset within a few hours after exposure, the onset of respiratory symptoms and eventual death by respiratory distress may be delayed for several days. In a case involving a 6-year-old child, the concentration of paraquat present in the liver and kidney at necropsy was 200 mg per 100 g of kidney. One accidental case involved an individual who mistakenly took a mouthful of the herbicide from a "stout" bottle; and although he spat it out almost immediately, 14 days later cyanosis and severe dyspnea developed. The patient who administered paraquat by subcutaneous injection had chest radiograph changes 3 days after administration but did not develop respiratory symptoms for an additional 11 days.

The toxicology of bipyridyl herbicides was reviewed by Conning and associates (1969). In animal studies all species examined showed the same response after a single large dose of paraquat given by mouth or by subcutaneous or intraperitoneal injection. There was an early onset of hyperexcitability which in some cases led to convulsions or incoordination. The animals died over a period of 10 days after administration. Early deaths were not associated with any specific systemic pathology. Later deaths that occurred at 2 to 5 days after administration usually were accompanied by severe pulmonary congestion and edema with hyaline membrane formation and inflammatory infiltrates. Animals that survive the pulmonary edema associated with a single dose occasionally show progression of lung lesions to fibrosis and eventual death from respiratory failure. As in man, a single dose may produce pulmonary fibrosis in the dog. The feeding of 0.03 percent or more of paraquat in the diet of experimental animals led to the production of pulmonary fibrosis in most all of the animals. Studies of organ cultures of lungs treated with paraquat revealed extensive necrosis of alveolar cells. Inhalation of paraquat aerosols for several hours produces severe congestion, alveolar edema, and bronchial irritation 2 to 3 days after the exposure. However, if the animal survives during this period there is, surprisingly, no further chronic fibrosis produced.

The LD_{50} for paraquat in guinea pigs, cats, and cows is in the range of 30 to 50 mg/kg. Rats appear to be somewhat more resistant with an LD_{50} of about 125 mg/kg. The LD_{50} for man is estimated at about 40 mg/kg (Conning et al., 1969). Studies of several species indicate that absorption of paraquat from the gastrointestinal tract is relatively low, in no cases exceeding 20 percent of the administered dose. There is a rapid disappearance from the blood with 90 to 100 percent of the dose excreted in the urine within 48 hours. Since there is a long delay until onset of respiratory signs, this compound has been classified among the "hit-and-run" types of toxic agents. Exposure of the skin to solutions of dipyridyls results in erythemia and a mild reactive hyperkeratosis which may be associated with pustule formation.

Diquat produces acute and chronic effects that differ from those produced by paraquat in that marked effects on the lung are not observed. Oral doses near the LD_{50} produce hyperexcitability leading to convulsions and distention of the gastrointestinal tract with discoloration of intestinal fluids. The only pathology associated with long-term feeding of diquat at levels of 0.05 percent was the production of cataracts in about 10 months. A related compound, chlormequat, has as its target organ the kidney. In both rats and dogs kidney lesions were the only striking pathology noted in both acute and chronic studies.

It has been suggested that the mechanism of the herbicidal action of the dipyridyls is mediated by free radical reactions, and a similar mechanism has been proposed for the action in mammals. Gage (1968) has shown that free radicals can be produced from paraquat and diquat incubated in the presence of reduced NADP and liver microsomes.

CARBAMATE HERBICIDES

This class of herbicides contains a large number of aromatic and aliphatic esters which for the most part have relatively low acute toxicities (Dalgaard-Mikkelsen and Poulsen, 1962; Woodford and Evans, 1965). The compound propham is a typical example of this class of herbicides. Its LD_{50} by oral administration in rats and rabbits was of the order of 5000 mg/kg. Feeding rats dietary concentrations of 1000 ppm for 3 months produced no signs of effects on general condition and growth, fertility, or pathologic changes. Barbane is somewhat more toxic than propham with an oral LD_{50} of 600 mg/kg for rats and rabbits and 24 mg/kg for guinea pigs. Daily oral administration of 75 mg/kg for 22 days produced some loss of weight, while half of this quantity produced no toxic action. Feeding experiments with rats showed no toxic action of 150 ppm in the diet for 18 months. Barbane, however, is a potent skin-sensitizing agent in man, and allergic reactions and rash may develop on subsequent contact.

SUBSTITUTED UREAS

Like the carbamate herbicides the substituted ureas are, as a class, rather nontoxic by acute oral administration. Monuron and diuron are typical examples with LD_{50} values in rats of over 3000 mg/kg. They are also without toxic action when fed at relatively high concentrations in the diets of rats and dogs for several months to 2 years.

TRIAZINES

Most members of this class of herbicides also have low oral acute toxicities ranging above 1000 mg/kg. Simazine was nontoxic to a variety of animal species including mice, rats, rabbits, chickens, and pigeons. Rats survived daily doses of 2500 mg/kg for 4 weeks (Dalgaard-Mikkelsen and Poulsen, 1962). Simazine is, however, more toxic to sheep and cattle. Sheep were killed by three daily doses of 250 mg/kg, 14 daily doses of 100 mg/kg, or 31 daily doses of 50 mg/kg. Cattle were killed by three daily doses of 250 mg/kg (Palmer and Radeleff, 1964). The acute toxicity of atrazine to rats is greater than for simazine; however, cattle and sheep appear to be more resistant to atrazine than to simazine.

The herbicide amitrole (3-amino-1H-1,2,4-triazole), although not classified as a triazine, is structurally somewhat similar. This compound also has a very low acute oral toxicity to rats and mice (ranging from 15,000 to 25,000 mg/kg). However, amitrole is a rather potent antithyroid agent, and feeding levels of 2 ppm in the diet resulted in significant effects on thyroid function (Strum and Karnovsky, 1971). These functional changes occurred after only 1 week of feeding of amitrole, and goiters can be induced by amitrole with long continuous administration. Amitrole given to rats in the diet at 100 ppm for 2 years resulted in the development of thyroid adenomas and adenocarcinomas. This has resulted in prohibition of this compound for use as a herbicide where residues might occur on food crops. Amitrole inhibits peroxidase activity in livers and thyroids, and the mode of action in producing thyroid tumors appears to be related to the goitrogenic effect of amitrole with resultant increased TSH (thyroid-stimulating hormone), since other antithyroid agents that result in TSH stimulation also can produce thyroid tumors experimentally (Sinha et al., 1965). The amitrole case illustrates an important principle in toxicology, that is, the fallacy of assuming safety purely on the basis of low acute toxicity. As is illustrated by this compound, which is practically nontoxic acutely, rather profound functional changes can occur that directly or indirectly may lead to irreversible pathology, e.g., cancer.

AMIDE HERBICIDES

Several aniline derivatives esterified with organic acids are currently used as herbicides. These compounds also have relatively high oral LD50s for rats. A typical example is the herbicide propanil which is used extensively to control noxious weeds in rice crops. The rice plant is selectively resistant to the herbicidal action of propanil because it contains an acylamidase that hydrolyzes propanil to 3,4-dichloroaniline and propionic acid. An interesting case of herbicide potentiation was observed in field studies in which propanil was applied to rice following the application of organophosphate insecticides. This procedure resulted in damage to rice plants and was subsequently explained on the basis that the organophosphates inhibited the hydrolysis of propanil, and thus the parent compound was preserved and exerted its herbicidal action in the rice (Matsunaka, 1968). Williams and Jacobson (1966) demonstrated that mammalian livers also contained an amidase that hydrolyzed propanil, and they speculated that organophosphates and carbamates might potentiate the acute mammalian toxicity of this herbicide. Studies of interactions did not reveal a significant potentiation, however. Further investigation demonstrated that inhibition of liver acylamidase by triorthocresyl phosphate (TOCP) prevented the cyanosis that was observed when mice were given toxic doses of propanil (Singleton and Murphy, 1973). The cyanosis was due to methemoglobin formation following hydrolysis to 3,4-dichloroaniline. Other signs of poisoning, i.e., CNS depression and death, were not prevented by inhibiting the hydrolysis of the herbicide. It appears, therefore, that aromatic amides that are hydrolyzed to aniline derivatives may produce methemoglobin, but that the acute lethal action is due to a different mechanism.

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MS. WINE: We are really running out of a lot of time. We want to get on because we have added a third speaker to this afternoon's program. Dr. Kutz will be speaking on the EPA monitoring program. Dr. Cranmer will be here from 5:00 to 7:00. If you have questions, he will answer them at that time.

All of your questions will be reviewed and entered into the record. I am going to let you have a 5-minute break.

INTRODUCTION OF PANELISTS

MS. WINE: We are adding to the panel Morris Cranmer and James Witt, so if you want to come up and be part of the panel, we would be glad to have you.

Our panelists are: DR. PHILIP KEARNEY, and he is the Acting Pesticide Coordinator in the Office of the Secretary of the Department of Agriculture.

We are also fortunate to have DR. RENATE KIMBROUGH from the Center for Disease Control in Atlanta. Dr. Kimbrough has worked in toxicology and pathology at CDC with the main emphasis being on human health.

We also have as a panelist MR. CALVIN MENZIE, Environmental Specialist in Toxicology with the Division of Habitat Preservation Research in the Fish and Wildlife Service of the Department of Interior.

We have DR. MATTHEW MESELSON, Professor of Biochemistry, Department of Chemistry and Biochemistry, Harvard University. Dr. Meselson and his students have devised the first analytical technique for detecting TCDD in environmental samples in the parts per trillion level and are continuing this work.

We have DR. LOGAN NORRIS, a supervisory research chemist with the Pacific Forest and Ranger Station in Corvallis, Oregon, and DR. GEORGE STREISINGER, research associate with the Institute of Molecular Biology at the University of Oregon in Eugene.

At the present time Dr. Streisinger is developing a vertebrate model utilizing fish analyses of genetic and developmental problems for measuring dose responses to mutagens and teratogens.

DR. GUNTER ZWEIG, Office of Pesticide Programs at EPA. Dr. Zweig was recently awarded the Wiley Medal from the Association of Pathological Chemists for past achievements in pesticide analysis by chromatography.

The first speaker is DR. VIRGIL FREED, Director, Environmental Health Sciences Center at Oregon State University in Corvallis. His interests lie in the chemistry and environmental chemistry of pesticides. He has done extensive work on the behavior of chemicals in the environment, particularly in soils and the metabolism of pesticides and their mode of action.

FATE IN THE ENVIRONMENT OF FAMILIES OF CHEMICALS USED AS HERBICIDES IN FORESTRY: MONITORING, BREAKDOWN, AND RESIDUES UNDER CONDITIONS OF USE, PHYSICAL MOVEMENT, FOOD CHAIN ACCUMULATION, AND HUMAN AND ENVIRONMENTAL SAFETY WHEN APPLIED

Virgil Freed

DR. FREED: Thank you very much. Ladies and gentlemen, I am very honored to have been asked to appear to address such a distinguished group of scientists and so on, and I might add that I feel a little inadequate knowing some of the expertise that is sitting both at this table and in the audience. That is my speech.

In the interest of time I have quite a number of slides, and I know Jim Witt is just going to give me fits about having so many slides and such poor ones when we get home, but forgive me. I just got back from Colombia, South America, and I didn't have time to get very well organized. Incidentally, they do have real problems there, the likes of which I am afraid those of us here wouldn't appreciate.

This afternoon I will talk mostly about the behavior of chemicals in the environment. There are some, but I am sure none in this audience, who have rather mysterious views about how chemicals behave in the environment, as if the whole thing were something quite mysterious.

Well, it is complex but not beyond the realm of understanding. There are principles and processes that we do understand relative to the behavior of the environment. I am reminded of Einstein's quotation to the effect, when they asked him about the universe, he said, "God is often complex, but never mysterious," and I think this is the way of the behavior of chemicals in the environment—here, really, is what it is all about—the different interrelationships—and we are grateful to Clive Edwards for this particular diagram.

Let's start out by pointing out some of the chemicals, the manufacture, and the amount used. Some of these are redundant. Here Jim Witt had this slide, I think, and I did it in a bit more detail on the amount of chemical used, the 278,000 pounds of 2,4-D and the 186,000 pounds of 2,4,5-T used by the Forest Service. Estimated acres in the U.S. treated with herbicides; and here you have the agricultural, lawn, rights-of-way, Federal Government lands treated, and so on, in terms of acres and the types of pesticide or herbicide used.

Now, when a chemical is released into the environment and finally reaches the target site, there are basically four processes or four steps that it follows. The transport and interaction, the environment interaction of the boundary of the organism, transport through the organism and, finally, the action at the sensitive site.

(Slide)

On the righthand side are some of the things that happen. These are things that happen during these processes or during these steps. We are interested in the first one, namely, the behavior in the environment; and behavior in the environment depends on the extensive environmental parameters—light flux, water flux, and so on—and some of the intensive properties or factors in the environment; but beyond that, it is dependent on the properties of the chemical.

You know, doesn't it seem so obvious and so simple-minded to tell you that if you took gasoline and crankcase oil and you put a drop each on the sidewalk, that the gasoline would evaporate first? The gasoline does it because of its particular properties. The motor oil lasts longer because of its particular properties. All of these interactions that go on, the properties and physical and chemical data on the lefthand side and the processes on the righthand side are an interaction of the physical-chemical properties of the material with the environmental processes.

Now, due to this—that is, these interactions—we have a distribution of the chemical in the environment. This is nothing more than the old Boltzman equation and we have, say, five compartments in the environment, and the number of molecules that would distribute into the various compartments of the environment is due to the energetics involved in the interaction of the physical properties with the processes going on in the environment. The E_{ij} is the important factor, the measure of energy required to bring about that distribution. Some of the properties of compounds are of concern. Note the properties of 2,4-D, 2,4,5-T, and the 2,3,7,8-TCDD. Note, (a), the vapor pressure of TCDD—unfortunately I don't have it there for the 2,4-D and 2,4,5-T. We will look at the vapor pressures of esters of that later.

Notice the water solubility indicative of behavior patterns. The MR, molecular refractivity, gives an indication of certain internal forces of the molecule, and that is indicative of the strength of interaction that molecule will have with surfaces such as soil or a plant leaf.

The larger, the more refractivity, the more strongly the material is bound, the less available it is biologically and the less mobile it will be in the environment.

(Slide)

And properties of some of the other herbicides that have been talked about here today. Now the esters of 2,4,5-T, silvex—we have a variation, other vapor pressure and water solubility there. The vapor pressure is reasonably low. I can remember back in the dark ages when I was taking organic chemistry, anything with less than the minus 10 of mercury was considered nonvolatile.

Now 10 to the minus 5 is considered measurably volatile. So science has advanced since the time I studied it. The 2,4-D esters—I didn't help it to advance. It has been lucky that I haven't set it back 100 years.

(Slide)

Let's talk a little bit about some of the impurities in 2,4,5-T that came up.

Here is a listing I came across in an EPA publication. Some of the resources of information I have seen on this would indicate this is approximately correct. So EPA is occasionally right.

(Slide)

Physical properties of picloram.

(Slide)

Let's move along. These are the organic arsenicals. Let's talk about some of the processes that go on in the soil and why the properties that I have been showing you are important. First, the absorption, Here is roughly and very simply an equation for absorption of a material by soil—but it could be by any surface—and if you specify your conditions, you find that you can repeat the experiment so that you have an equilibrium for which an equilibrium constant can be written. With algebraic manipulations of thermodynamic quantities, you can get an estimate of the strength at which a chemical is absorbed. Equation seven illustrates that.

(Slide)

There is a relationship between the latent heat of abosrption, that is, the strength of binding and the amount that is bound and the strength at which it is held.

You can see as you go from the dichlorbenil, the dichlorobenzonitril through chloropropham, monuron, and the TCPA, you have an increasing delta age and an increasing amount of absorption, and the binding is tight. By the time you get Monuron with 6 molecules, you have a substance resistent to moving through the environment, leaching through the soil. It is strongly bound. As you go from one soil type to another, you find differences in absorption, from sandy soil to loam, to clay, to peat, in the increasing amount of absorption that occurs by soil type.

You can describe the absorption in the good old Frolich isotherm of which this is a description. As materials move through the soil, we would like to quantitate that and understand it.

Here are various models—you have a statistical, a stochastic model offered by Lambert and his coworkers years ago. There is the one by Lindstrom, and when you begin to sort it all out and you come to the letter "U," this is our latent heat of absorption which is a critical factor.

The latent heat of absorption gives us an indication of the strength of binding, and that appears in an exponent that tells us how readily a material will leach. And here are some data on the leachability of certain compounds from different soils. You note monuron, with its latent heat of solubility or latent heat of absorption, rather, in terms of—does not leach readily. A lot of water runs through there.

John Hamiker did a clever thing. He went through and determined the partition coefficient between the compounds and the organic matter of soil to give an index of how mobile it might be in terms of leaching. There is a beautiful correlation between that. All of this is an attempt on my part not to insult your intelligence but just simply to reinforce your knowledge that there are principles that govern the behavior of chemicals in the environment that we have some knowledge of—that we can utilize.

(Slide)

Vapor behavior. Here is a relatively newly developing area. I remember years ago, Dr. Warren Shaw, when he was doing research on herbicides, used to give enthusiastic lectures on the vapor behavior of some of these materials and that we needed to know more about it. Dr. Shaw, I think we are learning more about it these days. We have finally the tools to do some measurement.

Here again are some of the relationships. The particularly important one that I think is of value to us now is the HANGMUIR relationship, and we have expanded. We have been doing a bit of work at Oregon State on this, expanded, and I think made it a more useful equation in terms of dealing with pesticides.

Now, with this equation we can go one of two ways. We can take the vapor pressure and estimate the amount of chemical that will vaporize from a surface or we can go back the other way, take some of the pure chemical, put it in a container, and measuring the rate of loss at a given temperature, we get a fair estimate of the vapor pressure.

(Slide)

Now, let's turn to breakdown. I think, as has been pointed out several times today, the chemicals do break down. They are metabolized both in the living organism and in the environment. This assumes you don't overload either the organism or the environment. There are a variety of ways in which a material will decompose in the environment. A number of studies of the degradation of materials in the environment has suggested to us—and quite properly—that this might be a pseudo-first-order reaction.

In other words, it would have this relationship in terms of breakdown. Now, others have studied some other compounds that are a different rate, a different order of breakdown, so they come up with this power rate model relationship, and in the limiting case, this does turn out to be the first pseudo-first order, but the Morgan equation is here. From that, that is, once you have the rate, you have the relative constant of breakdown, you can calculate an energy of activation for breakdown and from that make an estimate of how long the term will persist under a given set of conditions.

The first time that this was done, it was done by a young German student in my laboratory, and we published the paper with some trepidation. As I recall, we did this on aminotriasol. The work was repeated a year later by an Italian scientist, and he came out with much the same figures that we did which we found most gratifying that our work could be confirmed.

(Slide)

I am trying to list here the persistence of some of the chemicals in the environment given certain conditions, and you see they do have finite persistent times—some shorter than others—and that persistence will vary according to the conditions.

Next, I mentioned that I was in South America just recently, and you go everywhere—in the coastal plains, the tropical plains up to a temperate climate at 9,000 feet in Bogota—there are interesting data there in terms of persistence of chemicals. In tropical coastal plains almost any chemical you use disappears quite rapidly through a variety of factors. But at the higher elevation, let's say Bogota or Lima, the persistence is much longer because of the lower temperature.

I borrowed data here from my colleague, Dr. Norris, some of the work he had done, a persistence of 2,4,-D and 2,4,5-T in the forests of the Pacific Northwest.

Dr. Cranmer was talking about the buildup of chemicals in the environment, and they reach sort of an equilibrium state. Here is the case of a chemical with a 6-month half-life. There is a yearly application of 2 pounds. And you see at the end of multiple applications, the maximum amount you have in the environment is double the annual application.

(Slide)

Biomagnification is another problem, but again it follows certain well-defined, physical-chemical principles. The partition and coefficient are a fairly good measure of the propensity of a compound to biomagnify or to bioaccumulate. Incidentally, you see that excellent correlation there. I call your attention to the fact that TCDD falls well off that scale because of its solubility behavior—its very low solubility in both water and organic solvents.

(Slide)

At the risk of being redundant and without being presumptuous, I want to end recapturing some of the principles of toxicology because it applies in the environment. Starting out, all chemicals in sufficient dose are toxic and going through the other points. The toxicity is purely redundant from what Dr. Cranmer has told you, but let me conclude with this point. There is a difference between toxicity and hazard. I think this reinforces something Dr. Witt said. What are the points in hazard? A compound may be intrinsically toxic, but the manner of use, its mobility, and a variety of other things determine whether it is a hazard or not; so here, number one, the intrinsic toxicity of the compound is one point in hazard; number two, the selectivity, that is what species are susceptible to; number three, the stability in the environment, does it persist long enough to be a hazard?

One of the phosphates was toxic, but it didn't last long, so they were unable to kill many people with it. Then, finally, that mobility.

Ladies and Gentlemen, I have gone a minute and 30 seconds over my allotted time. I apolozige to Madame Chairperson for that, but I want to thank you for your courteous attention and the honor of inviting me here. Thank you.

POST-SYMPOSIUM RESPONSES TO QUESTIONS SUBMITTED TO VIRGIL FREED

QUESTION: Your discussion of binding suggests a high delta H means little environmental contamination (e.g., leaching); yet, this discounts especially in the agricultural context, the significant movement, the soil erosion. Since soil erosion particles can spend up to 4 years in hydrologic systems prior to disposition "at sea," doesn't that suggest that soil binding, per se, is not a measure of contamination potential?

ANSWER: Obviously, this is a very perceptive question, and one that I should have anticipated in the presentation, but the constraints of time precluded my addressing it. Certainly the movement of contaminated soil to which I referred in the presentation does result in movement of the chemical in association with the particle. However, it should be equally clear that in talking about the latent heat of adsorbtion and its influence on leaching that this was in the context of the movement of the free chemical and not the bound chemical. Thus, once bound to the soil colloid or other appropriate surfaces, those chemicals with a high binding affinity are released in only small quantities and, hence, are not readily mobile as the free species.

Should the particle of soil to which the chemical is bound be eroded by wind or water, it may then, indeed, be carried some distances. However, the individual asking this question should be aware that it is the amount of chemical that determines the degree of contamination as used in the sense of this question; since if imperceptible amounts are moved either as free chemical or bound chemical, we would not detect this movement.

QUESTION: What is the current status of the Volcanus-II? Is the plume being monitored for health effects, and what are the results of the monitoring off Johnson Island after the burning of the surplus "Agent Orange?"

ANSWER: To the best of my information the Volcanus has completed the incineration of the supply of "Agent Orange." This took a number of days in completion in order to ensure complete combustion. Nothing has come to my attention as to whether the crew of the vessel was being monitored for health effects, though I suspect if it was as carefully a conducted operation as it should have been, they will have been monitored not only for health effects but to determine levels of exposure.

Prior to incineration of "Agent Orange," a number of studies were done on the combustion of chlorinated materials in the ship's incinerators. In fact, this vessel was used to incinerate a number of such wastes from plants in Texas. The degree of incineration, the various products admitted, and their dispersal during incineration were thoroughly monitored. These studies indicated that a chlorinated material, such as "Agent Orange," would be completely incinerated to carbon dioxide, water, and hydrogen chloride. The dispersal in the plume was concluded to be so rapid and extensive as to afford neither environmental nor health hazard.

QUESTION: How much taxpayer money is represented by "Agent Orange" destroyed on the Volcanus?

ANSWER: I have seen various estimates of the value of the butyl esters of 2,4,-D and 2,4,5-T that were to be incinerated aboard the Volcanus, but my memory is a bit hazy so that the figures I quote should not be taken as exact. The figure that sticks in mind is approximately $10 million worth of chemical which amounted to something like over 2 million gallons of material.

QUESTION: How many angels can dance on the head of a pin?

ANSWER: Whoever submitted this question obviously realizes it is a frivolous one. Perhaps it was intended to indicate that the subject of the address has little to do with the reality of the world. If this is the case, I would like to assure the questioner that our knowledge of the principles of behavior of chemicals in the environment is well founded on science, has been well established by ever so many experiments, and accepted as a branch of knowledge by scientists and individuals smarter than I.

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MS. WINE: Before our next speaker, Carolyn Offutt, is introduced and brought on stage, I would like you to be aware of the fact that there are two other project managers from the Office of Special Pesticide Reviews here who will be happy to answer questions for you this evening.

First of all, Harvey Warnick is our project manager for 2,4,5-T. He will be available in room 207 from 5:00 to 7:00 p.m.

Second of all, in the back in the blue dress, Mary Reece, who is our project manager for 2,4,5-Trichlorophenol, will also be available from 5:00 to 7:00 p.m.

Once again, I would remind you that you are at liberty to have anything submitted for the record. You can give it to either me, Dave Ketcham, or whatever. Also in room 207 this evening we will have Rupert Cutler and Ed Johnson, and many of the questions that we are getting from the floor pertain to 2,4,5-T and TCDD and the status of our scientific reviews at EPA. The project managers will be happy to answer the questions as best they can from 5:00 to 7:00 p.m.

CAROLYN OFFUTT is the Dioxin Project Manager in the Office of Pesticide Programs at EPA. As project manager she is responsible for the Dioxin Implementation Plan designed to develop the modeling for dioxin analysis and to provide scientific support for EPA regulatory actions regarding pesticides containing dioxins. CAROLYN OFFUTT.

EPA MONITORING STUDIES—A CASE HISTORY ON DIOXIN

Carolyn K. Offutt

The Federal Insecticide, Fungicide, and Rodenticide Act, as amended, directs the U.S. Environmental Protection Agency (EPA) to register all pesticides for use in the United States. That regulatory authority—and it is important to realize that EPA is a regulatory agency and our efforts must be directed toward accomplishing our regulatory responsibilities—that regulatory authority requires us to evaluate the risks and benefits of a *particular* use of a *particular* pesticide and not to register any pesticide which will cause unreasonable adverse effects on the environment.

Several herbicides used in forestry management have been referred to EPA as candidates for a special review of the risks and benefits of the continued use of these herbicides. This intensive scientific review will determine whether a rebuttable presumption exists against continued registration for some or all uses of these herbicides—hence the "Rebuttable Presumption Against Registration"—or RPAR. These herbicides include 2,4,5-T, silvex, and some related compounds which are chemically derived from chlorinated phenols. One of the concerns is the potential for some phenoxy herbicides to be contaminated with dioxin compounds, particularly with 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). Dioxins may be produced as a manufacturing contaminant during the production of the pesticide raw materials. TCDD is recognized to be a very toxic compound.

It is important to emphasize that the phenoxy herbicides are the registered products and that any EPA pesticide action regarding dioxin wil be taken with respect to the registered product. That is to say, we have not registered dioxin; therefore, there is no registration of TCDD to cancel. We will regulate phenoxy herbicides based on an evaluation of their risks and benefits, including an evaluation of risks from any dioxin contamination.

Many of you are familiar with the history of the Dioxin Program which is closely tied to several Federal regulatory actions regarding 2,4,5-T. These actions resulated in EPA initiating, and then withdrawing in July 1974, cancellation and information gathering proceedings against 2,4,5-T and related compounds. Also in July 1974

EPA held a Dioxin Planning Conference to discuss the analytical, monitoring, and toxicological needs to make a final determination on whether 2,4,5-T causes "unreasonable adverse effects."

DIOXIN IMPLEMENTATION PLAN

As a result of the Planning Conference the Dioxin Implementation Plan was developed in a collaborative effort of EPA, USDA, Dow Chemical USA, and the Environmental Defense Fund. The Plan was finalized in February 1975. The Plan was designed to develop the analytical methodology for detecting TCDD in the low *parts per trillion* (ppt) range, to conduct monitoring for detecable amounts of TCDD in environmental samples, and to support research on the toxicological effects of TCDD.

Under Phase I of the Dioxin Implementation plan a promising analytical methodology has been identified for analyzing dioxin at levels around 10 parts per trillion (ppt). *See Table.*

The goal of Phase II is to determine actual dioxin levels in environmental samples. Therefore, Phase II is emphasizing further corroboration of this methodology by several laboratories and the possibility of lowering the detection limit to 1 ppt or less. This analytical method is being applied to the monitoring studies under Phase II of the Plan. See Table.

PHASE I

The analytical methodology developed under Phase I of the Plan involved an acid-base extraction of TCDD from the environmental sample with cleanup of the sample by column chromatography, followed by analysis by gas chromatography interfaced with high resolution mass spectrometry. One of the goals in Phase I was to develop an extraction and cleanup which consistently provided a recovery of greater than 50 percent of the TCDD in the original sample. This can be determined by adding a known quantity of radioisotope-labeled TCDD to the sample before extraction. The recovery of TCDD native to the sample can be related to the recovery of the TCDD isotope.

With the spohisticated analytical instrumentation available today, it is not too difficult to quantify levels of TCDD in the low parts per trillion range if pure TCDD is spiked in a pure solvent.

However, working with environmental samples, that is not the case. With environmental samples it is like looking for extremely low levels of a chemical in a 3 percent salt solution, such as ocean water; it is like looking for a particular compound in a waste sludge with all of its varied components; or, in our case, it is like looking for TCDD in the parts-per-trillion range in tissue samples of animals or people with the ubiquitous contamination of PCB's and DDE, a metabolite of DDT. These latter chemicals particularly interfere with the analysis of samples for parts-per-trillion levels of TCDD. The challenge is to clean up the sample and to separate the TCDD from the interfering compounds that may be present.

Based on the results of the collaborating laboratories, this method is valid for detecting levels of TCDD greater than 10 ppt in environmental samples.

Under Phase I the original forestry samples from the Pacific Northwest submitted by the U.S. Department of Agriculture for the 1974 hearings were reanalyzed. This was an attempt to confirm the 1973-1974 forest sample data using present analytical techniques. Unfortunately, the results from the two laboratories vary widely. Therefore, the confirmation analyses still do not give a precise quantification of the amount of TCDD present. It does appear, however, from a qualitative standpoint that TCDD was present in a small percentage of the forest samples collected in 1973.

A beef monitoring study was set up under Phase I of the Plan to look for detectable levels for TCDD in beef cattle. The samples were to include cattle likely to be marketed for human consumption and grazed on lands treated with 2,4,5-T. The first 128 samples—85 beef fat and 43 beef liver—were collected in February and March 1975 from Missouri, Kansas, Texas, and Oklahoma.

Based on a 1976 evaluation of the 85 beef fat samples, including 18 samples from control areas and 67 from potentially exposed areas, one sample showed a level of TCDD about 60 ppt, two around 20 ppt, and some other samples showed the possibility of TCDD, but those levels are at or below the detection limit of 10 ppt. None of the beef liver samples were positive for TCDD.

I am working with the dioxin collaborators in finalizing a status report on Phase I of the Dioxin Implementation Plan. This report would present in more detail the efforts in Phase I which I have just outlined briefly. This status report should be available early in the spring.

PHASE II

Under Phase II of the Dioxin Implementation Plan we are seeking to corroborate the analytical methodology we developed under Phase I by conducting a study with several laboratories analyzing spiked samples in the low parts-per-trillion range. The analytical goal for Phase II is to validate a method to detect TCDD levels of 1 ppt or less. As well as further testing of the analytical method from Phase I—acid-base extraction with cleanup on chromatography columns, followed by analysis by gas chromatography interfaced with high resolution mass spectrometry—we are considering different extraction methods and different cleanup steps as well as different analytical instrumentation, such as capillary gas chromatography and high pressure liquid chromatography. We are working with the original collaborators as well as with the collaborating laboratories as we strive to reach the goal of a TCDD detection limit of 1 ppt or less.

Under Phase II we are continuing our monitoring for detecable levels of dioxin in the environment. One of the major concerns about the use of herbicides based on chlorinated phenols is the potential for human exposure to TCDD. Because of the lipophilic nature of TCDD, human exposure might de detected by analyzing human fat tissues. One source of human fat available with relatively little risk to the donor is in the milk of lactating women.

The concern for potential human exposure to TCDD through the use of 2,4,5-T and related compounds has led EPA to expand its human milk sampling program in the Office of Pesticide Programs to include additional sampling and analysis for TCDD in the low parts-per-trillion range. The first portion of the study is to determine whether detectable amounts of TCDD are present in human milk in the Pacific Northwest. Milk will be analyzed from a total of about 100 women in the Pacific Northwest in potentially exposed and control areas in California, Oregon, Washington, and Alaska. EPA is curently investigating the possibility of expanding to TCDD/Human Milk Study to other areas of high 2,4,5-T use. We are hoping to develop any expansion into a cooperative study with industry and other Federal agencies.

In order to understand better the possible sources of TCDD contamination in the environment from the current use of herbicides, we have undertaken a contract to analyze several phenoxy herbicide technical products which potentially may contain TCDD. The contract requires the detection limit for the analyses by gas chromatography-mass spectrometry for possible levels of TCDD to be 0.01 ppm or 10 parts per billion.

We also are working through the EPA regional offices to obtain samples from a variety of rural and urban environments for possible TCDD contamination.

CONCLUSION

The Dioxin Implementation Plan is now 3 years old. Much progress has been made on the development of analytical methodology for very low levels of TCDD. I believe it is time to conclude some portions of the Dioxin Implementation Plan, yet some aspects of the monitoring program are continuing to provide useful information on the presence of the TCDD in the environments.

But the question remains of how the dioxin monitoring program relates to EPA's pesticide regulatory authority. How will the data be used in the RPAR process? The monitoring data generated under the Dioxin Implementation Plan will provide information on whether detectab!e residues of dioxin may be found in human and in environmental samples. This information will be used

Table
DIOXIN IMPLEMENTATION PLAN

Phase I

- Analytical Studies
  - —Acid-base extraction and column chromatography clean-up
  - —Analysis by gas chromatography interfaced with high resolution mass spectrometry
  - —Method not valid below 10 ppt
- Monitoring Studies
  - —Forestry samples
  - —Beef fat and beef liver study
- Toxicological studies
  - —Long term chronic studies undertaken
- Phase I Status Report being written

Phase II

- Analytical Studies
  - —Corroborative evaluation of Phase I analytical method
  - —Evaluation of alternative extraction and cleanup procedures
  - —Evaluation of alternate analytical instrumentation
  - —Goal to reduce detection limit to 1 ppt or less
- Monitoring Studies
  - —Human milk studies
  - —Other human studies
  - —Analysis of technical products
  - —Other environmental studies—beef, small mammals, soil water, etc.
- Toxicological Studies
  - —Long-range chronic feeding studies being concluded
  - —Dioxin monitoring data will be considered in pre-RPAR review of those phenoxy herbicides potentially contaminated with TCDD

in evaluating exposure and other risks that may be associated with the continued use of those herbicides with potential dioxin contamination. And this is, after all, the purpose of the RPAR process and the goal of our pesticide regulatory authority.

POST-SYMPOSIUM RESPONSES TO QUESTIONS SUBMITTED TO CAROLYN OFFUTT

RESPONSE to question on the possible carcinogenicity to TCDD.

Studies have been conducted on the possible chronic effects of 2,4,5-T and other pesticides potentially contaminated with TCDD. Under the regulations for registration, reregistration, and classification of pesticides, 40 CFR Section 162.11(a)(3)(ii)(A) provides that a rebuttable presumption shall arise if a pesticide "incudes oncogenic effects in experimental mammalian species or in man as a result of oral inhalation, or dermal exposure . . ." Section 162.3(bb) defines the term oncogenic as "the property of a substance or a mixture of substances to produce or induce benign or malignant tumor formation in living animals."

A Notice of Rebuttable Presumption against the continued registration of 2,4,5-T was issued on April 11, 1978. On the basis of scientific studies and information summarized in the position document supporting that notice, the agency concludes that the herbicide 2,4,5-T meets or exceeds the risk criterion for oncogenicity. Although there is concern that oncogenicity and carcinogenicity are related, the Notice of Rebuttable Presumption only addresses the oncogenic potential of 2,4,5-T registered products.

RESPONSE to several questions on the burning of forests and brush sprayed with 2,4,5-T.

Dr. Logan Norris of the Forest Service indicated that very little TCDD would be produced if brush sprayed with 2,4,5-T were burned 3 months after spraying—the 3-month period to allow for dessication in preparation for burning. In some areas burning is delayed for several growing seasons after 2,4,5,-T application for best burns. The possibility of TCDD production in burning would be less with less 2,4,5-T residue remaining in the brush.

RESPONSE to a question on soliciting human milk samples through organizations such as Citizens Against Toxic Sprays (CATS).

We share the concerns about the selection of donors for the human milk monitoring program. The study was not designed to include strong pesticide critics in the collection phase, and the Citizens Against Toxic Sprays (CATS) have not participated in the selection of donors. However, members of CATS have not been eliminated from the volunteer donor pool merely due to their affiliation with that group.

RESPONSE to comments about Ken Shifferd's statemments on dioxin in human milk in Oregon and 2,4,5-T in football players in Florida.

A recent study (R.C. Dougherty and K. Piotrawska, *Proc. Natl. Acad. Sci.* USA, 73:1977, 1976) was conducted at Florida State University to develop a screening procedure for organochlorine residues in humans by applying negative chemical ionization (NCI) mass spectrometry to human urine extracts. The study qualitatively identifies NCI mass spectra of urine extracts of a number of students. including members of the swimming and football teams, and postulates possible structures for the various ions. One of the proposed ion structures is derived from 2,4,5-T.

Preliminary analyses of human milk samples by researchers at Harvard University indicate the possibility of low levels of dioxin contamination. However, those preliminary results cannot be confirmed because of insufficient sample media. The study undertaken by EPA to determine whether detectable levels of dioxin are present in human milk should provide further data on this subject.

RESPONSE to a question on the relationship of use-patterns of herbicides, possible exposure to people, and presently tolerated levels of TCDD in 2,4,5-T.

The relationship of the use of 2,4,5-T and possible human exposure to 2,4,5-T and TCDD is discussed in detail in the newly released 2,4,5-T RPAR position document.

RESPONSE to several questions on the Dioxin Monitoring program at EPA.

The Dioxin Implementation Plan was developed in 1975 as a cooperative effort of EPA, USDA, Dow Chemical, and the Environmental Defense Fund to resolve some of the scientific issues regarding the continued registration of 2,4,5-T and other pesticides potentially contaminated with dioxin.

Under Phase I of the Plan an analytical method was developed for dioxin analysis in the range of 10 parts per trillion. The goal of Phase II is to determine actual levels of dioxin in the environment. This information will be used in evaluating human exposure and other risks from dioxin-contaminated materials, as part of the intensive scientific review of 2,4,5-T currently being conducted under the RPAR process.

RESPONSE to question on symptoms of dioxin exposure in humans.

We are aware of no documented cases of adverse effects from human exposure to dioxin which did not also include the occurrence of chloracne.

OTHER REFERENCES:

Langer, H. G., T. P. Brady, and P. R. Briggs. Formation of Dibenzodioxins and Other Condensation Products from Chlorinated Phenols and Derivatives. *Environmental Health Perspectives*. 5:3-7. 1973.

Stehl, R. H. and L. L. Lamparski. Combustion of Several 2,4,5-Trichlorophenoxy Compounds: Formation of 2,3,7,8-Tetrachlorodibenzo-p-dioxin. *Science*. September 2, 1977. p. 1008-1009.

Ahling, B., A. Lindskog, B. Jansson, G. Sundstrom. Formation of Polychlorinated Dibenzo-p-dioxins and Dibenzofurans during Combustion of a 2,4,5-T Formulation. *Chemosphere* No. 8 p. 461–468. 1977.

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MS. WINE: We are adding to the program a paper presented by DR. FREDERICK KUTZ, who is the Acting Chief, Ecological Monitoring Branch, Technical Services Division in the Office of Pesticide Programs at EPA.

Dr. Kutz wil discuss human and environmental monitoring for herbicides used in forestry. He has been the author of numerous articles on pesticide residues in the environment and the food chain.

DR. KUTZ.

HUMAN AND ENVIRONMENTAL MONITORING FOR HERBICIDES USED IN FORESTRY

Frederick W. Kutz

To effectively regulate the use of pesticides, it is quite important to have some knowledge of the extent to which man and the environment are exposed to pesticides. Knowing the relative distribution of pesticides in the environment, coupled with laboratory test data showing possible harmful effects, is an essential element in pesticide regulation.

Monitoring man and the environment for pesticides is the responsibility of the Ecological Monitoring Branch. The branch operates five national pesticide monitoring programs. These programs sample air, urban soil, surface water, estuarine organisms, and human tissues, all collected on national probability designs and analyzed for a broad range of pesticide residues.

On several occasions, the branch has also operated or assisted with special monitoring studies, such as examining the general population of the Southeast for Mirex residues or monitoring air for ethylene dibromide and dibromochloropropane.

Among those compounds which are routinely detectable are a number of herbicides used in commercial forestry. It should be emphasized here that ambient monitoring activties detect the environmental exposure from all uses of pesticides and that usually exposure from discrete usage patterns is rarely identified. Positive detection for some of these herbicides has been recorded from the human, air, and surface water monitoring programs.

NATIONAL HUMAN MONITORING PROGRAM

The National Human Monitoring Program is designed to determine on a national basis the incidences, levels, and exposure to pesticides of the general population. This program, which has been analyzing human adipose tissue for pesticide residues for several years, has recently begun examining human urine and blood serum as part of a cooperative program with National Center for Health Statistics of the U.S. Public Health Service. Along with other pesticide residues the urine is analyzed for the herbicides 2,4-D, 2,4,5-T, silvex, and pentachlorophenol.

This program is scheduled for completion in late 1979 with an expected 7500 samples to be collected. Presently, some 400 samples have been analyzed. The frequency of 2,4-D, 2,4,5-T, and silvex has been extremely low or detected only in trace amounts. However, nearly 85 percent of the samples have shown quantifiable amounts of pentachlorophenol, a constituent of many wood preservatives and also a contact herbicide.

These are only preliminary results and of course are subject to change as more samples are analyzed. However, these data do indicate that a portion of the general population is being exposed to this class of pesticide.

AIR MONITORING PROGRAM

Air probably represents a major transport pathway for the movement of pesticides from target to nontarget areas. This presents an important route of exposure to pesticides for the general population.

From 1970 to 1972 the air monitoring program collected ambient air samples from selected agricultural sites. Fourteen States were sampled in 1970 and 16 States in 1971 and 1972. A number of esters of 2,4-D and 2,4,5-T were detected.

These data suggest that potential for exposure to airborne pesticides does exist. The air program has recently shifted emphasis from agricultural to suburban areas, and several years of continuous monitoring are necessary before firm conclusions about airborne levels are defined.

NATIONAL WATER MONITORING PROGRAM

The National Surface Water Monitoring Program is responsible for determining levels of pesticides in surface water and bottom sediments for the major drainage basins of the United States. The program is operated jointly with the U.S. Geological Survey.

A total of 153 sites are located around the country and are sampled quarterly. The program began in 1976, and since that time residues of 2,4-D and 2,4,5-T have been detected on several occasions.

Since this is a relatively new project, it will be several years before specific residue trends can be seen. However, these early results do indicate that these pesticides find their way into the major river ecosystems of the country.

EPA PESTICIDE MONITORING RESPONSIBILITIES

1. OPERATE NATIONAL MONITORING PROGRAMS
   - HUMAN
   - SOILS AND CROPS
   - SURFACE WATER
     COOPERATIVE PROGRAM WITH U.S. GEOLOGICAL SURVEY
   - AIR (PILOT PROGRAM FOR FY 76)
   - ESTUARINE FISH AND SHELLFISH
   - OCEAN FISH
     COOPERATIVE PROGRAM WITH NOAA
2. CONDUCT SPECIAL ENVIRONMENTAL MONITORING STUDIES
3. DEVELOP AND ADMINISTER THE NATIONAL PESTICIDE MONITORING PLAN (SEC. 20, PL 92-516)

PHENOXY HERBICIDE RESIDUES DETECTED IN VARIOUS ENVIRONMENTAL MEDIA

Herbicide Name	Percent Positive	Arithmetic Mean (Concentrations in ng/m^3)	Maximum Value
	Air[1]		
2,4-D, Butyl	0.77	0.1	59.6
2,4-D, BOEE	10.53	4.1	205.2
2,4-D, Isopropyl	2.55	0.4	67.3
2,4,5-T, BOEE	0.49	0.1	43.0
2,4,5-T, Isooctyl	0.49	0.4	160.9
Dacthal	0.49	<0.1	2.1
Trifluralin	4.01	0.1	30.3
	Water[2]	(Concentrations in ppb	
2,4-D	0.36	<0.1	1.91
2,4,5-T	0.04	<0.1	0.85
Silvex	0	—	—

[1] Based on the analysis of 2479 ambient air samples collected between CY 1970 to CY 1972.

[2] Based on the analysis of 2500 whole water samples collected between FY 1976 to FY 1978.

OCCURENCE OF PESTICIDE-RELATED PHENOLIC RESIDUES IN HUMAN URINE[1]

Residue Name[2]	Percent Positive	Arithmetic Mean (PPB)	Maximum Value (PPB)
Pentachlorophenol	84.8	6.3	193.0
3,5,6-TC-2-P	16.1	<5.0	31.7
2,4,5,-TCP	1.7	<5.0	32.4
Para-Nitrophenol	1.7	<10.0	113.0
Silvex	0.2	<5.0	3.2
2,4-D	0	—	Trace
2,4,5-T	0	—	Trace
Dicamba	0	—	—

[1] Based on the analysis of 416-418 samples collected from the general population via the Health and Nutritional Examination Survey II, National Center for Health Statistics

[2] Limits of Detection Range from 5 to 30 PPB

POST-SYMPOSIUM RESPONSES TO QUESTIONS SUBMITTED TO FREDERICK KUTZ

QUESTION: With regard to the positive findings you reported, were any confirmatory studies done to validate that these chemicals were actually present? What was the validated sensitivity of the methods used for each chemical? The extremely low incidence of so-called positive samples certainly cannot be equated to widespread contamination of streams in the U.S. PCP may be present as a metabolite of HCB, not from use of PCP.

ANSWER: Chlorophenoxy residues in human urine are identified by gas-liquid chromatography with an electron capture detector on two columns. The limits of detectability for the compounds reported at the symposium are as follows: 2,4,5-T—10 ppb, 2,4-D—30 ppb, PCP—2 ppb; silvex—5 ppb. All quantifiable residues in one out of every five samples are confirmed by a Hall electrolytic conductivity detector. The procedures for the detection of these chlorophenoxy compounds were reported in the Journal of Agricultural and Food Chemistry, Volume 21, Number 2, page 295, March/April, 1973.

Concerning the water data presented, the positive samples from rivers of the United States were detected using gas-liquid chromatography with a Hall detector; all but one of the positive detections were confirmed by combined gas chromatography-mass spectrometry.

The water monitoring program is, as stated in our presentation, a relatively new program. Before any comments concerning widespread contamination of U.S. rivers can be made, we feel it is necessary to collect several years worth of data. At that time we might possibly be able to make a statement concerning residue trends and contamination in U.S. river systems. I don't believe that we indicated that the distribution could be characterized as widespread.

In addition to exposure from wood preservative and contact herbicide usage, we realize that pentachlorophenol may be present in humans as a metabolite of hexachlorobenzene or lindane. Our data reflect total human exposure from all sources and uses of PCP.

QUESTION: How do you reconcile your findings on 2,4,5-T and silvex with those of Dougherty reported by Shifferd?

ANSWER: We are aware of Dougherty's work at Florida State University; however, we feel there are some major differences between our ongoing study and that which was reported by Dougherty and Piotrowska, "Screening by Negative Chemical Ionization Mass Spectrometry for Environmental Contamination with Toxic Residues: Application to Human Urines," *National Academy of Scenice, U.S.A.*, Volume 73, Number 6, June 1976.

Dougherty's work involves the development of a new methodology for the detection of toxic compounds. He applies this method to human urine and proposes possible structures for the compounds found. However, his work is developmental in nature, and there may well be compounds involved in his study other than those for which structures are proposed. The sample population from which urine samples were collected was a much smaller, confined group.

The analytical methodologies used by our program involves a multiresidue technique for the determination of low levels of halo- and nitrophenols in urine, as reported by Shafik, Sullivan, and Enos, "Multiresidue Procedure for Halo- and Nitrophenols: Measurement of Exposure to Biodegradable Pesticides Yielding these Compounds as Metabolites," *Agricultural and Food Chemistry*, Volume 21, Number 2, March/April 1973. The method is based on electron-capture-gas chromatography of ethyl ether derivatives of the phenols. The use of these two varying methods may have some impact on the results.

Also, the sample size and collection locations are quite different. Our report gave preliminary results (400 samples) from an ongoing program for which a total of 7500 samples are expected to be collected in Florida, Louisiana, and California. Since these are only preliminary results, we feel it is inappropriate to compare them at this time. However, these early results would indicate that a portion of the general population is being exposed to this class of pesticide.

How extensive or widespread this exposure is cannot be determined until the study is completed.

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PANEL DISCUSSION

MS. WINE: I would imagine that we have some questions on the individual presentations that have developed in the panelists' minds. I will start with Dr. Zweig. Did you have specific comments you wanted to discuss at this time?

DR. ZWEIG: I would just like to make some comments. Jim Witt raised a point on impurities that he thought that the agency had taken a stand on 0.1 percent impurity to be significant as far as impurities are concerned in pesticide products.

Reading the guidelines, which have not been published but will be coming out shortly for comments by the public, I find a number in there, 0.01 percent, and so this is, I believe, the only time a number is mentioned.

I know that the specific number was a subject of many debates and discussions because, as rightly pointed out, if the impurities had been set at 0.1 percent, we never would have found TCDD.

To be realistic, one should have a number which would not entail the type of sophisticated analyses which Carolyn (Offutt) pointed out which have been used for the implementation of TCDD.

I imagine the reason I am on this panel is that the audience may want to hear a little bit about what the new requirements are. Dr. Blair pointed out that the requirements for environmental studies have become more expansive during the past 10 years, and he is entirely correct. However, I would say that, again agreeing with my colleague, Dr. Wells, the reason for the expansion in test requirements is one that we actually know more about, the movement of pesticides; and, therefore, we can ask more intelligent questions we weren't capable of asking maybe 10 or 20 years ago.

Those of you who have been in pesticides on the other side, let's say in industry or at the university for a number of years, remember that it was 1970 when at that time the Department of Agriculture, which was responsible for the registration of pesticides, came out with a PR notice called 70–15, and it was at that time that suddenly for the first time it was put down on paper the type of environmental studies and tests that would be required for the future registration of pesticides.

Since that time on we have been living sort of on an ad hoc basis and this has been now formalized as promised many years ago and as mandated actually by the bill in 1972, so that we have now come to the point where the guidelines are just about ready to be published after they have been commented on by the USDA. They will, hopefully, then be published in the Federal Register, this very popular daily newspaper that many of you subscribe to. It makes highly thrilling reading. But they will be published in there, and there will be a comment period.

I would just like to say that the basic principles underlying these guidelines for the environmental chemical requirements are pretty much what Dr. Freed was trying to state in rather academic terms: that we are trying to establish the movement of pesticides, and these guidelines are supposed to be guides as to what type of experiments the agency would like to see and would like to recommend that the registrant undertake in order to bring in results which will somehow show the movement and the fate of pesticides which are laid down, let's say, in forests or on crop land.

And, again, possibly, this is maybe looking into the future more than looking into the past, although the same type of guideline requirements in all probability will be used for the generic standard system.

A unique feature of the guidelines will be a so-called "conditionality." That means not all environmental tests would have to be performed for all uses. There would be little sense if a pesticide were recommended for greenhouse use that we would have to have an aquatic study done. The pesticide is used for other purposes, for direct aquatic use obviously an aquatic study would have to be performed.

The purpose of the conference here is the forest environment. That is a complex terrestrial-aquatic environment. We have a number of requirements that we will be asking for those pesticides which will be registered where a use will be recommended for forest purposes, and I am talking about all pesticides, that is herbicides, insecticides, and other pesticides. And basically the type of test—I will just read them to you—again, you are probably familiar with those mentioned by Dr. Freed.

Hydrolysis studies, photodegradation. My personal view of photodegradation, and we are inviting your comments on it, probably in a forest environment is maybe minor because it is shaded out. The soil may be shaded out, but still this is a requirement.

Aerobic soil metabolism and aerobic aquatic metabolism, the effect of microbes on pesticides. A field ecosystems study, which could entail a study of the effect of the pesticides on microbes themselves, leaching, and field dissipation in water.

Absorption experiments and fish accumulation. This is sort of a general shopping list and you can see it is rather comprehensive, and it may be costly to an extent; and yet, it is one of the requirements that we must know from a scientific, from a social point of view, from a public health point of view, and also from the point of view of safety to wildlife, where these pesticides go, how fast they dissipate, and into what type of metabolites or other type of degradation products they might form.

I believe that is all I have to say now. Obviously, I would like to answer any questions that may be coming from the audience.

MS. WINE: Dr. Streisinger, do you have some remarks?

DR. STREISINGER: I would like to make a brief remark now and perhaps more later. One point was raised by two of our previous speakers, I believe, Dr. Cranmer and Ms. Offutt.

Dr. Cranmer presented calculations on the basis of previous TCDD exposures in the old days when the 2,4,5-T samples were supposedly very dirty. You, I believe, Ms. Offutt, suggested that there was a thousandfold improvement, is that what you said, in the cleanliness of samples, three orders of magnitude?

MS. OFFUTT: Yes.

DR. STREISINGER: So the question is: need we worry now when things are so much cleaner than previously? So I am a little concerned because data I have seen vary a little bit from the ones you have heard. Let me quote from an article which appeared in the *Environmental Health Perspectives,* Volume 5, 1973.

> The best estimates on dioxin content in past samples of 2,4,5-T come from an extensive survey of approximately 15 million pounds, 200 samples, conducted by the U.S. Air Force. Of the 200 samples of Herbicide Orange, 136, or 68 percent, contained 0.5 parts per million or less of TCDD.

You remember, people referred to thousandfold differences. Looking at the actual data, one can see that more than 50 percent of the samples had less than .25 parts per million and only three samples out of the 200 analyzed had levels of TCDD that were higher than 10 parts per million. So my conclusion, in fact, is that the samples of the old "Agent Orange" were not extremely different, the majority of them, than present-day samples. There may be better results I am not familiar with.

MS. OFFUTT: I did not say that because of any reduction that has occurred that we need not worry. I would like to correct that on the record now. I would like to indicate that there were samples analyzed of drums of Herbicide Orange which is 50 percent 2,4,5-T, 50 percent 2,4,-D. There is no tetradioxin contribution from the 2,4-D. The analyses indicated about 43 parts per million, which would, therefore, in a 50/50 mixture be over 80 parts per million in the 2,4,5-T.

I am not saying all were that way. I am just saying that the manufacturing and the distribuion of 2,4,5-T did include dirtier samples than currently are available.

I understand your concern, but I would like to set the record straight that there were samples analyzed as much as 80 parts per million.

DR. KIMBROUGH: I think, if you review the literature in general, that most of the TCDD levels were lower, particularly after the period 1970. Some of the products that had these very high TCDD levels may have come from a company that closed either in 1970 or 1971 and are not the products of the producers that supply now most of the 2,4,5-T.

The other question that I have and that I have sort of belabored with members of the EPA is that TCDD is present in other products as well, and we always concentrate on 2,4,5-T, and we say that 2,4,5-T causes all of the problems with TCDD, but I don't think we really know that because 2,4,5-trichlorophenol contains TCDD and hexachlorophene, which is made from that, also may contain very low concentrations of TCDD. We don't know what happens to the higher chlorinated benzodioxins in the environment. Woodburning was mentioned earlier. That was done in the laboratory. We don't know whether this would happen in the environment. We had an accident in a plant in New Jersey recently which had large stocks of PCB's, and we tried to analyze to see whether we could find chlorinated benzopyrines. We didn't find any, so it is possible this doesn't occur in the environment.

I would like to make a few remarks on some of the things said earlier. One was that there was a tolerance level for kepone in fish. There was an X level, not a toelrance level. I don't know whether you understand the difference between tolerance level and X level. The X level is not something that is really permitted as a level in food. It just happens to be in the food, and the Food and Drug Administration decides that perhaps a concentration of less than 0.1 parts per million over a short period of time may be permissible, but they would never set this as a tolerance level.

The other thing brought out was that aflatoxins are more carcinogenic than TCDD. I think if we review the data becoming available, we will find that TCDD is probably in some animal species at least as carcinogenic as the aflatoxins.

RESPONSES TO QUESTIONS FROM ATTENDEES

QUESTION: Dr. Cranmer, do you know of any authenticated cases of birth defect (human or animal), sterility, death, or serious illness related to 2,4,5-T or 2,4-D normally in forestry use?

DR. CRANMER: No. I might expand on that a little bit. I have made an effort to try to find documented cases of that. In addition, we did an epidemical study in Arkansas, not with forests but with the use of 2,4,5-T in the State, and examined the birth defect records including cleft palate back for, I believe, 40 years, and we were not able to associate the introduction or the use of these herbicides with cleft palate. I must hasten to add that just because one observes a cleft palate as a birth defect in a mouse, one does not presume that would be expected in humans. Anyway, the answer is no.

MS. WINE: Jim, did you have questions that you wanted to direct to the speakers? I don't have any other questions from earlier this afternoon.

DR. WITT: No.

MS. WINE: Next we have Dr. Logan Norris, and we have a couple of questions for you, but I will first give you an opportunity to comment on the papers that you have heard.

DR. NORRIS: I guess I will pass commenting on most of the papers other than to reemphasize a point made by almost everyone that spoke, and I guess that speaks to its importance—and that is the concept of evaluating hazard on the basis of consideration of both toxicology as well as probability of exposure. To make a general comment, and I think then I will pass, there has been a substantial amount of research done with 2,4,5-T, TCDD, and some of the other herbicides used in forestry. In fact, comment was made this morning by Mr. Johnson, I believe, that some of the so-called overregistrations are short on data.

I guess that is maybe true for some materials. I don't believe that is true for the phenoxy herbicides which are rapidly accumulating probably one of the largest bodies of literature of probably any of the modern-day pesticides.

MS. WINE: Let me ask a couple of questions from the floor that were directed to you, if I might.

QUESTION: This morning, Dr. Cutler mentioned that fish hatchery incident in Oregon, and there was a question from the floor if herbicides were to blame for the incident or if you have more specific information on the incident?

DR. NORRIS: I am familiar with the incident. In fact, I was asked to investigate the incident by the Oregon State Department of Forestry. It is almost always rather difficult to come into an incident and try to look back and determine with great accuracy what happened. You end up probably dealing with probabilities.

When we assessed the evidence available from that incident, which I think he said 7000 fish died—these are little guys this big—it amounts to 10 pounds of fish, maybe. You get a different perspective on the magnitude of the incident.

When we looked at the evidence available, we found that there was in a water sample, that was taken during the time the mortality was occurring, about a little more than a part per billion of herbicide in that water, which was, we understand, the toxicology of that material in aquatics is not sufficient to cause mortality in that species.

When those fish were examined chemically for residues in their tissues by the Oregon State Department of Agriculture, they failed to detect measurable residues with an acceptable method and with a level of sensitivity that was adequate for the job.

The only thing that I could conclude from that, from investigating the site and the incident, was that herbicides could not be clearly implicated as being involved in the fish mortality.

In fact, I considered it rather unlikely that they were; but also because we came into the incident after it occurred, it also meant that they could not be positively ruled out. My professional judgment, based on my experience from working in the field, is that the likelihood that herbicides were involved is rather low.

MS. WINE: There was another question here directed to you, Logan, concerning spray and burn with 2,4,5-T.

QUESTION: Is it equivalent to spraying with 2,4,5-T with the dioxin content of 1.6 parts per million almost three times the median concentration used in Vietnam, how can you just spray and burn?

DR. NORRIS: I am not sure I followed all the numbers. I guess, first of all, spray and burn is a management tool that management decides whether they wish to use as a tool or not. I think your regular question is: Does the use of 2,4,5-T as a dessicant prior to burning of land constitute some type of toxicologic hazard that is not acceptable? The implication of the question is that perhaps there is some tetrachlorodioxin that is produced as part of the combustion process. There are laboratory experiments that will show this, that it is possible for the reaction to take place when relatively high concentrations of herbicide are present under the right combustible conditions.

The test that most nearly resembles outdoor burning, if you wish to call it that, shows that a relatively small amount of 2,4,5-T may be converted to tetrachlorodioxin.

The point is that the production of that on-burning requires the presence of 2,4,5-T, and we have substantial amounts of residue data from 2,4,5-T that exists in forest vegetation at various times after application has been made. Using the conversion factors that have come from the laboratory experiments, coupled with the residue levels of 2,4,5-T that occurs in vegetation at various intervals after application, say, 1 month and 3 months after application, when burning might logically be done after a spraying has taken place for dessication, I find that the level of TCDD that would be produced is in the neighborhood of 5 to 15 parts per trillion which is in the same order of magnitude as the level of TCDD that would have been applied with the herbicide initially.

To get to the question of whether that is toxicologically significant, you must consider both the nature of the exposure and the toxicology of the compound. I don't want to speak to the toxicology, but let's talk about exposure.

An organism must come in contact in order for it to be taken up and exposure to occur. Areas that are burned are not habitable areas. Vegetation is unlikely to be consumed by animals, so I think that the probability of organism exposure to any TCDD which might be produced on combustion, I would consider to be fairly small. That is a long answer to the question.

The bottom line, at least in my estimation, is that it doesn't pose an unreasonable hazard.

MS. WINE: Thank you. Mr. Menzie, would you like to discuss how the studies are going to help the Fish and Wildlife Service in protecting endangered species, et cetera?

MR. MENZIE: That is rather loaded.

MS. WINE: It is a loaded question.

MR. MENZIE: It is not a difficult one. EPA and the Fish and Wildlife Service have had interaction on this particular problem—ongoing interaction. The problems are continually being discussed, and at this point in time I don't really see that there is a serious problem from the standpoint of the rare and endangered species as long as we continue to talk to one another about it.

There are areas where use of herbicides would destroy habitat that is necessary for preservation of some species, particularly birds. These areas have been avoided through consultation between the two agencies. Is there a specific question, perhaps?

MS. WINE: We haven't got one yet. We probably will have a specific question shortly.

Dr. Kimbrough, did you have anything further that you would like to add on the papers?

DR. KIMBROUGH: Something that we forgot to mention is the biodegradation of TCDD. There is a lot of conflicting information available on that, and I guess it depends on whether it is exposed to light or whether youn find it somewhere inside the soil. We had an episode in Missouri where TCDD as a waste product got into the environment, and that is another source of TCDD that was not mentioned.

The concentrations that we sort of left behind in Missouri were between 0.5 and 1 part per million in soil. We measured this in '74 and went back in '76, and there was still the same amount of TCDD. Now, we tried to get back to exactly the same areas, which is very difficult to do in these types of epidemiological studies, but the TCDD was mixed with an oil. There was PCP in the mixture. There was also trichlorophenol. Whether the presence of all the other compounds and the soil had something to do with the persistence of TCDD in those particular areas is something we also don't know, and maybe Dr. Kearney has comments on that.

MS. WINE: Bill?

DR. KEARNEY: Thank you. I think we have been looking at rates of degradation of TCDD and the herbicide silvex in a microecosystem. It is a terrestro-microecosystem in which we could measure a number of parameters, i.e., the amount that moves off the soil into the air, the amount that moves from the plant surface into the thatch, degradation time of each component.

I don't think we have changed much of the concepts developed in the early '70's based on these new experiments. We have more precise measurements. We are down in femtogram range. We can measure concentrations 10 to the minus 15 grams.

It still remains a persistent molecule under certain conditions. Incorporated into the swill, it doesn't seem to break down rapidly. Dr. Calvin at the University of California suggested as a method of decontamination we might want to look at the possibility of fortifying the job to see if we could accelerate the degradation process. Those experiments are underway now in which we have flooded swills and then supplemented them with carbon sources such as sewage sludge or manure, high in microbial activity and various components.

Right now our indications are that these are very inconclusive. We haven't seen anything yet that accelerates it over a 2-month period, and I am not optimistic we are going to be able to do this. I do think we need to know more about the metabolism of this compound. We have some evidence in the vapor phase in the air that there is photolysis, vapor-phase photolysis, and this appears to be substantial depending on the conditions.

Obviously, the scientists are studying hard the vapor-phase phenomena as well as vapor phase in general, contaminated surface, and materials in the one to three to see if they can lower concentrations. We need more information on the biodegradation of the materials.

MS. WINE: Dr. Meselson, you had a paper you wanted to read.

DR. MESELSON: Yes.

MS. WINE: Dr. Zweig, in the guidelines we have reentry registrations for the agricultural worker. They want to know why there are no reentry guidelines for forestry workers—tree planters—who often have to enter replanted sites. Are those in the guidelines?

DR. ZWEIG: Yes. In the present draft the reentry requirements are not included for forestry use. However, even the reentry guidelines for other crops are not very well defined, because at this moment we still don't know exactly the kind of questions we are asking.

I think the only one that we can define in any way is possibly dislodgeable residues, but even having those, I think the toxicologists do not know how to relate dislodgeable residues to reentry dates.

For the present time—in the present draft—and this is not cast in concrete, look for it in the Federal Register. The consensus was to leave out the reentry requirement for pesticides for forestry use.

THE EVALUATION OF POSSIBLE HEALTH HAZARDS FROM TCDD IN THE ENVIRONMENT

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For several years we have been developing and applying methods for the measurement of TCDD (2,3,7,8-tetrachlorodibenzo-*p*-dioxin) in the environment (1,2,3). TCDD is present as a contaminant in certain pesticides, including the herbicides 2,4,5-T and silvex (4). Although the concentration of TCDD in these chemicals is very low, the great toxicity of TCDD and its possible accumulation in the environment make it advisable to determine how much TCDD is reaching various human populations and what exposure level might reasonably be considered hazardous to man.

The analysis of animal fat and milk is of particular interest because TCDD concentrates preferentially in lipid components of the body. Our current method for determining TCDD in fat and milk uses neutral extraction, four steps of column chromatography, and analysis by high resolution mass spectrometry (3). Before extraction a known amout of the ^{37}Cl heavy isotopic isomer of TCDD that we synthesized for this purpose is added to each sample to serve as an internal standard. The great specificity and sensitivity of high resolution mass spectrometry make it especially well suited to the measurement of low levels of TCDD. Figures 1 and 2 show examples of TCDD peaks as they are recorded by the mass spectrometer at the two TCDD mass/charge ratios which we routinely use for analysis, m/e = 319.897 and m/e = 321.894. In an individual mass spectrometer run the amount of TCDD is determined by measuring the height of one or the other of these peaks relative to the height of the peak from the internal standard at m/e = 327.885 (not shown).

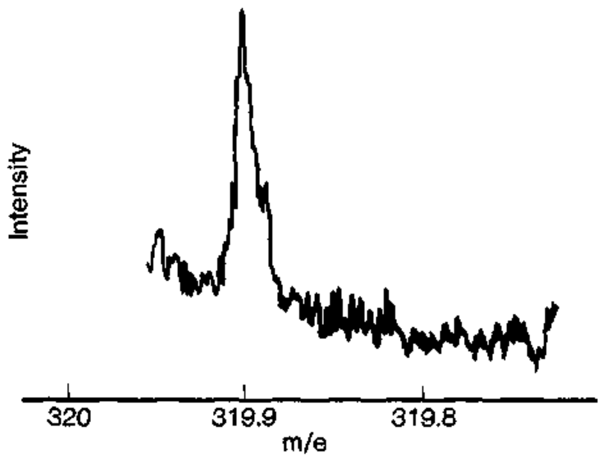

FIGURE 1. Beef fat 1 gram sample 13 PPT TCDD.

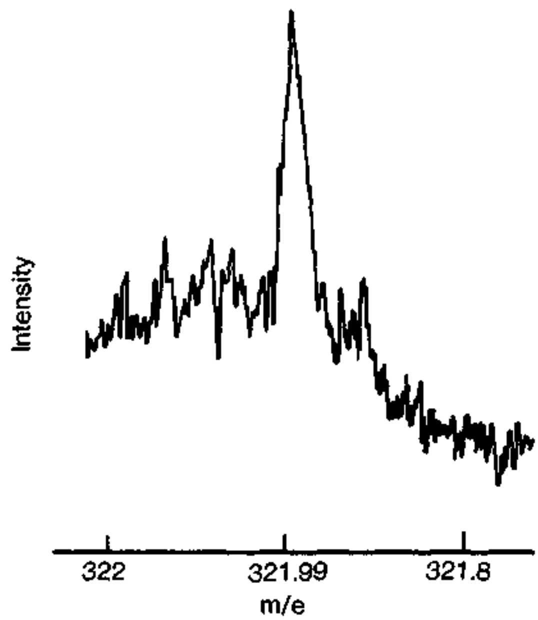

FIGURE 2. Bovine Milk 15 gram sample 0.7 PPT TCDD

Figures 3 and 4 show the results of analyzing samples of beef fat and human milk containing various amounts of added TCDD, submitted to us by the Environmental Protection Agency and the Food and Drug Administration in order to test the sensitivity and accuracy of

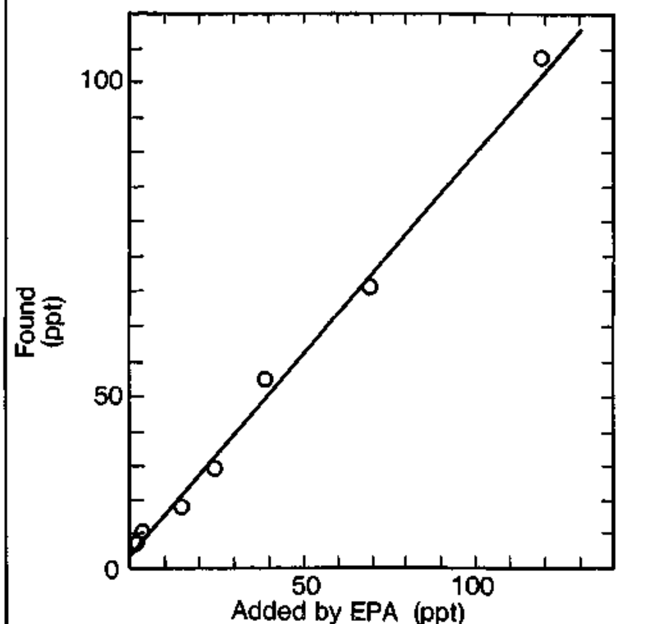

FIGURE 3. TCDD in beef fat.

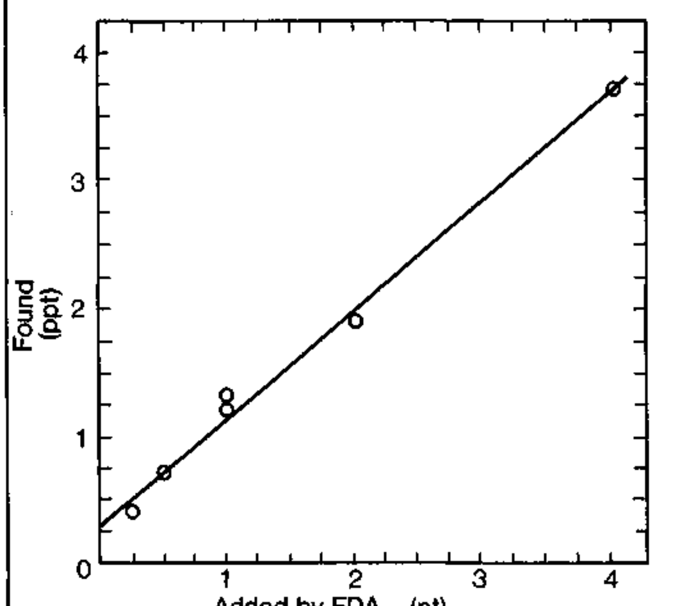

FIGURE 4. *TCDD in human milk.*

the analytical method. No TCDD above the limit of deduction imposed by background noise in the mass spectrometer was found in control samples without added TCDD. As may be seen, the relation between added and measured TCDD levels is very close to linear over the entire range tested. TCDD was detected when added at levels as low as 2 parts per trillion (ppt) in beef fat and 0.25 ppt in human milk. However, near these limits, the measured amount of TCDD exceeded the amount added by a factor of up to three, an effect we are presently examining. Although analytical methods for TCDD have improved enormously over the last several years, further refinements are underway to permit accurate measurements at even lower concentrations and to provide improved discrimination among the positional isomers of TCDD, some of which may be present in the environment in addition to the 2,3,7,8 isomer (5,6).

As part of the initial phase of an effort by EPA to monitor TCDD, analyses have been done by a number of laboratories on fat from cattle grazed on 2,4,5-T–treated rangeland in Kansas, Missouri, Oklahoma, and Texas and from cattle grazed on untreated land. We received for analysis by our current method 14 samples from the 2,4,5-T group and one control. The samples were selected to include several which had been reported to contain TCDD by other laboratories.

We found TCDD in 11 of the samples from treated rangeland but none in the control or in beef fat samples from a Cambridge, Massachusetts, market. The four samples with the highest levels were found to have 70, 24, 20, and 12 ppt, respectively. The overall results of our analyses and those of others participating in the study were summarized by EPA in June 1976, as follows:

> Of the fat samples (85) analyzed, one shows a positive TCDD level at 60 ppt; two samples appear to have TCDD levels at 20 ppt; five may have TCDD levels which range from 5–10 ppt. While several laboratories detetced levels (5–10 ppt) in this range, the values reported were very near the sample limits of detection. There exists a great deal of uncertainty of the analytical procedure below 10 ppt.

This interim summary needs a little clarification. Actually, the number of beef fat samples was 89, of which 68 were from the 2,4,5-T group and 21 were controls from unsprayed land. No consistent finding of TCDD was reported for the controls, of which 17 were analyzed at a sensitivity of 10 ppt or better, 10 of them by more than one laboratory. Only 25 samples from the 2,4,5-T group were analyzed at a sensitivity of 10 ppt or better by more than one laboratory. Among these 25 there were nine samples for which two or more laboratories reported positive TCDD levels, one sample at *ca.* 65 ppt. two at *ca.* 20 ppt, and six in the range *ca.* 5–20 ppt. This ignores positive results obtained by low resolution mass spectrometry since they are unreliable. If one employs somewhat less stringent criteria for including samples in the tally, while still excluding low resolution positives, there are several more samples for which TCDD levels of *ca.* 5–30 ppt were reported plus numerous ones in which TCDD was not detected. Since June 1976 EPA has accumulated more data, and it is to be hoped that this and the data on which the 1976 statement were based will be released before much longer.

There appears to be a significant association between the use of 2,4,5-T and the positive TCDD analyses of beef fat. This is not altogether unexpected at the application levels used, *ca.* 1 lb 2,4,5-T/acre with ca. one head of cattle per 2 sprayed acres and assuming there was about 0.1 part per million (ppm) TCDD in the 2,4,5-T. Under these conditions the accumulation of a few ppt of TCDD in beef fat would correspond to only a small percentage of the amount applied per head. Nevertheless, it is possible that at least some of the TCDD came from now-discontinued industrial operations in Missouri known to have released TCDD into the environment. More analyses of samples from carefully chosen locations may be needed to settle this point.

Meanwhile, we have taken a different and possibly more direct approach to estimating human exposure to TCDD, through the analysis of human milk. This can provide a measure of the level of TCDD intake of the individual. In a preliminary study we analyzed milk samples from 18 women living in areas where 2,4,5-T is used on rangeland or in forestry and six women from the Boston area. We found four positive samples (with about 1 ppt each) in the former group and none in the latter. This possible association with the use of 2,4,5-T does not involve a large enough number of samples to be statistically significant. Nevertheless, it has led us in collaboration with the National Institute of Environmental Health Sciences to initiate a somewhat larger study, which includes blanks and calibration samples interspersed among the samples from 2,4,5-T areas. Analyses for TCDD in mother's milk on a still large scale are being undertaken by the EPA using samples from women living near sprayed forests in the Pacific Northwest.

As estimates become available for the level of human exposure to TCDD, more accurate information will be needed regarding the level of chronic exposure which may be toxic. The EPA has attempted to estimate levels below which there is unlikely to be any detrimental effect in man, using laboratory data from long-term feeding of TCDD to rats. This use of long-term exposure data is important because there are indications that the toxic effects of TCDD may be extraordinarily cumulative (7). However, the rat is not a very appropriate species for making extrapolations to man. It is relatively insensitive to the lethal effect of TCDD when compared with other species such as the guinea pig and, more importantly, the rhesus monkey.

It is already clear from a 9-month feeding experiment that the lethal level for chronic TCDD exposure in monkeys is less than 500 ppt in the diet, possibly much less (8). If TCDD toxicity were completely cumulative in the monkey, the lethal chronic dietary level could be about 20 ppt. Toxicity of a different nature at even lower levels is suggested by a report that TCDD can be carcinogenic to rats at dietary levels as low as 5 ppt (9). Although there is no evidence that anyone in the U.S. is receiving this much TCDD on a steady basis, it is customary to set the permissible level of human exposure to toxic substances very much below the levels found to be lethal or carcinogenic to laboratory animals. Thus, considering the range of uncertainty in both the level of human exposure and the level which might be toxic, it cannot yet be said whether or not current environmental exposure to TCDD poses a serious, widespread hazard. However, progress in analytical methodology and in understanding the toxicology of TCDD is continuing and, if efficiently exploited, should provide a greatly improved perspective on the TCDD problem before much longer.

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MS. WINE: There were a number of questions directed to Dr. Kutz that can be answered later, and there were some for you, Dr. Freed, if you will address them again in the meeting after we leave here.

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POST-SYMPOSIUM RESPONSES TO QUESTIONS SUBMITTED TO RENATE KIMBROUGH

QUESTION: Please respond to Dr. Meselson's paper. Does the presence of TCDD in a few selected samples of beef represent a threat to the American people if herbicides are used properly?

ANSWER: In the United States analysis of beef fat samples collected in Missouri, Oklahoma, and Kansas revealed measurable levels of TCDD in a certain proportion of the samples. All but two TCDD levels reported were below 50 parts per trillion. Although the beef samples were collected from animals that grazed in areas where 2,4,5-T was applied, no detailed information on these beef samples is available. It is not known what the TCDD concentration was in the 2,4,5-T used on the ranges. It was not established whether TCDD contamination of the soil existed prior to the application of the herbicide, nor is it known whether the animals had been exposed to other chemicals which might have contained TCDD, or whether they would have been exposed to industrial waste material such as contaminated salvage or fuel oil in which TCDD was present. Hazardous chemical waste material, if improperly disposed, represents a tremendous threat to human health and our environment. This is very well illustrated in two articles which I recommend for further information on this subject. One is entitled: "Illicit dumping of hazardous chemical wastes poses serious health and safety problems," *Chemical Week Report,* March 8, 1978. (See also: "Waste disposal: It's a dirty business," *Chemical Week Report,* March 1, 1978.) The other is one of many episodes the Center for Disease Control was involved in which was published in *Science* 188:738–740,, 1975, and *Arch. Environ. Health* 32: 77–86, 1977. Sewage sludge from sewage treatment plants may be an additional source of hazardous chemical wastes. In order to determine whether the present concentration of TCDD in 2,4,5-T presents a hazard and would appear in the food chain, appropriate experiments would have to be conducted to determine this. This has so far not been done. However, if TCDD were continuously present in most of our food at these concentrations, it would represent a health hazard.

QUESTION: Many chemicals contain TCDD as you reported. Wouldn't it be a mistake if EPA bans 2,4,5-T because TCDD is found in the environment? 2,4,5-T as currently manufactured and used in the USA does not pose a threat to man or his environment. Let's forget Vietnam.

ANSWER: Before 2,4,5-T with the present low levels of TCDD is banned, it should be determined whether TCDD in these very low concentrations will enter the food chain. No measurable amount of TCDD, however, should be permitted to enter the food chain, and TCDD from other sources should also be controlled. Recent results obtained in animal toxicology studies indicate that levels below the present limit of detection for TCDD would not be safe if all of our food were contaminated with TCDD. Although not much information on the presence of TCDD in food is presently available, it is likely that most of our food is not contaminated with TCDD.

QUESTION: Has CDC investigated reports of birth defects from 2,4,5-T use? If they have been investigated, what are the findings?

ANSWER: No independent investigation was done by CDC. The agency reviewed data from Vietnam and concluded that it was not interpretable.

POST-SYMPOSIUM RESPONSES TO QUESTIONS SUBMITTED TO LOGAN NORRIS

QUESTION: Many thousands of people 60 miles west of your home breathe for many days smoke from units triggered with 2,4,5-T and then burned. Are you aware of this? Have you monitored the air?

ANSWER: I know that some units treated with 2,4,5-T are later burned and those in the area are likely to breathe some of the smoke. I have not personally monitored the air from this type of operation to determine the level of either 2,4,5-T or TCDD.

QUESTION: The data of Stehl and Lamparski (1977) predict that "spray and burn" with 2,4,5-T might be equivalent to spraying with 2,4,5-T with a dioxin content of 1.6 ppm, almost three times the median concentration of 2,4,5-T used in Vietnam. How can you justify spray and burn?

ANSWER: The previous two questions do not specifically so state, but I believe the concern relates to the possibility that combustion of 2,4,5-T and 2,4,5-T-treated materials may result in the production of significant quantities of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin. The comparison between "spray and burn" as done in forestry and the dioxin content of 2,4,5-T used in Vietnam is preposterous.

In laboratory experiments it is possible under special conditions to produce TCDD on heating or burning 2,4,5-T-treated materials. The probability of significant production of TCDD in the field from burning, however, is vanishingly small. The amount of TCDD produced is dependent on the amount of 2,4,5-T which is present, and current research shows more than 90 percent of the 2,4,5-T applied to the forest is gone in 30 days. Therefore, unless burning occurs within the first 30 days after application, no increase in TCDD levels over the initial level after application is expected to occur. The probability of fire occurring within 30 days of treatment in areas treated with 2,4,5-T is remote. Based on the detailed analysis below, I do not believe the possibility of thermal production of TCDD on burning areas sprayed with 2,4,5-T is sufficiently high to warrant serious concern.

There are several questions involved when considering the probability and consequences of TCDD production from combustion of 2,4,5-T. The first question deals with the formation of TCDD from the combustion of 2,4,5-T. The second question deals with the quantities of TCDD which might be produced from burning areas treated with 2,4,5-T. A third question considers the possible environmental implications of this TCDD production.

1. Is it possible to produce TCDD on heating or burning of 2,4,5-T or 2,4,5-T-treated materials?

ANSWER: Yes, in laboratory tests. The conditions of combustion and herbicide concentration are crucial. The tests reported by Baughman and others show TCDD formation when 2,4,5-T is heated in a closed container under alkaline condition such that the sodium salt of trichlorophenol is a significant degradation product. The amount of herbicide employed in these tests was very high. Langer et al., (1973) showed control of the decomposition reaction to produce trichlorophenol was necessary since heating above the decomposition point (300°C) produced no TCDD. Concentration of herbicide is very important because the formation of TCDD is apparently a bimolecular reaction; that is, it requires the joining together of two molecules of sodium 2,4,5-trichlorophenate. If conditions of heat and alkalinity are conducive to the condensation of the phenol to form TCDD, then the extent of condensation varies with the number of molecules available to interact with one another. This is most easily explained by analogy. Take two 50-gallon barrels and place 10 small lead pellets in one and 1000 lead pellets in the other. Close the lids and shake each barrel for 5 minutes and count the number of times that two pellets collide in each barrel. Obviously, there will be more collisions in the barrel with 1000 pellets than there will be in the barrel with only 10. Formation of TCDD results from the interaction (collision) between two molecules of sodium 2,4,5-trichlorophenate.

Experiments like those of Baughman and others are useful only to show that thermal production of TCDD is chemically possible. Experiments which use closed systems and high concentrations of 2,4,5-T drastically overestimate the levels of TCDD which might be produced in burning situations in the field because (a) the concentrations of herbicide are several times greater than the levels of 2,4,5-T which occur in the field and (b) heating is prolonged and uniform, but combustion does not actually occur. Temperatures at which thermal decomposition of TCDD occurs (800°C) are not attained in these test situations. Actual burning will result in temperatures near those used in laboratory tests only briefly. As temperatures approach 800°C, thermal decomposition of TCDD will also occur. When combustions can take place with a free exchange of air, temperatures above 1200°C are common. Under these conditions we expect complete oxidation of all carbon compounds including 2,4,5-T, trichlorophenol, and TCDD.

For these various reasons I conclude the laboratory studies of the thermal production of TCDD from 2,4,5-T maximize TCDD production and minimize the opportunities for its dissipation. Laboratory studies, then, will vastly overestimate the level of TCDD production which might occur in the natural environment.

2. How much TCDD is produced when 2,4,5-T is burned?

ANSWER: There are only limited experimental data. Watts and Storher (1973) noted burning and heating of such 2,4,5-T-treated products as vegetation, meat, and fat did not produce detectable tetrachlorodioxin. The sensitivity of their analysis was not adequate, however, to detect environmentally important quantities of TCDD. Present methodology with sensitivities that approach 10 parts per trillion is sufficient.

The most pertinent data comes from a laboratory experiment in which grass treated with 2,4,5-T at 12 pounds per acre was burned under conditions marginally resembling those which might occur in the field (Stehl and Lamparski, 1977). Their study showed an approximate 0.00016 percent conversion of 2,4,5-T to TCDD. This involved a semi-closed system, however. Thus, any TCDD which might normally have been lost to the air as vapor or adsorbed on smoke particles in forest burning was captured and retained in this system.

The amount of TCDD produced is dependent on the concentration of 2,4,5-T in the vegetation. Studies by Norris, et al., (1977) of the persistence of 2,4,5-T in Oregon forests shows levels of herbicide and calculated levels of TCDD (Table 1) which might be produced by burning, assuming the conversion ratio reported by Stehl and Lamparski holds in this case.

TABLE 1—2,4,5-T residues on vegetation (measured) and TCDD (caluclated) that might be produced on burning vegetation[1]

Months after Application	2,4,5-T[2] (ppm)	Possible TCDD level if burning occurs at time indicated (ppt)
0	95.	152.
1	9.1	14.
3	0.10	0.16
6	0.07	0.11
12	0.01	0.02

[1] Assumes 0.00016 percent percent conversion of 2,4,5-T to TCDD (Stehl and Lamperski, 1977).

[2] From Norris et al. 1977.

Clearly the amount of TCDD produced depends to a major degree on when burning occurs after treatment. Burning which takes place from 1 to 3 months after the application may result in TCDD levels of 14 and 0.2 parts per trillion, respectively. In some brush types, burning is delayed for 12 months or more. Immediately after application the level of TCDD present on the vegetation is approximately 10 parts per trillion, assuming the 2,4,5-T contained 0.1 parts per trillion TCDD. Research of Getzandaner and Hummel (1975) and Crosby and Wong (1977) indicates the TCDD originally applied will be largely gone within 1 month of the application. Therefore, the levels of TCDD which might be produced by burning are not expected to substantially exceed TCDD levels present as a result of the original application of herbicide.

A forest fire could conceivably occur at any time. However, they are most likely to occur during the driest parts of the year. These do not usually coincide with periods when 2,4,5-T is sprayed for vegetation control. Unless a forest fire occurs within 1 month of herbicide application, the possible TCDD production from burning would be less than that calculated for the case where 2,4,5-T is used as a preburn desiccant.

3. What are the implications of possible TCDD production on the burning of 2,4,5-T treated vegetation?

ANSWER: Toxic hazard from TCDD requires that the organism receive exposure to toxicologically significant quantities of the chemical. A substantial amount of toxicology has been done on TCDD. In a recent 13-week feeding study (Kociba et al., 1975), 0.01 micrograms of TCDD per kilogram of body weight per day did not affect rats. Assuming these animals consume 10 percent of their body weight per day in food, the no-effect dosage level in this experiment is equivalent to 100 parts per trillion TCDD in the diet. The calculated possible levels of TCDD in forest vegetation immediately after treatment with 2,4,5-T (about 10 parts per trillion) is only one-tenth of the established no-effect level in this study. If burning occurs 1 month after spraying, the concentration of TCDD which might be produced is still approximately one-tenth of the no-effect level. However, there are several factors which operate to further reduce the probable exposure levels. Areas which are burned do not make favorable habitat for animals. Therefore, animals are not likely to be present in such areas for any significant period of time. The burning required to produce TCDD destroys the vegetation that would have to be consumed if ingestion of the combustion products is to occur. Burning produces charcoal which is a highly effective adsorbent for TCDD and is likely to prevent dermal absorption and reduce or eliminate absorption in the intestine.

TCDD uptake by ingestion and dermal absorption as a result of burning 2,4,5-T-treated vegetation is unlikely (even if substantial quantities of TCDD are produced on burning). Inhalation is the only other probable means of exposure. The production of TCDD by burning is associated with the rapid heating, expanding, and rising of air mass. TCDD in that air mass will be dispersed and greatly diluted, thereby minimizing the exposure for individual organisms.

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QUESTION: Can you comment on the incident at the Gnat Creek Fish Hatchery in Oregon, which Dr. Cutler referred to in his speech this morning. Were herbicides to blame? Are herbicides such as 2,4,5-T likely to be found in streams in biologically significant quantities following forest applications?

QUESTION: What level of herbicide was found in samples taken at the time of the death of the fish from the Gant Creek Fish Hatchery? Are data available for exposure of similar fish at OSU?

ANSWER: Both of these questions refer to an incident of fish mortality which occurred at the State of Oregon, Department of Fish and Wildlife hatchery at Gnat Creek in northwest Oregon. This hatchery raises winter steelhead trout and had a population of about 475,000 fingerlings (about 750 fish per pound) at the time of the incident. Herbicide spraying which took place a relatively short distance upstream from the fish hatchery is alleged to have been the cause of the fish mortality.

As is true for most instances of this kind, some visual observations and a few pieces of hard data are available, but they do not provide a direct answer to the question "Did the chemical brush control project cause fish mortality?" The hard data, the literature, and my experience are the bases upon which I have evaluated the incident and reached my conclusions. The following is a summary of the observations and hard data.

May 11—143 acres (Figure 1) were treated with 2 pounds per acre each of 2,4,-D and 2,4,5-T in 10 gallons of spray carrier per acre. The specific formulation was Dow's Esteron Brush Killer. An orientation flight was made with a representative from the State Department of Forestry prior to the application of herbicide. They noted no water visible from the air in Unit VI.

May 15—0.6 inches rain in 24 hours ending at 9:00 a.m. Unusual behavior and mortaility noted on May 15. One hundred fifty dead fish were counted at 5:00 p.m.

May 16—0.2 inches rain in 24 hours ending at 9:00 a.m. Fish tanks were vacuumed on this day and 1500 fish collected. The cleaning operation collects both dead fish which float (floaters) and those which sink (sinkers). The 1500 fish collected in the cleaning operation on May 16 therefore reflect fish which died on May 15 as well as May 16.

May 17—0.4 inches rain in 24 hours ending at 9:00 a.m. Three hundred dead fish counted (floaters) at 5:00 p.m. A water sample containing 0.4 ppb/2,4-D[1] was collected at the outfall from one of the six tanks in which mortaility was occurring. A sample, taken at about the same time from a small tributary within the spray unit, contained 1.8 ppb 2,4-D and 7.2 ppb 2,4,5-T. A water sample taken from Gnat Creek at the water intake site showed no detectable levels of 2,4-D or 2,4,5-T.

May 18—No rainfall in the previous 24 hours. Fish tanks were cleaned again. Fish mortality was 5000. The 5000 fish represent a large number of sinkers which may have died any time between 5:000 p.m. on the 16th and 5:00 p.m. on the 18th.

A pathologist examined the dead fish and reported no obvious signs of disease or parasitism in the dead fish. The Oregon State Department of Agriculture analysis of dead fish from the Gnat Fish Hatchery did not find detectable residues of 2,4-D or 2,4,5-T. The minimum

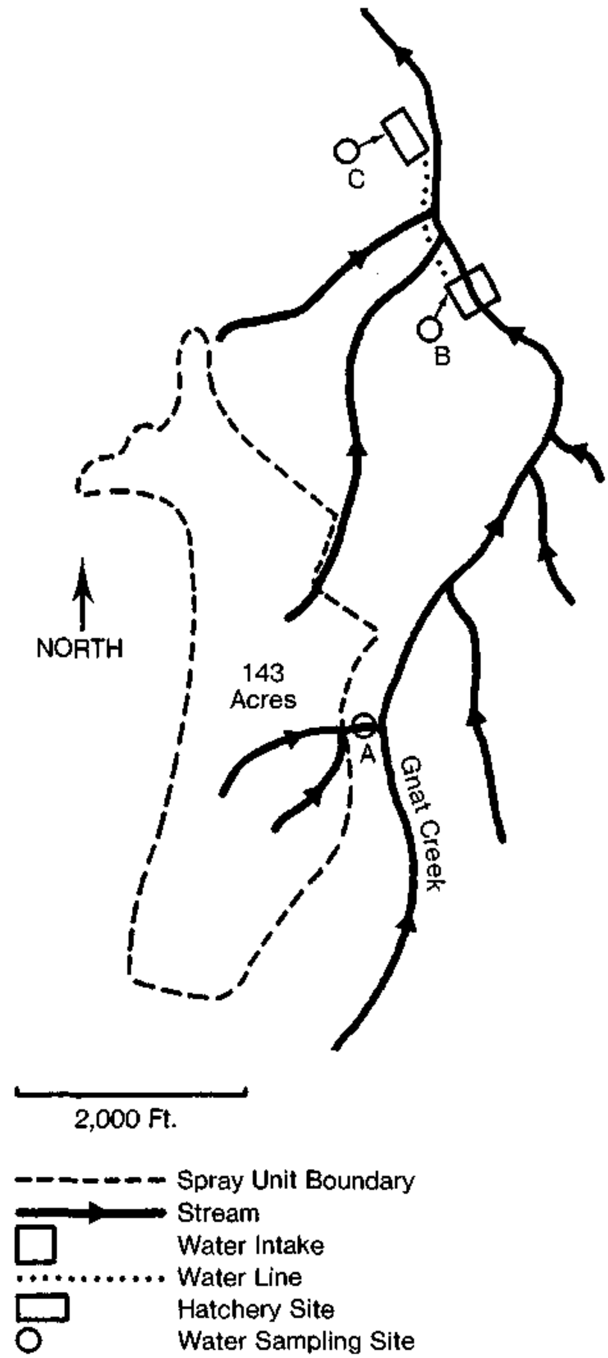
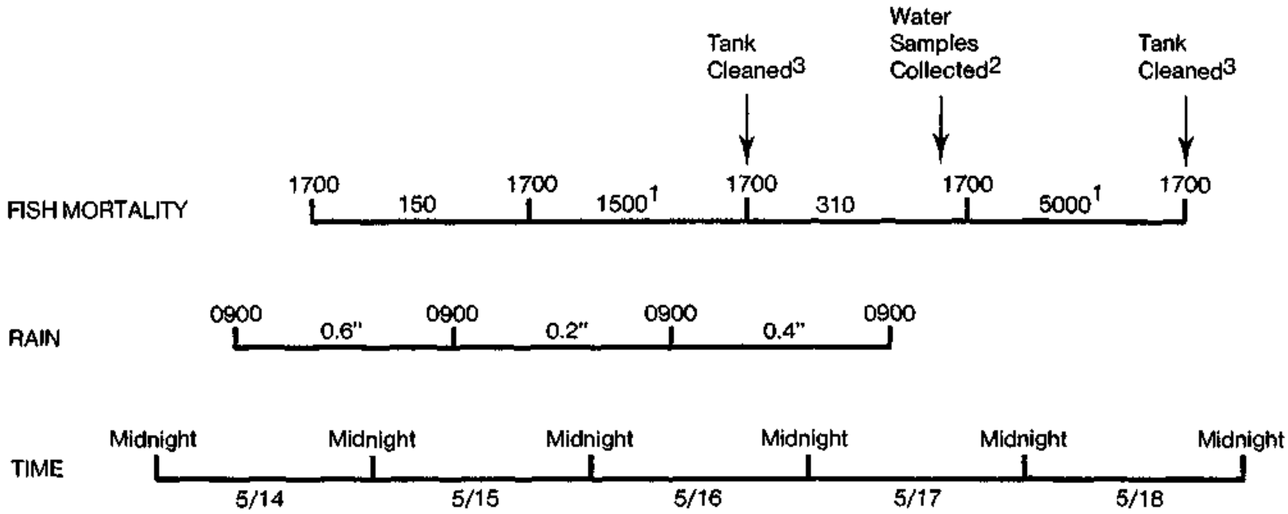


FIGURE 1. SPRAY UNIT, STREAMS AND GNAT CREEK FISH HATCHERY.



[1] Includes floaters (dead fish that float) for one day and sinkers for 2 days.

[2] Water Sample	Location	Date	Time	Herbicide, ppb 2, 4-D	Herbicide, ppb 2, 4, 5-T
A	In Spray Unit	5/17	1600 Hrs.	1.8	7.2
B	Gnat Creek at Water Intake	5/17	1600 Hrs. (Approx.)	0	0
C	In Hatchery	5/17	1600 Hrs.	0.4	0.05

[3] Dead fish did not contain detectable herbicide residues (<0.01 ppm).

FIGURE 2. Schematic of events at Gnat Creek Fish Hatchery during May 1977 fish mortality incident.

limit of detection was 0.01 ppm. Figure 2 shows the patterns of precipitation, fish mortality, and water sampling.

The Research Division of the Oregon State Department of Fish and Wildlife conducted a bioassay of winter steelhead fry from the Big Creek hatchery (near Gnat Creek) and the same herbicide formulation which was applied to the area upstream from the Gnat Creek Hatchery. Following a 48-hour acclimatization to the test tanks, fish were exposed to the toxicant on May 31, 1977. The percent survival of various exposed steelhead fry is in Table 1.

One steelhead fry died at nominal concentration of Esteron of less than 800 ppb during the 96-hour exposure. At the two high concentrations, no mortalities occurred during this 24 hours, but 50 percent of the group exposed to 1200 ppb died between 24-48 hours of exposure. The 96-hour LC_{50} for steelhead trout fry on the basis of this test would be about 1 ppm.

Some of the fish exposed to herbicide were analyzed for whole body residues (Table 2). Data in Table 2 is conclusive. Fish exposed to sufficient 2,4-D and 2,4,5-T in water to cause death will have measurable residues of these herbicides in their bodies.

After inspecting this site, studying the data, and consulting with the fish toxicologist, I reached the following conclusions.

CONCLUSION: The herbicide cannot be discounted as contributing to the fish mortality, but the probability of its involvement is extremely low. The evidence for and against herbicide involved is listed below.

TABLE 1—Survival of Big Creek winter steelhead fry exposed to Esteron (Fairplay Laboratory, OSU, Corvallis) May 31-June 4, 1977

Nominal Concentration (ug/liter)		Exposure time (h)	Percent survival (range)
Control	(60)[a]	96	100.0
1	(60)	96	100.0
7	(60)	96	100.0
25	(60)	96	98.3 (100–96.7)
75	(60)	96	100.0
150	(60)	96	100.0
450	(60)	96	100.0
800	(60)	48[b]	88.3 (100–76.7)
1200	(63)	48[b]	50.8 (80–24.2)

[a] Total number of fish exposed in replicated tanks under static conditions.

[b] Test tanks set up June 2 in a.m.; exposure initiated in p.m.

TABLE 2—Herbicide residues in winter steelhead fry exposed to Esteron Brushkiller in water.

Exposure (nominal) Water ppb	Time hours	Fish Condition	Residue 2,4-D (ppm)	Residue 2,4,5-T (ppm)
75	96	Live	0.9	1.9
150	96	Live	41	44
800	48	Live	20	26
800	48	Dead	64	60
1200	96	Live & clearance [1]	8	8
1200	48	Dead	165	100

[1] Fish placed in clean water for 48 hours before being sacrificed for chemical analysis.

FACTORS WHICH INDICATE HERBICIDE WAS INVOLVED

A. Location and time of herbicide application made it physically possible for herbicide to enter the hatchery system.

B. The fish mortality occurred coincidentally with heavy rains. The rain could have mobilized herbicide in and around the ephemeral stream channels in the spray unit, resulting in herbicide in the water supply for the hatchery.

C. Herbicide residues were (0.4 ppb 2,4-D) in the hatchery water during the time fish were dying. Although 0.4 ppb herbicide is not a toxic concentration, the levels could have been higher earlier.

D. Disease, parasites, temperature, and turbidity do not appear to be factors in the mortiality.

FACTORS INDICATING HERBICIDES WERE NOT INVOLVED

A. Herbicide residue levels measured in the hatchery are not toxic to fish. Water sample B collected at the water intake contained no detectable herbicide; however, stream dilution would have reduced the concentration of herbicides from sample Point A, so it would not be detectable at B. The residence time of water in the line from Gnat Creek to the hatchery is about 6 hours, so residues in sample C reflect conditions in Gnat Creek at least 6 hours earlier. Presence of residues in sample C, but not in B, indicates herbicide residues in the water were transitory.

B. Fish and Wildlife Service research with an Esteron 2,4-D formulation shows a no-effect level at 40 ppb in very young cutthroat trout exposed *continuously for 60 days.* Dilution potential in moving from the spray unit into Gnat Creek is at least 40 to 1 (20 cfs in Gnat Creek vs. an estimated 0.5 cfs in the stream in the unit). Dilution with downstream movement in Gnat Creek is at least 40 to 1. Therefore, if the small tributary in the spray unit (sample point A) had at one point an herbicide concentration of 1000 ppb (higher than measured in Oregon in 15 years), the concentration in Gnat Creek would be 25 ppb which is less than the no-effect level for cutthroat trout. If an additional 40 to 1 dilution occurred with downstream movement, the concenration at the hatchery would be 0.6 ppb.

C. The lack of measurable herbicide residues in dead fish argues strongly against herbicide as a causal agent of death.

D. Fish mortality occurs periodically in the course of hatchery operations. Gnat Creek Hatchery personnel related other incidences of fish mortality resulting from hatchery operations paint, zinc pipes) which were more extensive than the mortality which occurred in this incident. Failure to find other causative agents besides temperature, turbidity, parasites, or disease does not automatically assure that herbicide was the cause of death.

To put this incidence in perspective, the total of approximately 7500 fish which died in this incident represented less than 2 percent of the hatchery population and weighed a total of 10 pounds. Hatchery personnel felt that the magnitude of this incidence would have absolutely no impact on productivity of the hatchery.

* * * * *

(Whereupon, at 4:45 p.m., the symposium was recessed, to reconvene at 8:30 a.m. the following day, February 22, 1978.)

SECOND DAY PROCEEDINGS START

Barry Flamm, Moderator

8:30 a.m.

MS. WINE: Good morning. At the conclusion of yesterday's presentation we had a panelist, Dr. Matthew S. Meselson, who presented a paper. DR. GEORGE STREISINGER waived his time in the afternoon to allow Dr. Meselson an opportunity to give his remarks.

We are going to start this morning with Dr. Streisinger, remarking on yesterday's proceedings briefly, and then go into today's program. DR. STREISINGER.

ASSESSMENT OF HAZARDS POSED BY TCDD

George Streisinger

Attempting to assess hazards posed by herbicides is especially important because of their widespread use. Dr. Cutler introduced this subject during his opening remarks to this Symposium and raised two key questions: What are the levels of human exposure, and what risks may be incurred due to those levels?

It is surprising that these central questions have received so little attention during this Symposium. I would like to discuss possible hazards posed by TCDD (2,3,7,8 tetrachlorodibenzo-*p*-dioxin), a contaminant of the herbicide 2,4,5-T.

That human exposure to TCDD is likely is demonstrated by the results of the EPA-sponsored environmental monitoring program. Ms. Offutt and Dr. Meselson commented on some of the data at this Symposium: as indicated by Dr. Meselson, about one-third of the samples of fat from beef cattle grazing on rangeland treated with one pound or more of 2,4,5-T were found to contain TCDD at concentrations of from 5 ppt (parts per trillion) to 65 ppt. The average level of TCDD in the beef fat of *all* the animals from treated rangeland is of the order of 10 ppt. TCDD levels have also been measured under the auspices of the EPA in animals collected from the Siuslaw National Forest in Oregon (see Worthington, 1978). About 15 percent of the samples were found to contain TCDD; the mean level in all animals examined (including those in which no TCDD was detected) was about 10 ppt, and the values ranged from 12 ppt to 143 ppt.[1]

Do these levels pose a hazard to humans? Since the toxicity of TCDD to humans has not been determined, hazard can only be estimated from animal studies. In assessing the hazard, it is essential to consider the following factors:

1. The effects of TCDD are additive in monkeys over long periods of time. Allen (1967) fed groups of monkeys diets containing various low levels of TCDD.[2] The monkeys fed with the lowest levels died after 445 days, the ones fed higher doses died after shorter periods, and the time of death after a short initial period was *exactly proportional* to the dose. The exact proportionality suggests that any dose of dioxin is harmful if the monkeys are exposed long enough. Dr. Allen's initial results have been confirmed by more recent experiments performed both by Dr. Allen and Dr. McNulty.

2. Individual animals vary greatly in their sensitivity to TCDD. Among a group of monkeys receiving identical chronic diets with 500 ppt of TCDD, some monkeys were acutely ill or dead late in the study while others appeared essentially normal.

In setting levels of hazard for humans it is essential to assume that humans vary with respect to degrees of sensitivity. Since the use of herbicides is extremely widespread, a small proportion of especially sensitive individuals still constitutes a very large total number.

Assuming that the effects of TCDD are additive in humans (as they are in monkeys), hazardous levels need to be defined on the basis of the total amount of TCDD to which individuals are exposed, regardless of the period of time during which that exposure occurs: thus, exposures to low levels, over long periods of time, must be assumed to be the equivalent to higher levels, over shorter periods of time.

In order to determine levels of hazard in quantitative terms, let us assume that exposure to TCDD is exclusively through the diet, and that *some* meals eaten by humans may contain meat from animals which have 10 ppt of TCDD in their fat. A serving of meat is assumed to consist of one-half pound of meat with 20 percent fat. We can then calculate the number of such meals which can be eaten by humans before reaching levels I define as hazardous on the basis of various animal studies.

Table 1 shows the total amounts of dietary TCDD which have been observed to cause death in monkeys, or gross physical symptoms in monkeys (Allen et al. 1977), or reduced weights of the thymus gland in rats (Kociba, 1976) or guinea pigs (Harris et al. 1973). I assume that "no-effect" levels are tenfold lower than this, and set a "no-effect" level for humans 100-fold below that for animals: this safety factor of 100 is included (as is customarily done) to provide for the possibility that humans are more sensitive than monkeys and to provide for the variability that is likely to exist between different individuals. Levels of TCDD are defined as hazardous to humans if they exceed the "no-effect" levels for humans as defined above, and Table 1 shows the number of portions of meat (from animals with a mean level of 10 ppt TCDD in their fat) which can be eaten before reaching the hazard level thus defined.

In these terms the hazard presented to humans can be estimated by calculating the likelihood of eating the indicated number of servings of meat from animals with TCDD in their fat. These calculations need to be performed not only for the mean levels of TCDD to which the entire population may be exposed but also for subpopulations which may be exposed to levels higher than the mean. For instance, among the animals from the Siuslaw National Forest which had detectable levels of TCDD, the mean was 70 ppt with a range of 12 to 143 ppt. If these levels are representative of deer as well (for which no data are available), a fraction of hunters (eating deer meat stored in their freezers) will be exposed to *servings of deer meat with levels of TCDD considerably* higher than used in the calculations on Table 1. Though the proportion of individuals included in this category may be small, the absolute number is likely to be quite large.

In order to discount the possibility of hazard, it is often argued that there are no cases of harm to humans or animals which can be proven to be due to the use of herbicides; the many attributions of human and animal illness to herbicide use are dismissed as being anecdotal. In considering this question, it is important to realize that it is virtually impossible to *prove* that an observed harm is in fact due to pesticides. Consider for instance the loss of 8000 winter steelhead trout at the Gnat Creek Hatchery in Oregon in May 1977 which was already mentioned at this Symposium. On May 9 and May 11 approximately 140 acres of forestry timberland were sprayed with one pound of 2,4,5-T and one pound of 2,4-D per acre, with no buffer strips left along several small tributaries of Gnat Creek. Fish losses at the hatchery began increasing above normal on May 11 and peaked

TABLE 1—Hazardous Dietary Levels of TCDD for Humans

Nature of effect	Approximate total dose of TCDD (in μg per kg) to animal for the observed effect	Total calculated "no effect" dose for a 60 kg human	Maximum number of meals * before exceeding the "no effect" level
Death of monkey	3.4	0.20 μg	408
Gross clinical symptoms, monkey	1.0	0.66 μg	120
Decreased weight of thymus gland, rat or guinea pig	0.65	0.04 μg	78

Meals are defined as containing ½ lb of meat with 20% fat from animals with 10 ppt TCDD in their fat.

on May 17, the periods of peak losses coinciding with rains on May 11 and again on May 15–17. Fish died in each of the six separate concrete ponds at the hatchery. On May 17 water samples were collected from the hatchery and contained 0.4 ppb of 2,4-D and 0.05 ppb of 2,4,5-T. The fish pathologist who examined the fish reported "symptoms similar to a chemical poisoning" (that had occurred a few years earlier) and found "no diseases, parasites, or abnormalities that could have caused the fish loss." Dr. Logan Norris (of the Pacific Northwest Forest and Range Experiment Station), in response to a question at this Symposium, stated as his opinion that the fish kill was not related to herbicide use. Only the most widescale epidemiological studies could provide meaningful evidence concerning actual harm, and such studies have not been performed.

FOOTNOTES

1. The analyses of forest samples may have been performed without sufficient cleanup procedures and thus may be misleading results because of the interference of other compounds. Three samples were reanalyzed in 1976 at both Harvard University and Wright State University; the mean levels of these three samples are: 77 ppt (1974 analysis); 124 ppt (Harvard 1976); 59 ppt (Wright State 1976). These results are in remarkably good agreement, especially when one considers possible inhomogeneities within small samples. Two other samples which were initially positive were only analyzed at Wright State; they were negative. In evaluating these results, it must be kept in mind that many samples which were reported to be negative after the original analyses most likely contained TCDD which could not be measured because of high limits of detection. The mean limit of detection for all samples was 52 ppt, and more than half the samples exhibited limits of detection greater than 15 ppt.

2. The TCDD used in these experiments was in a "toxic fat" preparation. Later analysis of the sample of toxic fat used by Allen demonstrated that tetrachloro-*p*-dioxin was present in this fat in a higher concentration than the sum of all other dioxins (Flick et al. 1973). Baughman and Meselson (personal communication) have reanalyzed the samples used by Allen and confirmed the presence of TCDD.

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Worthington, R. E., 1978. Final Environmental Statement, Vegetation Management with Herbicides, Pacific Northwest Region Forest Service, U.S.D.A. See Exhibit 8, Appendix H, pp H–86 to H–88.

MS. WINE: Thank you, Dr. Streisinger. We are fortunate in having Barry Flamm, the Environmental Coordinator with the Secretary's Office of the Department of Agriculture, to moderate today's program.

MR. FLAMM: Good morning. It is a real honor to be the Moderator on the second day of what I feel is an historic symposium. I think the future of vegetation management will be dated from this point in time. The symposium presents really a huge challenge to all of us, particularly the policymakers and the practitioners, because how we follow up on the symposium is going to really tell whether it was worth the effort. I think—and I know we will.

Yesterday, under Moderator Jan Wine, we talked about the chemical side of herbicide use in forestry. Today we have another outstanding group of panelists and speakers, only today we are looking at it from a somewhat different perspective. We are looking at it from the use side, and you will see quite a bit of emphasis will be placed on alternatives—and we will be looking at objectives in vegetative management rather than just herbicides.

You will see, also, that there are speakers and panelists that view herbicides as an essential and valuable tool in vegetative management. Others of our speakers and panelists will strongly advocate minimum use or perhaps no use at all. So you will hear today a whole spectrum of views on the use of herbicides in forestry. It will, I think, be an interesting day.

Our schedule is extremely tight, and I want to apologize in advance that I will have to just push the program on. This is the first time I have attended a week-long symposium in 2 days. If you think yesterday was busy, today is twice as busy.

To begin with, we have three outstanding speakers to present an overview of the use of herbicides in forestry; first from the perspective of public land management; secondly, from a perspective of industrial ownership; and, thirdly, from a use on the non-industrial forest. We will then break, and for the rest of the day we will be in various panel discussions.

There will be a timber management panel in the morning, and there will be three more panels in the afternoon. In each case our expert speaker will get the ball rolling with no more than about a 20-minute speech introducing the subject and then we hope to have an indepth discussion.

I will try to at least get things going by a lead-off question or two, and then we hope that you on the floor will submit your questions, and we will do our best to answer them. The ones we are unable to answer because of time we will try to get answered for the official record.

To start off this busy day, I think it is quite appropriate that we have as our first speaker the Deputy Chief of the Forest Service in charge of the National Forest System.

Dr. Tom Nelson has a bachelor of science degree in Agriculture from the University of Wisconsin and a master of science degree from Michigan State University and his doctorate from Michigan State University. Dr. Nelson has had many Forest Service assignments. I haven't looked up the record yet, but I think he holds the record for a number of Deputy Chief assignments, and I had the pleasure of working with him on one of the assignments.

After being Director and Associate Chief-Private, he went from Deputy Chief of Programs and Legislation to Deputy Chief of State and Private Forestry and now is in his current position as Deputy Chief for the National Forest System. It is my pleasure to introduce the first speaker, DR. THOMAS NELSON.

VEGETATION MANAGEMENT ON PUBLIC LANDS: *An Overview With Special Reference to Herbicides*

Thomas C. Nelson

This paper presents an overview on the use of herbicides in vegetation management on the National Forests. We think it generally exemplifies management rationale and procedures on all public lands.

The public lands of the United States and their resources are important to everyone. These lands belong to all of us, and all of us should be eager to see that they are managed for the maximum benefit of the general public.

Public lands contribute importantly to meeting the needs of the American people. The Federal Land Policy and Management Act of 1976 provides that public lands be managed in a manner which recognizes the Nation's need for domestic sources of minerals, food, timber, and fiber.

In 1970, 1.6 billion acres, about 69 percent of the Nation's area, was classified as forest and rangeland. Of these acres 66 percent (1.1 billion acres) were rangeland and noncommercial forest land; 31 percent (500 million acres) were commercial forest land; and 3 percent (48 million acres) were inland waters.

As of 1970 about 73 percent, some 365 million acres, of commercial forest land were in private ownership. The National Forest System contained 18 percent (about 92 million acres); other Federal lands contained 3 percent (some 15 million acres) of the total; and the remaining 6 percent was in State, county, or municipal forests.

From the period 1936 to 1970 available data suggest that there may have been a 45.7 million-acre increase in rangeland. However, due to the lack of a common data base and different definitions, it is probable that no real change took place. In recent decades there has been an increase in noncommercial forest land, primarily a result of the establishment of parks, wilderness, and other reserved forested areas. Between the years 1962 and 1970 the area of commercial forest land in the United States dropped by more than 8 million acres and more recent forest survey reports covering years after 1970 indicate the drop is continuing.[1]

It has been estimated that the population of the United States will increase to 362 million people in the year 2020 from the 204.9 million population base in 1970. The increasing population is expected to accelerate the conversion of private commercial forest land to food crop production, and public range and commercial forest land to recreational uses. The demands of the increasing population for outdoor recreation and wilderness, wildlife and fish, forest-range grazing, timber, and water on this shrinking land base can only be met by intensive management. Vegetation management forms the basis for intensive management and is essential if the demands of the increasing population are to be satisfied.

VEGETATION MANAGEMENT OBJECTIVES

Much of the management of public lands is basically vegetation management. Vegetation management is the manipulation of the kinds, amount, quality, or condition of the vegetation resource. This vegetation management may range from complete protection of natural vegetation in botanical areas and research natural areas to intensive management to favor a particular species of plant. Vegetation is a key component supporting natural resource activities such as recreation, timber, range, watershed, soils, wildlife, fisheries, and fire management.

On public lands the objectives of vegetation management vary within and between the different resources. Probably the most complex vegetation management job occurs in the outdoor recreation resource. The types of outdoor recreation areas range from well-groomed public parks, with very intensive management of nonnative vegetation, to areas with mostly native vegetation managed to maintain the esthetic quality of the vegetation and to protect the public from hazards such as poisonous plants and dangerous trees and to areas managed for multiple use where the outdoor recreation resource may be secondary to other uses.

Management of vegetation to enhance the wildlife, fish, and water resources is the primary objective on some areas, while on others it is secondary to forest-range grazing and timber production. Vegetation management primarily to benefit wildlife is done on such areas as wildlife refuges, game winter ranges, and the Kirtland's warbler management area in Michigan. Streamside buffer strips are managed on range and commercial forest land to benefit fish and maintain water quality. Water yields are increased by vegetation management in selected watersheds and the control of stream channel vegetation in areas of chronic water shortage. On forest-range vegetation management is done to increase the livestock–carrying capacity of the range by favoring the more productive native plant species or introducing nonnative species. On most of the rangeland increasing the value of the forage is the primary objective. However, on commercial forest land which is grazed, increasing timber production is usually the primary objective.

On most timber lands enhancement of timber production is the primary objective of vegetation management. Vegetation is usually managed to favor the most productive timber species for the site. And, of course, final harvest of a timber crop is itself a form of vegetation management used to maintain commercial forest land in a highly productive state. A second objective of vegetation management of most commercial forest land is the enhancement of one or more of the other resources. Often this enhancement of other resources is achieved as a byproduct of the timber management objective or modifications of this objective. In some instances timber management may be subordinate to one or more of the other resources.

There are a number of methods used in vegetation management. They may be mechanical, manual, fire, biological, animal grazing, use of genetics, use of a particular species of plant to displace undesirable vegetation, and chemical—the use of herbicides.

[1] Forest Service, U.S. Dep. Agric. 1977. The Nation's Renewable Resources—An Assessment, 1975. Forest Service, U.S. Dep. Agric. Forest Resource Report No. 21: pp. 21–22.

CRITERIA FOR HERBICIDE USE

As a method of vegetation management the use of herbicides is chosen only after careful analysis has shown that it is the most effective or the most economical, or both; and that the herbicide considered is registered by the Environmental Protection Agency for the intended use.

The use of herbicides on National Forest land is controlled by:

Forest Service policy that only those herbicides registered by the Environmental Protection Agency for the planned treatments are used, and label instructions and precautions are followed.

EPA is responsible for the registration and reregistration of all pesticides in the country. This process ensures, based on current scientific data, that registered pesticides, when used according to the label, present no unreasonable risks to human health or the environment.

The Department of Agriculture policy which states that "A principal mission of the Department is to assure an adequate support of high quality food and fiber and a high quality environment for the American people. . . . It (the Department) will select all methods including pesticides for use in its pest management programs on the basis of their appropriateness and relative safety." (Secretary's Memorandum No. 1929)

We use herbicides because they do a better job than other methods of vegetation control. For instance, we choose nonselective herbicides to use on right-of-way brush or site preparation and similar projects.

For release of young conifers or grasses, however, we must depend on selective herbicides. Silvex and 2,4,5-T are two selective herbicides often used as they are registered by EPA.

We use herbicides also because they are cheaper than other methods of vegetation management, although this is not the primary criterion for determining their use.

An analysis made on the Ozark-St. Francis National Forest[2] in Arkansas shows that without herbicides the cost of roadside brush control increased fivefold, i.e., from $18.50 per mile using herbicides, to $100 per mile using hand tool and mechanical methods—the only alternative available. The cost of electric power line right-of-way maintenance done by hand tools increased nine times over the cost of vegetation control with herbicides. The costs of site preparation by hand and mechanical methods increased 50 percent over costs for the same area using herbicides. Additional costs were also incurred because undesirable sprout growth which suppresses planted trees must be controlled. Release and thinning costs more than doubled without herbicide use. Some release work could not be done by hand because the large number of stems created a safety hazard to workers using hand tools. The analysis concludes that forest productivity losses, plus increased costs of doing business on that forest alone, would be in excess of $1 million annually.

In the Pacific Northwest Region of the Forest Service an analysis was made of the impact of not using herbicides on four brush types. These brush types have the potential of occurring on 2,442,000 acres of Forest Service administered commercial forest lands located west of the crest of the Cascade Mountains in Oregon and Washington. If alternative methods are used for vegetation management in these types, there will be a net loss of jobs and timber production. To accomplish the current yearly program in these four brush types by alternate methods, an increase in funding from $6,134,000 to $14,251,000 will be required. Even with this increase in funding, it was estimated that timber yields would decline 110.4 MMBF per year with a net loss of 73 jobs. At current budget levels timber yields were estimated to decline 538.2 MMBF per year, with a loss of about 3750 jobs.

WHERE HERBICIDES ARE USED

Herbicides are used on public lands to manage and control unwanted vegetation in a variety of situations such as:

Control of noxious weeds to improve range conditions. Some of these weeds pose a threat to adjacent private land. If noxious weeds are not controlled on public land, it becomes seed sources from which the noxious weeds may invade adjacent farm and ranch land.

Increase forage production for livestock by managing vegetation to favor the more productive range plants.

Habitat improvement for fish by controlling weeds which choke lakes and waterways.

Release of timber crop trees from competing vegetation in order to improve growth rates.

[2] Forest Service, U.S. Dep. Agric. 1976. Impact of Court Injunction of Herbicides. Ozark-St. Francis National Forest report (unpublished): pp. 1–13.

Thinning of overdense stands of timber to provide optimum growth of crop trees.

Site preparation for planting or seeding to provide optimum growing conditions for new seedings.

Improvement of water yield by manipulation of vegetation. Water yields can be increased or decreased by modifying stand density and species.

Site maintenance around administrative and other structural improvements to enhance personnel safety, esthetics, and to protect from fire and pests (rats, snakes, poisonous plants, etc.).

Improvements of recreation area usability by controlling plants poisonous to people.

Right-of-way vegetative management to improve vehicle travel safety, esthetics, and to reduce maintenance costs.

Maintenance of fuel breaks for fire protection.

Fuel management by replacing a high fire risk vegetation type with a vegetation type having a lower risk.

Seedbed preparation and treatment at tree nurseries to enhance survival and provide optimum growth of tree seedlings.

Seed orchard site maintenance to improve seed yields and to ease of operating equipment.

SOURCES OF CONTROVERSY

About 70 different herbicides are used on the National Forests for various purposes. Among these are the phenoxys 2,4,5-T, silvex, and 2,4-D. These are selective herbicides and are widely used on the National Forests for release and site preparation. The phenoxy herbicides and all other chemicals used in forestry are subjects of interest to some segments of the population and, therefore, newsworthy. There is local opposition to the use of herbicides in Arkansas, California, Oregon, Washington, Michigan, Minnesota, Wisconsin, and elsewhere. At present there are two court injunctions against herbicide applications: One in Arkansas and one in Oregon.

Aerial application of herbicides generates much opposition among the public. Herbicides have been successfully used as aerial sprays to release conifers for many years. About 95 percent of the herbicide applied for all forestry uses in Oregon, Washington, and California is applied by air.

Aerial applications are usually recommended when there are numerous small stems to be treated where roads are lacking or when large acreages must be treated in a short period of time.

The contaminant tetrachlora-dibenzo-p-dioxin (dioxin or TCDD) is produced in the manufacturing process of 2,4,5-T and silvex. It is the source of considerable public worry. The primary concern regarding these herbicides is the fact that TCDD is a highly toxic material. It is reported to be a carcinogen in mammals and to have produced birth defects in laboratory animals. Present production methods are able to reduce the dioxin level to less than 0.1 ppm., making it acceptable under EPA standards for registration.

PROCEDURES FOR CONTROL

Vegetation management on all National Forests is subjected to a strict procedure which becomes even more rigorous when the application of herbicides is contemplated.

On National Forest System lands the need to manipulate vegetation is determined by various types of resource surveys and evaluation. For example, surveys are made on forest lands to determine if a particular deforested area needs site preparation prior to reforestation. Post-reforestation surveys are made usually at the end of the first or second and the fifth growing seasons following regeneration and, in some problem areas, at more freqent intervals. The post-reforestation stocking surveys determine the degree of reforestation success and identify treatment needs of the plantation to maintain stocking and growth of crop trees. The needs of a particular plantation might include release of the crop trees from competing vegetation. The decision that release from competing vegetation is needed is based on the synecological requirements and silvicultural guides for the crop tree species.

When release of plantation is needed, the District Ranger considers alternative methods for controlling the competing vegetation such as manual, mechanical, chemical, fire, or biological. Forest Service policy manuals, guidelines, research, current information, and professional training aid the District Ranger in deciding which vegetation control method to use. If chemical control is selected, a pesticide use project proposal is made and sent to the Forest Supervisor for review. Resource specialists in wildlife, recreation, range, timber, water, and soils are the included reviewers. At times the review team makes field visits to the proposed treatment areas.

For major types of herbicide use a consolidated pesticide use proposal is submitted by the Forest Supervisor to the Regional Forester. In the Regional Office the proposal for using herbicides is checked for its technical correctness against the EPA–registered label and silvicultural and range management guidelines. A member of the Region's Pesticide Use Coordinating Committee makes this review and makes recommendations for consideration by the full Committee. This Committee usually includes individuals representing Programming and Land Use Planning, Office of Information, Safety Officer, Lands and Minerals, Range, Timber, Fire, Recreation, Wildlife, Water, Soils, and Engineering. The regional Pesticide Use Coordination Committee then makes a recommendation to the Regional Forester for approval or disapproval of the herbicide use proposal. For minor types of herbicide uses, not submitted to the Regional Forester for approval, the Forest Supervisor approves or disapproves the herbicide use proposal after considering the recommendations of the Forest Pesticide Use Coordinating Committee.

The approval of the herbicide use proposal by the Regional Forester or by the Forest Supervisor authorizes the staff group concerned to process the proposal in accord with the requirements of the National Environmental Policy Act. It is the objective to have an Environmental Analysis Report written for each project or grouping of projects on similar areas to provide a means for giving environmental impacts careful consideration, as well as providing for State, public, and other agency review during the National Forest's planning and decision-making process. Preparation of the Environmental Analysis Report is a team effort involving resource specialists from the Supervisor's Office and Ranger District. If an Environmental Impact Statement is required, it is prepared by an interdisciplinary team and follows the procedures set forth in the implementation instructions for the National Environmental Policy Act.

Following the completion of the vegetation control project using herbicides, a survey is made by the District Ranger to determine the effectiveness of the application. The results are used to improve subsequent projects.

EXTENT OF HERBICIDE USE

Methods of applying herbicides are: Broadcast spraying by aerial or ground application equipment, injection, hack and squirt, basal stem and cut surface spraying or painting, full coverage spraying of individual plants using backpack sprayers or other types of spray equipment, application of herbicides in granular form on or below the soil surface, injection of liquefied gaseous herbicides into the soil, or placement of this type of herbicide under a sheet of plastic covering the surface of the soil, and ground incorporation of liquid herbicides. Much of the herbicide used on National Forest System lands is aerially applied. The use of aerial application has increased in recent years on National Forest System lands as it has in other areas of agriculture. However, methods not involving herbicides are still used much more extensively.

The following statistics for National Forest System lands are presented to place the use of herbicides in perspective. The data used are for a 15-month period from July 1, 1975, to September 30, 1976. This is a complete fiscal year plus the transition quarter when our record and fiscal year starting date was changed from July 1 to October 1. The table shows the total acres of commercial forest and rangeland and the total miles of roads and rights-of-way. In addition, the number of acres or miles of vegetation management accomplished during the 15-month period are shown, along with the number of acres or miles in each activity that were treated with herbicides.

Only a small area of commercial forest land, rangeland, Forest Service roads, or permittee rights-of-way is treated with herbicides in any one year for vegetation management.

In fiscal year 1976 (15-month period) herbicides, for example, were applied to 158,648 acres for range improvement and silvicultural purposes. This is less than two-tenths of one percent of the commercial forest acres. Actually, all Forest Service use of pesticides (including herbicides) involves less than two-tenths of one percent of the land in the National Forest System.

Many areas do not develop conditions requiring treatments; others, once initial conditions are corrected, should never need retreatment if properly managed. Still other areas may need treatments once or twice in a 40- to 100-year forest rotation cycle.

The increasing intensity of management on public lands has caused an upward trend in the use of vegetation control methods. The trend on National Forest System lands is shown in Table 5.

TABLE 1—Use of Herbicides on Commercial Forest Land F. Y. 1976 (15 mos.) National Forests

Timber ....92,000 acres

Purpose	All Vegetation Treatment (Acres)	Herbicide Treatment (Acres)[3]
Site preparation	398,814	20,635
Release and weeding	218,904	515,575
Precommercial thinning	359,958	10,824
TOTAL	977,676	147,034

[3] Forest Service, U.S. Dep. Agric. 1977. U.S. Forest Service Pesticide Use Report for F. Y. 1976 and Transportation Quarter. Unpublished Forest Service, U.S. Dep. Agric. Report: pp. 1-8.

TABLE 2—Use of Herbicides on Rangeland F. Y. 1976 (15 mos.) National Forests

Range ....100,452,000 acres[4]

Purpose	All Vegetation Treatment (Acres)	Herbicide Treatment (Acres)[5]
Range revegetation	95,000	11,614

[4] Total of commercial forest and range exceeds National Forest area because some commercial forest is also used as range.
[5] Ibid., pp. 21-22.

TABLE 3—Use of Herbicides on Forest Service Roads Rights-of-Way

F.Y. 1976 (15 mos.) National Forests
F.S. Roads ....220,000 miles

Purpose	All Vegetation Treatment (Miles)	Herbicide Treatments (Miles)[6]
ROW Maintenance	35,706	3,429

[6] Ibid., pp. 1-8.

TABLE 4—Use of Herbicides on Permittee Rights-of-Way (Roads-Utilities, etc.)

F.Y. 1976 (15 mos.) National Forests
Permittee Rights-of-Way ......60,310.5 miles

Purpose	All Vegetation Treatments (Miles)	Herbicide Treatments (Miles)[7]
ROW Maintenance	Unknown	13,190

[7] Ibid., pp. 1-9.

TABLE 5—Acres of Vegetation Control Accomplished

F.Y. 1973 to 1976
(F.Y. 1976—Regular 12 mo. Period)

Purpose	Units Accomplished by Fiscal Year 1973	1974	1975	1976
Site preparation	279,318	313,833	312,637	301,393
Release and weeding	132,961	113,629	122,223	173,557
Precommercial thinning	233,639	251,928	323,193	280,750
TOTAL	645,818	679,390	758,053	755,700

ROLE OF RESEARCH

For more than 20 years Forest Service research has had major programs focused on developing appropriate vegetation control measures. One aspect deals with the utilization of herbicides in conjunction with various silvicultural operations to release young conifers from brush and other competition, density control, and to prepare sites for reforestation. The objective of Forest Service research in vegetation management has always been to develop effective, environmentally safe, and economical methods of vegetation control. Past studies have shown a number of herbicides to meet these criteria when applied as directed.

Current studies test new or existing herbicides, compare disking and other mechanical site-preparation methods with herbicides and prescribed-burning, test the use of desirable cover crops to limit establishment of less desirable vegetation, and attempt to develop modified silvicultural practices to limit establishment of less desirable vegetation. A broad-based examination of alternatives for site preparation and release is being considered as a joint study in the Pacific Northwest by the Region and Pacific Northwest Station.

Three new herbicides show promise as effective substitutes for certain uses of 2,4,5-T and silvex: ammonium ethyl carbamoyl phosphonate (Dupont's Krenite), glyphosate (Monsanto's Roundup), and triclopyr (Dow's Carbon 3A). Only Krenite presently has an EPA registration for forestry use.

CONCLUSION

Some form of vegetation management is practiced on most public lands. Vegetation management includes activities such as the control of wildfire to protect existing vegetation, the use of herbicides to release desirable timber crop trees from competing vegetation, the harvesting of mature timber stands to replace them with thrifty young stands, the landscaping of campgrounds, and the removal of poisonous plants.

A very small part of the total vegetation management work is accomplished with herbicides. Where herbicides are considered for use, the potential environmental impacts from the herbicides and alternative methods of vegetation control are weighed and a preferred method selected, based on environmental concerns and benefit/cost ratio.

In the future vegetation management methods other than the use of present day herbicides very likely will be developed to discourage the encroachment of undesirable vegetation but allow desirable vegetation to flourish. This will involve the timely use of all of our best silviculture and range management techniques. The result will be fewer acres treated with herbicides at lower rates per acre.

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6. Forest Service, U.S. Dep. Agric. 1974. The Outlook for Timber in the United States. Forest Service, U.S. Dep. Agric., Forest Resource Report No. 20: 374 pp.

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MR. FLAMM: Thank you, Tom. Our next paper will be presented from the perspective of industrial-private forest management resource management. The paper has been jointly prepared by Dr. William Lawrence and Dr. Jack Walstad.

DR. BILL LAWRENCE has been employed by the Weyerhaeuser Corporation since 1956, first as a wildlife biologist in Centralia, Washington, and then as managing the research laboratory at Centralia. Dr. Lawrence is a graduate of Michigan State University. I don't know if it is a coincidence that Dr. Cutler and the first two speakers are also graduates of Michigan State.

DR. LAWRENCE: I have to set the record straight. It is the University of Michigan, not Michigan State University.

MR. FLAMM: DR. JOHN WALSTAD received his Ph.D. from Cornell. We broke the string here. He began his professional career with Weyerhaeuser Corporation as forest regeneration ecologist in Hot Springs, Arkansas. Jack conducted research in the protection of forests and environmental quality. In 1975 he received the outstanding contribution award from the Southern Forest Insect Conference for his work in integrated pest management.

The presentation will be a team effort. Dr. Lawrence will start the presentation with Jack Walstad taking the second half.

THE ECOLOGICAL BASIS FOR VEGETATION MANAGEMENT

W. H. Lawrence
J. D. Walstad

INTRODUCTION

The products and amenities provided by the forest for man's use can be perpetually renewable resources. However, the sustained supply of these invaluable resources must be predicated upon wise forest land management.

The management practiced by the forest products industry on its relatively small but highly productive portion of the Nation's commercial forest land represents an intensive application of silvicultural (ecologically based) practices. The management of public commercial forest land by State and Federal agencies represents, in most instances, an extensive application of these same silvicultural practices. The custodial forest management practiced by many small non-industrial landowners represents yet another level of intensity.

All three of the above levels of management have their place in sustaining the value of American forests. The intensive forest management practiced by industry (both large and small ownerships) attempts to optimize the production of wood and fiber products with due regard for other resources of the forest such as wildlife, water, and recreation. The forest management practiced by public agencies by law employs a "multiple use" approach which attempts to balance the outputs of forest land use amongst timber, wildlife, livestock, recreation, water, and mineral uses. The personal management of small woodlots and tree farms provides a source of income, recreation, and pride for many individual landowners.

Faced with an expanding demand for all forest resources and a constantly shrinking forest land base, it is imperative that productive and efficient management of our commercial forests by industry, public agencies, and private individuals be sustained. The ability to control competing vegetation is one of the key requisites in this common endeavor. Our paper will address certain of the ecological principles of vegetation management as they relate to intensive forestry.

ECOLOGICAL PRINCIPLES

Ecosystems

A forest is much more than a stand of sedentary trees. It is a biological community consisting of a variety of plants, animals, microorganisms, soil series, and abiotic factors which comprise a complex ecosystem.

Ecosystems are driven by energy. The initial source of this energy is, of course, the sun. Green plants are capable of capturing some of the solar energy and converting it through the process of photosynthesis to food (potential chemical energy). Thus, vegetation provides the basic life support system for other organisms, including the herbivores, carnivores, and decomposers. All ecosystems include the same basic components and functions. The life forms that plants and animals have may differ in appearances; but the need to collect energy and nutrients in order to live, grow, and reproduce is the same. Consequently, the management of renewable natural resources from agronomic crops to wildlife must be based upon a thorough understanding of the important interrelationships within a given ecosystem. The ecosystem of interest to this symposium is a commercial forest.

Competition

The biological structure of an ecosystem is arranged according to how efficiently component organisms utilize available resources. Each organism in a given ecosystem occupies a specific niche in which it is best adapted to perform its function. The resources of ecosystems—space, energy, moisture, and nutrients—are limited, thus forcing all organisms to compete for survival and growth.

In the case of forest ecosystems mature trees physically dominate other forms of vegetations. This is because of their unique structure and inherent productivity, characteristics which profoundly influence the environment and resources available to other plants and animals.

Despite their predominant influence, trees are not exempt from the competitive struggle for existence, particularly when as seedlings they must compete with a variety of plants for available moisture, nutrients, and growing space. During the establishment of a new forest, residual woody brush reduces the amount of sunlight available and needed for rapid juvenile growth of important commercial tree species. In addition, forest animals such as insects, rodents, and ruminants (deer, elk) can impact the survival and subsequent growth of forest trees.

Plant Succession

As mentioned earlier, ecosystems are dynamic entities. The landscape of forest ecosystems, in particular, can undergo dramatic changes through time as a forest renews itself. This process is known as *forest succession* and is the inevitable result of both natural and man-caused changes.

In nature, the sequence of forest succession begins with a major disturbance, such as a windstorm or an insect outbreak followed by fire. In the managed forest, renewal begins with a harvest cut. These types of events create relatively open conditions for the growth and development of pioneer plants. Grasses and forbs typify the prolific seeding and rapid colonization attributes of pioneer plants. Transitional (subclimax) species, usually comprised of light-demanding conifer and hardwood species (intolerant to mid-tolerant of shade), are the next to invade the site. These trees may retain control of the site for many years. If left undisturbed, these transitional species are slowly replaced by shade tolerant species, culminating in a self-perpetuating climax forest comprised of conifers and/or hardwoods.

This sequence of events is rarely completed over vast acreages of forest land. Man's intervention or periodic natural disturbances frequently short-circuit the successional process and continuously "recycle" the forest. It is common, therefore, to find extensive stands of transitional species of various ages from juvenile to mature. For example, the vast expanses of southern pine and Douglas-fir encountered by early settlers represent two examples of this phenomenon in nature. The cycle is being repeated today as evidenced by the man-established pine plantations in the South and the second-growth stands of Douglas-fir in the West.

OBJECTIVES OF VEGETATION MANAGEMENT

The first objective of vegetation management is to channel the limited resources of a given ecosystem into useable products or amenities. Instead of permitting a random allocation of water, nutrients, sunlight, and growing space among a variety of plant species, vegetation management attempts to direct these resources toward those entities deemed beneficial to man.

In the case of agriculture vegetation management is required to maximize crop production. By controlling or eliminating the competitive effects of weeds, farmers are able to produce a high quality crop which will meet market and financial expectations. Agronomic ecosystems are highly artificial. Intensive cultural practices are designed to *concentrate* all available resources to the chosen crop. While it does have some limitations requiring continual attention, this system of management has proven to be a most efficient and cost-effective means of food production.

In contrast to modern agriculture foresters manage a more natural ecosystem. The goal of vegetation management in industrial forest management is to utilize the full productivity of a given site by ensuring full stocking and maximum volume growth of the commercial species under management. This is done by *suppressing* the growth of competing vegetation.

Usually no attempt is made to eradicate this vegetation. The relatively low value and long time spans (or rotations) characteristic of forest crops would not justify high expenditures needed for *total* control. Consequently, one would find *most,* if not all, the plant and animal species in a managed forest that one would find in a "wild" forest at the same successful stage, albeit in a subordinate position.

Wildlife management likewise deals with natural ecosystems. Therefore, forest and wildlife management are usually compatible because of their focus on vegetation management. By intelligently manipulating various plant species, wildlife managers can create preferential habitats for desired animal species. For example, in the management of blacktail deer the selective control of certain overstory plants will enhance the development of understory plants that provide food and cover for this specific form of wildlife. Most of the vegetation management practices are directed at woody brush and noncommercial trees, which affect wildlife habitat as well as timber production. In addition, the mosaic of different timber age classes, characteristic of managed forest land, provides the habitat diversity necessary to support a variety of wildlife species.

The second objective of vegetation management is to maintain conditions favorable for the growth of commercially important transitional species, such as the southern pines and Douglas-fir. This is done by suppressing the development of certain pioneer species and by retarding the encroachment of certain climax species. The net result is an opportunity for the transitional species of economic importance to flourish. Again, no attempt is made to eradicate competitors. Consequently, the diversity of plant life and attendant wildlife characteristic of these types of forests is retained.

To summarize this introductory portion of our paper, the ecological effect of vegetation management can be viewed as a means of accelerating, decelerating, or "recycling" the successional process. Its influence on plant and animal communities will resemble the natural and historical events that have taken place in our forest ecosystems. In certain instances the objective of forest vegetation management is to return a site to its natural and productive forest cover; for example, abandoned fields in the South and extensive non-productive (in terms of both forest products and wildlife populations) brushfields in the West.

APPLICATION OF VEGETATION MANAGEMENT

Vegetation management is one of the key cultural tools used to ensure the production of vigorous crops. As previously discussed, the basic objectives of vegetation management are to channel the growth resources of a given site into preferred crops and to thereby maintain these crops in a dominant productive position through time. The intensity of vegetation management ranges from the total eradication of competing vegetation as done in agriculture to a more natural approach of control, characteristic of silvicultural operations which either speed up or delay forest succession.

Harvesting is the first step of vegetation management in forests through the removal of an old stand to replace it with a more productive, healthy stand of trees. The silvicultural application of vegetation management commonly begins during the regeneration phase of a new forest. Various *site preparation* methods are employed to create suitable conditions for the germination of seeds or planting of seedlings, and their subsequent survival and growth into the next forest crop. The methods of site preparation include prescribed burning (controlled burning), use of herbicides, mechanical equipment, various hand operations, and combinations thereof. These techniques are designed to create conditions similar to those one would find following natural catastrophic events that initiate forest succession.

The duration of the influence of site preparation treatments is sometimes too short to guarantee full realization of the growth potential of the new commercial forest. Many pioneer plant species rapidly invade a prepared site and may stress the young trees before they have fully captured the site. Residuals, such as brush or noncommercial trees remaining from the previous forest, may likewise retard the growth of the new stand. It is thus sometimes necessary to release the young trees from competing vegetation. Historically, the occasional passage of low ground fires through natural stands was effective in controlling competing vegetation. Today, aerial and ground application of herbicides has generally proven to be the most effective method of correcting this situation where it occurs. These decisions are made on an acre-by-acre prescription basis.

Finally, it is sometimes beneficial to remove the influence of competing brush and noncommercial trees during the latter stages of forest development. This operation is known as *timber stand improvement* (TSI) and frequently involves combining the use of herbicides with manual or mechanical methods. When properly done, this operation will increase the growth rate of the remaining crop trees as well as reduce the intensity of site preparation required for the establishment of the next forest.

VEGETATION MANAGEMENT ALTERNATIVES

Any evaluation of the various alternatives used in vegetation management must consider the limitations of each particular treatment as well as the anticipated benefits. Forest managers routinely do this as they formulate prescriptions for various parcels of forest land under management.

Mechanical methods of vegetation management include treatments such as shearing, crushing, chopping, and cutting. Heavy machinery is involved, which is quite effective at preparing sites for the establishment of a new stand. The use of such machinery is too damaging to stands which are already established and is, therefore, unsuitable for release purposes. Also, the use of mechanical equipment is restricted by topography and soil conditions. Other techniques must be used in such sensitive situations in order to avoid erosion and soil compaction.

Prescribed burning is used to dispose of the residual brush and slash left after the previous harvest operation. It frequently follows mechanical, manual, or chemical methods of site preparation to further facilitate forest regeneration efforts. Although prescribed burning most closely resembles "Mother Nature's way" of vegetation management, its application is increasingly limited by legal and environmental constraints. Also, it cannot be used as a release treatment until forest stands have matured beyond the stage of sensitivity to low ground fires. Therefore, prescribed burning is primarily useful as a site preparation treatment.

Manual methods of vegetation management consist of hand slashing with machetes and chain saws. These techniques are applicable in sparsely vegetated areas and along roadways, waterways, or adjacent to cropland. This approach is selective enoungh to be used in forest release operations. However, the practical application of manual weed control is severely limited by the labor force available and the onerous nature of the work. Manual cutting is less effective than chemical or burning treatments because many of the brush species resprout promptly, returning to their former stature.

Due to recent advances in biochemistry and plant physiology, a quantum jump in the practice of vegetation management has been made. A variety of new herbicides has been developed which controls only certain types of plants and not others. This selectivity allows the forest manager to suppress competing vegetation to favor the growth of commercially important species.

Their versatility and selectivity make herbicides useful to large and small landowners alike for all phases of forest management, ranging from site preparation to stand release and improvement. Herbicides can be applied in a number of ways ranging from aerial application to individual stem treatment, depending on the type of formulation. Thus, the selectivity and versatility of these materials account for their use in a variety of silvicultural activities at all levels of forest management.

The herbicides currently used in forestry do not necessarily kill competing weeds; they suppress weed growth to the extent that the growth of commercial trees is favored for a brief period of time. Frequently, this brief respite is all that is required for the commercially important trees to capture the site. Therefore, only one or two applications of herbicides are needed during the life cycle of a commercial forest (30 to 50 years or more).

Certain of the herbicides used in forestry affect a broad spectrum of plant species including commercially important ones. They are useful, therefore, only for site preparation prior to regenerating a new forest crop. For example, the "brown and burn" technique involves the use of a chemical desiccant to prepare brush sites for prescribed burning.

Other chemicals are quite selective in terms of the plants they control. For example, phenoxy herbicides are primarily effective on broadleaf weeds, while triazine herbicides are primarily aimed at controlling grass competition. Selective herbicides are particularly suited for releasing young conifer stands from competing brush. The aerial application of 2,4,5–T, for example, has proven to be the safest and most effective method of sustaining the development of young conifer stands growing on steep, brushy ground. Other approaches involving manual or mechanical means have simply not been practical or economically feasible in such situations.

Within these broad chemical categories there are numerous options depending on the specific plant species involved, the season of the year, and the phase of forest development. Thus the chemical methods of vegetation management are among the most sophisticated yet cost-effective tools available to forest managers.

The principal limitations on the use of herbicides are related to season of the year (weeds must be at a certain stage of growth before they are susceptible), daily weather (atmospheric conditions must be within certain limits in order to avoid drift onto sensitive crops or waterways), and regulatory statutes (herbicide use is carefully regulated by Federal and State agencies). All the available evidence indicates that the impact of herbicides on wildlife and other factors in the environment is transient at most.

Thus, a variety of vegetation management tools is available to forest managers to enhance the development of commercial forests; but each tool has certain limitations and must be carefully prescribed to fit the situation at hand. Of the techniques now available, chemical herbicides are the most versatile. These materials will effectively suppress a broad array of competing species with considerably more finesse than other alternatives or natural processes.

SUMMARY

Forests, if managed wisely, are a perpetually renewable resource. Faced with an expanding demand for forest products and a constantly shrinking commercial forest land base, we must continue our efforts toward efficient and economical management of this valuable national resource.

The practice of vegetation management is one of the principal means of optimizing the productive capacity of forest lands. The suppression of certain types of vegetation enables preferred animal and plant species to capture the limited resources of a given site and develop accordingly. A thorough understanding of the ecological relationships such as energy flow, competition, and plant succession allows us to manage the forest ecosystem without destroying its integrity.

The degree of vegetation control practiced by land managers ranges from the frequent and intensive treatments characteristics of agriculture to the more moderate and intermittent treatments typical in forest and wildlife management. The techniques applied to forest environments consist of a variety of mechanical, manual, chemical, and burning treatments. These are used to prepare sites for the initiation of a new forest as well as to enhance the development of established trees and wildlife habitat. Of the various tools available for accomplishing these tasks, the use of herbicides (such as 2,4,5–T) has proven to be one of the safest and most cost-effective approaches to vegetation management.

MR. FLAMM: Thank you, Bill and Jack.

MR. FLAMM: As most of you know, approximately 59 percent of this Nation's commercial forest lands are owned by over 4 million people. Our next speaker will discuss the use of herbicides on these non-industrial private forest lands.

THOMAS DIERAUF is Chief of Applied Research, Virginia Division of Forestry, Charlottesville, Virginia. He graduated from Rutgers in 1952 with a bachelor of science degree in General Agriculture. After serving in the Air Force, he obtained a master of forestry degree from Yale School of Forestry. It is a pleasure to have Tom Dierauf with us today.

USE OF HERBICIDES ON NONINDUSTRIAL PRIVATE FOREST LAND

T. A. Dierauf

INTRODUCTION

To prepare for this talk, I sent a questionnaire to each of the 48 contiguous States asking what kinds of herbicides are used on nonindustrial private forest land; in what ways they are used; and on how many acres each year. My talk will be based largely on the replies I got from this questionnaire. Forty-three of the 48 States responded. I will consider only those herbicide practices used to increase timber growth: preparing land for regeneration by planting, direct seeding, and natural seeding and control of unwanted vegetation that is competing with the preferred seedlings and crop trees. To my knowledge, there is very little use of herbicides on nonindustrial private forest lands for such things as fuel reduction, wildlife habitat improvement, aesthetics, or increasing water yields. There is considerable use of herbicides for controlling vegetation along power line rights-of-way, but this work is done by the power companies and not the owners of the forest land. I have not included right-of-way work in my talk, because this will be covered in a separate session this afternoon.

Let me start by saying that, in general, there is not much use of herbicides to increase timber growth on nonindustrial private forest land. There are several reasons for this:

1. The great majority of owners of nonindustrial private forest land do not manage their land to improve timber growth. Forest management practices intended to increase timber growth are applied to only a small percentage of these lands.

2. The majority of the forest management practices that are used to increase timber growth do not employ herbicides.

3. The forest management practices that do employ herbicides are rarely used more than once in a timber growing rotation, and rotations are rarely shorter than 25 years.

PRESENT USE OF HERBICIDES

The uses of herbicides for growing timber can be conveniently separated into four different practices based on the size and nature of the vegetation being controlled and the manner in which the herbicides are applied. I will discuss these four practices separately, illustrating with color slides what the practices are and why they are done, and present data on the acreage on which the various practices are used.

1. The most frequently used practice involving herbicides is individual treatment of unwanted trees, from large trees down to sapling size, for the purpose of:

1. preparing an area for regeneration
2. releasing a regenerated stand
3. removing unwanted trees from sapling, pole, or sawtimber size stands

The most commonly used herbicides are 2,4,5–T, 2,4–D, and Tordon 101R. The herbicide is applied to cuts made through the bark of the tree. The cuts are either made with an axe after which herbicide is applied to the cuts or with a special tool called an injector that makes the cuts and applies the herbicide simultaneously. The 43 States reported that this practice is used on a total of about 88,000 acres each year, and almost all of this acreage is in the States from Virginia south to Florida and west to Missouri and Texas. On about three-quarters of this acreage the objective is to free *pine* regeneration from competition from unwanted hardwood trees. On the remaining one-quarter the objective is to improve the stocking, quality, and species composition of sapling to sawtimber size hardwood stands by removing low quality and defective trees and slow growing and low value species.

2. The next most frequently used herbicide practice is aerial spraying, which is most often used to "release" established stands of conifer seedlings from competition from unwanted hardwoods. The hardwood competition is usually small hardwood sprouts and seedlings that are about the same age as the conifer seedlings being released, but sometimes the target is older and larger hardwoods left over from the previous timber stand. The herbicides used are low volatile esters of 2,4,5–T and, in some cases, 2,4–D. A total of about 27,000 acres is treated each year by the 43 States responding to the questionnaire. About 1500 acres are sprayed in Maine, 2800 in Minnesota, 2000 in Oregon, and 2400 in Washington. The remaining 18,000 acres are done in the Southeastern States, with Virginia doing 11,000 acres. In Virginia about 30,000 acres of nonindustrial private forest land are site prepared and planted with loblolly pine each year, and about one-third of this acreage is released by aerial spraying during the second to fourth growing season after planting.

Aerial spraying is also used for site preparation prior to planting or seeding. The 43 responding States report about 7000 acres are treated each year, and almost all of it is done in the three States of Virginia, North Carolina, and Mississippi. It is almost always used in combination with prescribed-burning, spraying 4 to 6 weeks prior to burning for the purpose of increasing the amount of fuel and improving the burn.

3. Several types of ground equipment can be used to spray herbicides on the foliage of unwanted woody vegetation, grasses, weeds, and vines. Some of the equipment is mounted on or towed by tractors, and some is carried by the individual doing the spraying. This herbicide practice is also used either to eliminate or reduce unwanted vegetation prior to planting seedlings or to control vegetation around seedlings already established. A variety of chemicals are used, but 2,4,5–T for woody vegetation and Simazine for grasses and weeds are used on over 90 percent of the acreage treated. The 43 responding States report about 18,000 acres are treated each year.

4. Finally, small hardwood sprouts and seedlings up to about 2 or 3 inches in stump diameter can be individually treated by spraying herbicide, usually 2,4,5–T, on the bark of the lower 6 or 8 inches of the stem. This practice is known as basal spraying. Its use was reported by only nine States on a total of less than 2000 acres each year.

Adding the acreages from these four practices gives a grand total of 142,000 acres treated annually with some type of forestry practice employing herbicides. How accurate is this figure? Twenty-nine of the 43 States that responded to the questionnaire provided estimates of the acreage treated each year. The 14 States that did not provide acreage figures and the five States that did not respond at all are all in the northeastern and western parts of the country where little herbicide is used. My guess is that this figure is reasonably good. There are approximately 300 million acres of nonindustrial private forest land in this country that is classified as capable of growing merchantable timber that can be harvested. The 142,000 acres treated with herbicide each year is less than one acre in 2000. Even if we double the reported acres to be conservative, less than one-tenth of one percent of the total acreage is treated each year.

How much herbicide is used? The predominant herbicide used is 2,4,5–T. In aerial spraying, practice #2 above, the standard rate is 2 pounds acid equivalent per acre, and most brands of 2,4,5–T contain 4 pounds acid equivalent per gallon. For individual tree treatments, practice #1 above, the per-acre application rate would average considerably less than one pound per acre. For practices #3 and #4 above, where 2,4,5–T is used, the per-acre rates would be similar to aerial spraying. For a ballpark estimate of the total amount of herbicide used each year on the approximately 140,000 acres treated, we could assume that 2,4,5–T is the only herbicide used, which would give a total of less than 200,000 pounds, or 50,000 gallons of 2,4,5–T. My guess is that an annual volume of this magnitude would put nonindustrial private forestry well down in the "minor use" category.

FUTURE USE OF HERBICIDES

Although most States are using little herbicide at the present time, 13 of the 43 States that responded felt that herbicide use would increase in the future. Two factors are involved: the almost certain future increase in the amount of forestry work done on nonindustrial private forest land and the likely future substitution of methods using herbicides for methods that do not.

The U.S. Forest Service has predicted that the use of wood may double by the year 2000, and much of the increased supply of wood must come from nonindustrial private forest land. Within the last 10 years there has been much concern over the fact that the majority of this land is producing wood well below its capacity. Considerable time and effort has been spent discussing and analyzing this problem and devising ways to improve growth on these lands. The fairly new FIP program (Forestry Incentives Program) is one result of this concern. It is a subsidy program that supplements the older ACP program (Agricultural Conservation Program) with the difference that the purpose of FIP is strictly to increase timber production. These programs pay a portion of the cost of various forestry practices, 75 percent in Virginia. There may be other financial inducements in the future to encourage forestry practices that increase timber growth, such as timber loans and tax benefits. Also, as competing resources become more scarce and more expensive, the cost of wood will rise. This will result in higher prices being paid to the forest landowner for his wood, which will be another incentive to practice good forestry. In the future, on nonindustrial private forest land, there will be greater use of many kinds of forestry practices designed to increase timber growth, and some of these practices will involve herbicides.

The expectation that forestry practices involving herbicides will increase relative to practices not involving herbicides is based on several factors, both economic and environmental in nature:

1. Changes in air pollution regulations may reduce the amount of prescribed burning that is presently done. In Virginia prescribed burning is our most important site preparation method. Burning not only cleans up logging debris so that a better job of planting can be done but also kills back residual hardwoods and brush. Not only is burning the cheapest thing we can do, but it seldom exposes mineral soil, so soil erosion is not a problem. However, if changes in air pollution regulations restrict prescribed burning, part of the slack will be taken up by using herbicides to control residual hardwoods and brush on tracts on which logging debris is not so heavy as to preclude planting.

2. The cost of site preparation methods involving large tractors (bulldozing, rootraking, shearing, disking, drum-chopping, and bedding) has skyrocketed in recent years. In Virginia the cost of bulldozing and drum-chopping, the two most frequently used mechanical methods of site preparation, has increased two and one-half times in the past 10 years, while the cost of aerial spraying has increased only about one-half.

3. Labor costs have also skyrocketed, and good quality labor is often hard to obtain. Herbicide practices involving areawide application, particularly aerial spraying, require less labor than most other kinds of forestry practices.

4. Concerns about non-point source pollution of water may cause some shift from mechanical methods that remove the litter and expose mineral soil to herbicide methods that do not. In general, accelerated erosion from forest land that has been mechanically site prepared is not a serious problem, but on some soils and on the longer and steeper slopes it may become advantageous to use herbicides instead of heavy tractors.

5. As wood becomes scarcer and more valuable, tree utilization during harvesting will improve. There will be less wood left on the land after a harvest cut—wood in the form of tree tops and small, defective, and low value trees. At present site preparation has two objectives. The most important objective usually is to remove the debris left after logging so the area can be reforested. The second objective is to reduce the amount of unwanted, competing vegetation. As utilization improves, debris removal will become a less important consideration, and this will permit the substitution of less expensive herbicide practices, which control competing vegetation but do not remove logging debris, for the generally more expensive mechanical site preparation methods that do both.

ENVIRONMENTAL CONCERNS

Everything we do in the woods has some effect on the environment. All forest practices affect the immediate environment on the tract of land where the harvesting, thinning, site preparation, planting, or release operations are actually carried out. Many forest practices also affect the environment around or even some distance away from the tract actually treated, usually in a down-hill, downstream, or down-wind direction. There are tradeoffs between different forest practices. The practice that would be most effective in increasing timber growth in a particular situation might be the most expensive, or might cause air pollution, or might cause more soil erosion than other practices that could be used. Expected growth increase, costs, and possible adverse environmental effects must all be considered in choosing a particular forest practice for a particular situation. Our challenge is to use those forest practices which provide the most acceptable balance between the increasing need for wood as raw material, the costs of growing more wood, and the undesirable or harmful environmental effects of the various forestry practices that can be used.

Some may ask why it is necessary to do anything at all? Why not leave the forests to Mother Nature and harvest what she provides, preferrably by selection cutting so that disturbances in the forest are kept to a minimum? Our reply to this question is that "Nature" is not concerned with maximum wood production. She is concerned with the successful reproduction and survival of a great variety of species, adapted to fit all the niches in the natural environment. Not all tree species produce the same amount of wood per unit of area per unit of time, and the wood of some species is more valuable to man than the wood of others. On most of the soils in the Coastal Plain and Piedmont of Virginia, loblolly pine, which is widely planted, can produce on the order of three times as much usable stem wood per acre per year as the native hardwood species that grow on this land when left to nature. And the wood of loblolly pine in this part of Virginia is worth on the order of two to three times as much as the wood of the native hardwoods.

This means that if we *are* going to need more wood from our forest land in the future, form the species of greatest value and usefulness to man, we can't just leave it to nature. We are going to have to clearcut in many cases, prepare the land for planting or seeding of the faster growing and more desirable species, and control the growth of unwanted, competing vegetation. We will have to balance harmful environmental effects against the need for wood. Just as a farmer cannot grow corn without causing some erosion and removing some nutrients from the soil, we cannot replace slower growing hardwoods with faster growing pines without some undesirable effects on the environment. But we don't have any choice. We *must* grow more wood, while keeping undesirable environmental effects to an acceptably low level. Herbicides will probably play an increasing role in the future, and they will be useful not only for holding down the cost of growing wood but also in minimizing the undesirable effects of forestry practices on the environment.

MINIMIZING UNDESIRABLE SIDE EFFECTS FROM USING HERBICIDES

If herbicides are to be used more on nonindustrial private forest land, we must take steps to see that they are used safely and in accordance with their labels. Occasional accidents and off-site damage to vegetation on areas adjacent to areas being treated will always occur, but we must minimize them. Off-site damage is most likely to occur from areawide applications of herbicides, of which aerial spraying is the most commonly used and most likely to cause problems. There is little chance of off-site damage from treating individual stems with herbicides. When off-site damage does occur, it almost always is due to equipment failure, the wrong equipment or herbicides being used, or mistakes by people applying the herbicide. When the proper herbicide is applied according to the label, with the proper equipment and using the proper precautions, there is little chance of off-site damage.

In Virginia, where about 14,000 acres of nonindustrial private forest land are sprayed from the air each year, we see a need for our organization, the Virginia Division of Forestry, to control aerial spraying operations. At the present time our foresters recommend aerial spraying to individual forest landowners, either for site preparation or release of an established pine stand, and then make the names of these landowners available to a dozen or so contractors who do aerial spraying in the State. We have little control over how, when, and under what weather conditions the actual spraying is done. We are dependent on the voluntary cooperation of the aerial contractors. At the present time we are exploring the possibility of our becoming the legal agent for landowners who would like to work through us. We would line up the spray work and put it out on bids to the aerial contractors. We would specify such things as:

1. Types, formulations, and rates of herbicides to be applied

2. Additives, carriers, and total volume of spray mixture per acre
3. Types of equipment that can be used
4. Acceptable weather conditions for spraying
5. Time of year when spraying can be done
6. Qualifications and experience of contractors
7. Adequate liability insurance to cover damage claims

The States of Maine and North Carolina already operate under such a system.

The objectives of such a system are to both minimize off-site damage and improve the quality (results) of aerial spraying operations. Without such a system we are afraid that adverse public reaction to occasional off-site damage could result in our losing the entire aerial spraying program.

"MINOR USE"

All uses of herbicides for forestry purposes are "minor uses" and will continue to be even if the use of herbicides in forestry expands considerably in the future. This will make it extremely difficult to obtain labeling for use of promising new herbicides as well as many existing herbicides. This "minor use" problem could become a serious obstacle to increasing timber production on non-industrial private forest land, and some way must be found to obtain necessary labeling for forestry use.

TABLE 1
Use of Herbicides on Commercial Forest Land F. Y. 1976 (15 mos.) National Forests

Timber . . . . 92,000,000 acres

Purpose	All Vegetation Treatment (Acres)	Herbicide Treatment (Acres)[1]
Site preparation	398,814	20,635
Release and weeding	218,904	115,575
Precommercial thinning	359,958	10,824
TOTAL	977,676	147,034

TABLE 2
Use of Herbicides on Rangeland F. Y. 1976 (15 mos.) National Forests

Range . . . . 100,452,000 acres[2]

Purpose	All Vegetation Treatments (Acres)	Herbicide Treatments (Acres)[3]
Range revegetation	95,000	11,614

[1] Forest Service, U.S. Dep. Agric. 1977. U.S. Forest Service Pesticide Use Report for F.Y. 1976 and Transition Quarter. Unpublished Forest Service, U.S. Dep. Agric. Report: pp. 1–8.
[2] Total of commercial forest and range exceeds National Forest area because some commercial forest is also used as range.
[3] Ibid., pp. 21–22.

INTRODUCTION OF PANELISTS

MR. FLAMM: Thank you, Tom. I would like to introduce our distinguished guests of the day. Unfortunately, one of our panel members, DR. FOIL, was taken ill and will not be with us.

Our first panelist on the far end is DR. DUDLEY MATTSON, Chief of the Forest, Industrial, Urban Economic Section of the Economic Analysis Branch in the Criteria and Evaluation Division, Office of Pesticide Programs, EPA.

Our next panelist is DR. MICHAEL NEWTON who is Professor of Forestry in the Department of Forest Science, Oregon State University at Corvallis, Oregon.

Our next panelist, who you met briefly yesterday, is DR. KENT SHIFFERD, Co-Director of Coalition for Economic Alternatives located at Ashland, Wisconsin. The Coalition for Economic Alternatices is a non-profit community development corporation whose purpose is to promote economic growth consistent with the long-term social and economic health of the country.

Our next panelist is DR. TED SILKER, Professor of Silviculture, Agriculture, and Applied Sciences at Oklahoma State University.

Our last panelist is MR. STEVENS VAN STRUM, President of the Citizens Against Toxic Sprays, Incorporated, located at Eugene, Oregon. This is a non-profit corporation disseminating information concerning pesticides and prevention of certain uses which its members deem harmful.

To stimulate our upcoming panel discussion and the question and answer period, first we will have a paper delivered by DR. MASON CARTER which was prepared jointly by Dr. Carter, DR. HARVEY HOLT, and MR. WESLEY RICKARD, who cannot be with us. Dr. Carter is head of Forestry and Natural Resources at Purdue University.

ALTERNATIVE METHODS OF VEGETATION MANAGEMENT FOR TIMBER PRODUCTION

M. C. Carter and H. A. Holt*
Department of Forestry and Natural Resources
Purdue University, West Lafayette, IN.
Wesley Rickard*
Forest Consultant, Tacoma, WA.

**Did not participate in the symposium*

INTRODUCTION

To have agreed to present a comprehensive discussion of cost/benefits from the use of herbicides in forestry suggests that my colleague and I have very large egos or very poor judgment, or both.

Many people are aware of the vagaries and variation in the biological reactions of the forest ecosystem; some appreciate the complex sociological climate and conflicts between owners, workers, users, and consumers of the forest resource. Very few fully understand the implications of labor, capital, markets, and taxation as they impact forest management decisionmaking.

All of these factors—biological, social, and economic—are of major importance in a discussion of vegetation management in timber production. We cannot hope to cover all of these factors in detail in the space and time devoted to this presentation. We will not attempt to discuss the future timber requirements of the Nation nor the roles to be played by various classes of ownership. We will work from the premise that an increased supply of timber and wood products serves the best interests of our Nation and that vegetation management is necessary to achieve this goal.

MINOR USES

Herbicides are used in forestry for a variety of "minor uses" where only a few thousand acres are treated annually nationwide. But these minor uses are quite important. For example, herbicides can produce sizable savings in weed control costs in tree nurseries. The data in Table I is an example. Gjerstad and South (1976) estimate that the 60 forest tree nurseries in the Southeast could save over $250,000 annually using herbicides instead of hand weeding. Hand weeding is the only alternative in most seedling nurseries because the small, fragile tree seedlings are easily injured by mechanical equipment.

TABLE 1—Effectiveness of herbicides in loblolly pine seedbeds in Georgia.

Treatment	Rate (lb/A)	Handweeding time[1] Days after sowing 49	78
Trifluralin	1	266*	245
	2	87*	211
Diphenamid	4	91*	217
	8	75*	131*
Control		647	292

[1] Time in minutes to hand weed 100 linear feet of seedbed.
* Significantly different from control at 5% confidence level.
Source: Dill and Carter (1973).

Seed orchards, firebreaks and, roadsides are other minor uses important in forestry. Special problems such as kudzu, Japanese honeysuckle, and multiflora rose occur in localized situations. Herbicides offer the only practical means of controlling these plants sufficiently to permit the establishment of other vegetation.

In the North Central and Northeastern States tree planting is not as extensive as in the South and West, but plantation establishment would be far less successful without herbicides (Byrnes, et. al., 1973; White, 1975; Bey, et. al., 1975). In Indiana, for example, the Division of Forestry will not authorize cost-sharing for hardwood tree planting by the private landowner unless there is a provision for weed control during the first growing season. A pre-emergence herbicide applied during the planting operation is the cheapest and simplest alternative for the private landowner.

MAJOR USES

But minor uses are not the principal concern of most people. When we discuss herbicides in forestry, we generally are referring to the use of 2,4-D [(2,4-dichlorophenoxy) acetic acid] and 2,4,5-T [(2,4,5-trichlorophenoxy) acetic acid] for competition control in forest stands. The objective of most competition control in forest management is to create and maintain conditions favorable for the growth and development of commercially important species or individuals. Many commercially valuable conifers (e.g., southern pines, white pines, Douglas-fir) are intermediates in the natural successional pattern. Frequently these intermediate species occur in nearly pure stands maintained by periodic natural disturbances, such as wildfires. The silvicultural methods used for these species are designed to simulate natural occurrences—but in a more controlled and orderly manner.

It should be emphasized that none of the vegetation management techniques currently used by forest land managers totally eradicate weeds. Such an objective is not economically feasible. Suppressing the growth of the weeds once or twice during a rotation of 30 to 60 years or more is currently acceptable to most managers.

Precise figures on the amounts of 2,4-D and 2,4,5-T used in forestry each year are not available since both materials are widely used for purposes other than forestry. It is estimated that of the 6 million pounds of 2,4,5-T and 40 million pounds of 2,4-D manufactured each year, less than 2 million pounds of 2,4-D and 2,4,5-T are used for silvicultural purposes on approximately 1 million acres of forest land. Approximately 200 million acres of corn, wheat, and soybeans are planted annually, and most receive one or more pounds of herbicide per acre. Thus the 2,4-D and 2,4,5-T used inforestry represent a small fraction of the total domestic herbicide usage.

Forestry uses of herbicides, mainly 2,4,5-T, are:

(1) Site Preparation—the reduction or suppression of unmerchantable woody vegetation prior to planting or seeding crop plants, including the conversion of one forest type to another.

(2) Release—the suppression of woody vegetation persisting or resprouting following site preparation and over-topping crop trees.

(3) Timber Stand Improvement—the reduction of understory competition as well as the removal of low grade or cull trees from the overstory.

Site preparation and release are usually accomplished with aerial application. Timber stand improvement may be conducted with ground sprayers or mist blowers for broadcast treatment or hand equipment for individual stem treatment.

BENEFITS AND COSTS

Table 2 depicts the extent to which non-merchantable growth exists in our Nation's forests, and Table 3 shows the gains that could be achieved with vegetation management. Seventy to 100 percent increases in merchantable wood production are projected. These estimates are conservative. Numerous examples can be cited where intensively cultured forest stands have produced more than twice the yield of natural stands (cf. Wahlenberg, 1965; Hansbrough, 1970).

The gains presented in Table 3 are based on a survey of industrial forest managers across the United States and represent their estimates of the benefits of vegetation control. These expectations are well documented by research results (cf. Arend and Roe, 1961; Newton and Holt, 1967; Erdmann, 1967; Zavitkovski, et. al., 1969; Hansbrough, 1970; Carter, 1972; Byrnes and Holt, 1975; Carter, et. al., 1975; Fitzgerald and Selden, 1975; Radosevich, et. al., 1976; Walstad, 1976).

To demonstrate the economic importance of vegetation management, we have estimated the present net worth and benefit/cost ratios for site preparation and release under average conditions in the southern pine and Douglas-fir regions. Table 4 lists the costs and production rates for various alternatives; the present net worth and benefit/cost ratios are shown in Table 5. Details of these calculations are given in the appendices which accompany this paper.

Table 5 represents only two of the major timber types in the continental United States. But chemical vegetation management would be expected to show simi-
such as ponderosa pine, hemlock-spruce-fir, and redwood
lar economic advantages in other important timber types, such as ponderosa pine, hemlock spruce fir, and redwood types in the West and northern pine types in the Northeast and Lake States.

The data in Tables 4 and 5 were based on 1975 costs. Both manual and mechanical costs are increasing more rapidly than chemical costs.

TABLE 2—Extent of Commercial Forest Land Dominated by Weeds in the Conterminous United States (Exclusive of Alaska and Hawaii)

Region	Total Forest Land Base	Commercial Forest Land Base	Commercial Forest Land Dominated by Weeds[3]	
	(Million Acres)[1]	(Million Acres)[1]	(Million Acres)[2]	(Percent)
North	187	178	35	20
South	212	192	134	70
Rocky Mountain	138	62	15.5	25
Pacific Coast	210	61	6.5	11
Total U.S.	747	493	191	39

[1] Source: U.S.D.A. (1973).
[2] Source: Walker, C. M. et. al. (1973).
[3] Defined as commercial forest lands which are either non-stocked or poorly stocked with appropriate timber species because of weed competition.

TABLE 3—Anticipated Gains in Industrial Forest Productivity as a Result of Various Weed Control Practices[1]

Region	Weed Control Category				
	Type-Conversion	Site Preparation	Release From Competition	Timber Stand Improvement	Combined
			—Percent Gain Expected—		
North	24	18	13	17	72
South	32	34	16	17	99
Rocky Mtn.	9	20	12	30	71
Pacific Coast	21	21	11	15	68
Avg. for U.S.	26	26	14	18	84

[1] Source: DeBell et. al. (1977).

TABLE 4—Typical Allocation, Costs, and Production Rates of Various Weed Control Practices in Two Regions of the United States[1]

Weed Control Practice	Douglas-Fir Region: Annual Percent of Reforested Land Treated by Each Method [2]	Douglas-Fir Region: Typical Treatment Cost [3]	Douglas-Fir Region: Typical Production Rate per Man or Machine [3]	Southern Pine Region: Annual Percent of Reforested Land Treated by Each Method [2]	Southern Pine Region: Typical Treatment Cost [3]	Southern Pine Region: Typical Production Rate per Man or Machine [3]
Site Preparation:						
Chemical	10%	$15/ac.	400 ac/day	25%	$15/ac.	600 ac/day
Mechanical	30	70	10	55	50	10
Manual	< 1	100	< 1	< 1	60	< 1
Prescribed Burning	20	50	40	70	10	40
None	50	—	—	10	—	—
Release:						
Chemical	70%	$10/ac.	400 ac/day	50%	$10/ac.	600 ac/day
Manual	< 1	110	< 1	< 1	60	< 1
None	30	—	—	50	—	—

[1] Based on information provided by industrial forest managers for the year 1975.
[2] Figures are not necessarily additive because of treatment combinations.
[3] Treatment costs and production rates are based on the following methods:

Chemical = aerial application of 2,4,5-T by conventional helicopter.
Mechanical = shearing of brush with bulldozer.
Manual = hand cutting of brush with chain saw or machete.
Prescribed Burning = broadcast burning of slash or brush.

TABLE 5—Comparison of Economic Benefits of Forest Management Dependent on Various Weed Control Methods[1]

Economic Criteria	Douglas-Fir Region: Chemical Weed Control	Douglas-Fir Region: Mechanical Weed Control	Douglas-Fir Region: Manual Weed Control	Southern Pine Region: Chemical Weed Control	Southern Pine Region: Mechanical Weed Control	Southern Pine Region: Manual Weed Control
Net present value at 8% discount rate after tax	$198/ac	$107/ac.	$ 78/ac.	$144/ac.	$ 92/ac.	$ 83/ac.
Benefit/cost ratio of present values at 8% discount rate after tax	3.0	1.6	1.4	3.5	1.8	1.7

[1] Values are derived in Appendices 1 and 2, and compare management regimes using the different weed control methods for both site preparation and release. The option of no weed control is not viable for areas needing weed control, if economic production of timber is to be expected. Calculated yield levels would have to be drastically reduced, and scheduled on much longer harvest rotations.

COMPARING CHEMICAL ALTERNATIVES

For chemical site preparation broad spectrum effectiveness is necessary. Several chemicals are available for this use, but none is equal to 2,4,5-T in the South and West on a cost/effectiveness basis. (cf. Romancier, 1965; Gratowski, 1975; Walstad, 1976).

The herbicide silvex [2-(2,4,5-trichlorophenoxy) propionic acid] is not as effective as 2,4,5-T and contains the same trace contaminants that have led to controversy over the latter. Amitrole (3-amino-1,2,4,-triazole) does not have an adequate phytotoxic spectrum for extensive use. Mixtures of picloram (4-amino-3,5,6-trichloropicolinic acid) and 2,4-D or dicamba (3,6-dichloro-o-anisic acid) and 2,4-D are registered for forest applications and could be used for site preparation. However, rates of these mixtures which give results comparable to the standard applications of 2,4,5-T cost two to four times as much. Picloram and dicamba are highly toxic to most conifers and neither could be used as a substitute for 2,4,5-T for release in existing stands. Picloram is far more persistent in the environment than is 2,4,5-T, and dicamba has not been widely tested for forest site preparation. For timber stand improvement using mist blowers or ground sprayers, there is no satisfactory substitute for 2,4,5-T. For individual stem treatments several materials may be substituted, some of which are more cost/effective than 2,4,5-T.

COMPARING CHEMICAL TO MECHANICAL ALTERNATIVES

Mechanical methods of vegetation management include bulldozing, shearing, crushing, chopping, disking, and bedding. In addition to providing initial weed control, these treatments also facilitate slash disposal and subsequent regeneration operations. Heavy machinery is required, so applications are limited to gentle topography and relatively dry soil to avoid erosion and compaction. These approaches are widely used in the Southern Coastal Plain.

The data presented in Table 5 show mechanical site preparation to be less cost/effective than chemical site preparation when the degree of competition control is comparable to 2,4,5-T. But some of the mechanical methods used for site preparation in the southern pine region produce greater pine response than can be achieved with the registered rates of 2,4,5-T as illustrated in Table 6. In this study with loblolly pine shear and burn or spray and burn were similar in cost and degree of vegetation control to those methods analyzed in Tables 4 and 5 and resulted in comparable pine growth and stocking. Disking or bedding, in addition to shearing, resulted in 50 percent to 80 percent increases in survival and growth compared to chemical treatment. On many sites disking or bedding increases competition control or reduces sprouting to the point where release spraying is not needed. Therefore, where terrain and soil conditions are suitable, mechanical site preparation may be preferred to chemical treatment if growth response is sufficient to justify the cost.

There are many areas, however, where the operation of heavy equipment is impractical. The mountainous areas of the western United States are especially unsuited for these techniques and thus much more heavily dependent on the use of herbicides for achieving adequate weed control. Soil disturbance is greater with mechanical site preparation than with chemicals. Although mechanically prepared sites revegetate rapidly, soil loss may be greater than on chemically treated areas.

Table 6—Stocking and Tree Height after Three Years for Planted Loblolly Pine on the Aerial Spray vs. Mechanical Site Preparation Study.

Site preparation	Pine Stocking (trees/A)	Pine height [1] (ft)
Sheared and burned	660	4.0
Sheared, piled, disked	865	5.3
Sheared, piled, bedded	700	6.6
Aerial spray and burn	600	3.6

[1] Differences in tree height are significant at the 0.05 level.
Source: Carter, et al. (1975).

The relationships between tree growth and competition control on the one hand, and cost and competition control on the other, are shown in Figures 1 and 2. Both relationships are geometric, but weed control costs rise at a faster rate than growth response. These curves were derived from one study in southern pine (Carter, 1972), and coefficients will vary widely from one situation to another. But they depict a general relationship that usually exists and demonstrate the need for careful analysis in each managerial situation to select the techniques with the most desirable benefit/cost relationships.

Mechanical site preparation is very capital intensive. Most private, nonindustrial landowners do not have adequate capital resources to permit the large, long-term

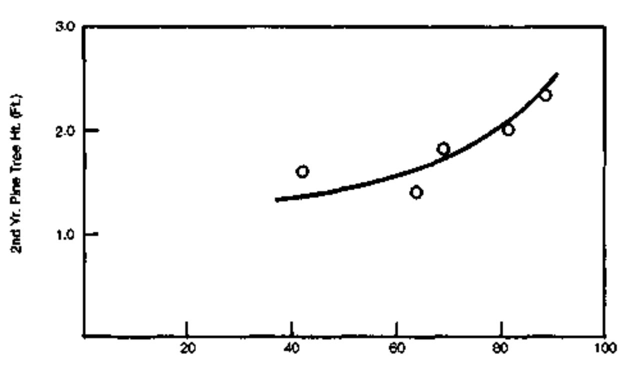

FIGURE 1.

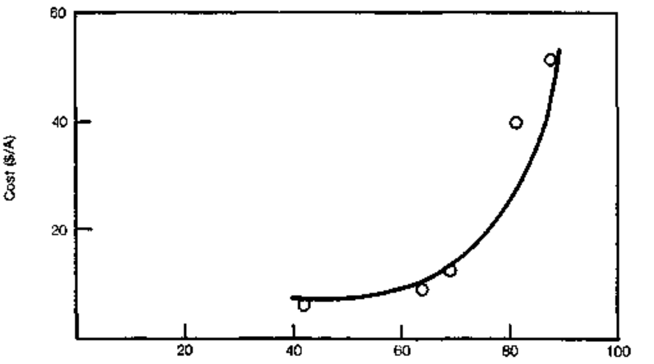

FIGURE 2.

investments which mechanical site preparation demands. Many industrial owners are likewise unwilling or unable to make such capital outlays.

Aerial application of herbicides at rates used for site preparation rarely result in more than 80 percent kill of the existing woody stems (Carter, 1972). These survivors produce mast valuable to wildlife species. Mechanical site preparation usually removes all existing stems. Although most species sprout or re-invade the prepared sites, mast production is interrupted for a longer period on mechanically prepared areas. An Alabama survey indicated that wildlife habitat was considerably more diverse on chemically prepared sites than on those mechanically prepared (Carter, et. al., 1975).

COMPARING CHEMICAL TO MANUAL ALTERNATIVES

Manual cutting of competing vegetation is not a viable alternative to chemical treatment. The release of a typical Douglas-fir plantation, 100 acres in size, could require more than 100 man-days of hand labor and would cost about $11,000 to complete by hand, using 1975 costs. In contrast, the same operation using aerial application of 2,4,5-T would only take a couple of hours and would cost approximately $1,000.

Data from the Nicolet National Forest in Wisconsin demonstrate the economic advantages of chemical (in this case 2,4-D) versus manual control of competition in plantations of northern conifers on a very good site (Table 7). The cost advantages of the chemical treatment are readily apparent.

Table 8 compares the effectiveness of various methods of cull tree control in hardwood management. In this operation non-chemical methods, i.e., manual ax girdling, resulted in extensive sprouting which reduced

TABLE 7—Cost and Response of Red Pine-Black Spruce Plantation to Release. Area: 340 Acres, Age: 40 years.

Method of Treatment	Cost/ Acre	Total	Total Yield (cords)	Total Value
Herbicide (Aerial)	$18	$ 6,120	12,240*	$1,224,000*
Herbicide (Ground)	90	30,600	12,240	1,224,000
Hand (chain saw, ax, etc.)	$50 x 5 retreat-ments = $250	85,000	12,240	1,224,000
No Release			4,420	353,600

* Yields include some sawtimber as well as pulpwood.
Source: Anonymous (1977).

TABLE 8—Percent Defoliation after One Growing Season Following Tree Injection

Species	2,4,5-T Amine	2,4,-D Amine	Picloram + 2,4-D	Ax Girdle
Maple	69	53	68	47
Sassafras	87*	77*	100	79*
Beech	70	42	92	35
Ash	90	—	100	22*
Hickory	57	86	90	56*
Average All Species	79	73	88	48*

* Sprouts present on 30 percent or more of treated trees.
Source: Wickham and Holt (1977).

the effectiveness of the treatments and cost 50 percent more than chemical methods (Wickham and Holt, 1977; Wiltrout, 1976).

In 1977 the Josephine County Oregon Forestry Department, investigated the feasibility of using chain saws to reduce brush competition in young stands of Douglas-fir and western pine (Bernstein and Brown, 1977). They found that 31 percent of the conifer seedlings they were trying to release were damaged or covered with slash by workers. The cost per acre of brush cutting was five to six times that for pre-commercial thinning, a similar operation, mainly because the production rate on pre-commercial thinning was five to six times that in brush control. The injury rate for the project was twice that for the control period. Absenteeism on one area of the test was the highest ever experienced for the Department. The slash hazard created was rated as extreme.

This study carried out in the spring of 1977 showed manual brush control costs as taken directly from the county's cost accounting system, ranging from $556 to $1269, averaging $707 per acre. Although the crews used were highly experienced, with marginal workers long since weeded out, the actual production rate on these projects ranged from .05 acre per man-day to .12 acre per man-day, for an average of .10 acre per man-day.

The Roseburg BLM District, Oregon, has attempted to control brush by hand cutting since 1972 (Lewis and Higdon, 1977). Conclusions from this program were that brush cutting is not only expensive and ineffective but is also damaging to the conifer stand. Non-commercial species were more dominant after treatment than before.

Woody vegetation frequently sprouts vigorously from cut stems or roots when suppressing chemical or root disturbing mechanical equipment is not used. In the study illustrated by Table 7 five hand cuttings were needed to achieve the same level of conifer release produced by one chemical treatment. If an individual could cut 1 acre of brush per day, more than 5 million man-days might be necessary to accomplish the same results now achieved with the 1.5 million pounds of 2,4,5-T used annually in forestry. Energy consumption for transporting or housing such a labor force would be staggering. Hand cutting of woody vegetation is grueling, monotonous, dangerous work. In our modern society few people are amenable to such labor on a continuing basis.

High unemployment rates and dwindling supplies of petroleum have prompted speculation that human energy might be substituted for chemical energy in many forestry and agricultural operations. In spite of quantum leaps in the cost of chemical energy, human energy remains far more expensive. It is unlikely that manual weed control will be practical in the foreseeable future. The only situations which might change that outlook would be a decision to impose heavy subsidies for manual weed control practices or the unhappy incidence of a severe economic depression, which might make labor available at extremely low rates.

THE FIRE ALTERNATIVE

In the Pacific Northwest burning slash after harvest is a common practice which assists the establishment of a new stand. Burning must be carefully timed to avoid extremely wet or extremely dry conditions. Land managers sometimes use the "brown and burn" technique, applying a chemical to dessicate vegetation in the area to be burned, leaving the surrounding succulent vegetation to serve as a fire break. These techniques are effective site preparation measures, but they do not preclude the need for later stand release from competition resprouting following burning.

Numerous studies and years of experience have shown that after southern pine is 10 to 15 years old, it can be subjected to repeated low intensity ground fires without injury to the trees or loss in productivity of the site. Most deciduous woody species cannot tolerate repeated burning and are thus reduced in numbers (Chen, et. al., 1977).

Repeated burning in established pine stands can so reduce woody competition that additional site preparation following harvest and release after planting is not necessary.

Fire has another attribute. It's a natural component of the southern pine ecosystem and stimulates the development of a variety of herbaceous plants highly beneficial to native wildlife.

But fire is a very sensitive tool to use. Setting the first prescribed fire in a stand that has not been burned for 10 years or more requires a great deal of experience or a great deal of ignorance.

Fire is most easily used in level or gently rolling terrain. In steep terrain it is difficult to burn uniformly and control the fire. Fire moving up the slope may become too hot and damage or ignite the crowns of the overstory trees. On the down slope the fire may be too cool to be effective.

The major limitations on the use of fire are its logistical problems and air pollution. To control weed competition in southern pine stands, fire must be used repeatedly. Five or more fires during the last 10 years of a rotation are generally required for satisfactory results. On a 30-year rotation, 15 percent or more of an ownership would have to be burned each year.

Summer burning, though highly effective and normally used for site preparation, is too dangerous for most prudent individuals for use in existing stands. Winter burning, usually in February or March, is more feasible. But the proper atmospheric and fuel conditions for a successful prescribed fire are infrequent and may not occur at all in some locations in a given season. Hence, men and equipment must be held in readiness for days or weeks awaiting the proper conditions. When these conditions occur, we would find 15 percent or more of the forestland in a given region burning simultaneously. Air pollution problems would be immense.

Thus fire for competition control must be a tool of opportunity or used in combination with other methods of weed control. When terrain, weather, and stand condition are appropriate, fire may be effectively used. But it is too undependable for continuing operations, and additional chemical and mechanical treatments are needed for adequate site preparation and release operations in most instances.

SUMMARY AND CONCLUSIONS

Thus, a variety of vegetation management methods have evolved. each tailored to fit specific weed situations. Chemical methods of vegetation management are generally preferred due to their lower cost and greater efficiency in comparison to other treatments. The application of 2,4,5-T has proven to be the *only* practical treatment for releasing conifers from severe brush competition (cf., Gratkowski, 1975; Walstad, 1976).

Herbicides, particularly aerial application, must be used with great care to avoid damage to adjoining property or contamination of water sources. Atmospheric and plant growth conditions must be within rather narrow limits for satisfactory results. Well trained, experienced personnel and sophisticated equipment is required. However, production rate is very high when conditions are favorable.

Based on the net present values prescribed in Table 5, the difference between vegetation management with 2,4,5-T and the next best method is $50 to $90 per acre. Using the $60 figure as an average, we could estimate that an additional $60 million dollars annually would be required to accomplish the present level of forest rehabilitation without 2,4,5-T. This measure of cost assumes that alternative methods *could* be scaled up to replace 2,4,5-T. Substitute chemicals for 2,4,5-T are not available, and mechanical and manual techniques are limited by the available supplies of labor, capital, equipment, operational conditions, and time. Thus, the economic impact of 2,4,5-T would be realized not only through increased treatment costs but as a decline in forest productivity as well.

The high costs of mechanical and manual weed control would discourage investment on all but the best forest sites, where timber growth rates might be high enough to justify the increase in cost. The private, nonindustrial landowner would be even less inclined to improve the productivity of his forest than he is at present.

The overall result would be slower forest growth and lower harvest yields. The loss of 2,4,5-T would seriously impact our domestic supply of forest products, the relative position of imported wood as compared to domestic production, and the price at which wood products are available.

OUTLOOK FOR THE FUTURE

We must be constantly aware of the changing economic, social, and technological climate in which we live. Priorities, alternatives, and objectives of today may change radically tomorrow. A weed is a weed only if it has no net value. Changing utilization patterns are changing our definitions of weeds in forestry. Total tree chipping is an increasing practice in some regions. In this operation all woody vegetation is removed and utilized. Advances in technology of wood utilization are providing increasingly efficient and effective reconstituted wood and fiber products.

The Department of Energy is expending large sums of money to explore the feasibility of wood as an energy source. Recent developments in cellulose hydrolysis may result in wood becoming an economic source of fermentable sugars which could be used as foodstuffs or converted to alcohol or other petrochemical substitutes. The renewable nature of the forest makes it a prime candidate for some of petroleum's niche in our technology.

We don't anticipate any decline in demand for traditional wood products or lessening of the importance of our presently preferred species. Rather, we expect increasing value and utilization of all woody vegetation, some of which now is classified as weeds. Increased utilization and rising values should improve the returns on investment in forest management provided low cost, efficient methods are available. The intensity of management on lands devoted to wood fiber production will probably increase, and vegetation management will be even more important than it is today. The objectives we seek and the tools we use may differ significantly from those of today.

Our renewable forest resources will play an increasingly important role in our welfare in the future, if we manage them properly in the present.

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APPENDIX 1.—Calculation of Economic Benefits of Forest Management in the Douglas-Fir Region Dependent on Various Weed Control Methods

		Chemical Weed Control			Mechanical Weed Control			Manual Weed Control		
Stand Age	Revenue or Cost Event	Before Income Tax	After Income Tax	Present Value at 8% After Tax	Before Income Tax	After Income Tax	Present Value at 8% After Tax	Before Income Tax	After Income Tax	Present Value at 8% After Tax
(Yrs)	($/acre)									
0	Site prep. cost:[1]									
	Chemical	(15)	(15)	(15)						
	Mechanical				(70)	(70)	(70)			
	Manual							(100)	(100)	(100)
0	Planting cost	(80)	(80)	(80)	(80)	(80)	(80)	(80)	(80)	(80)
	Capitalized costs	(95)	(95)	(95)	(150)	(150)	(150)	(180)	(180)	(180)
5	Release cost:[1]									
	Chemical	(10)	(5)	(3)						
	Mechanical[2]									
	Manual	—	—	—	(110)	(57)	(39)	(110)	(57)	(39)
	Net estab. cost	(105)		(98)	(260)		(189)	(290)		(219)
50	Harvest benefit:									
	Revenue[3]	20,800	14,589	311	20,800	14,605	311	20,800	14,614	312
	Yield tax[4]	(1,352)	(703)	(15)	(1,352)	(703)	(15)	(1,352)	(703)	(15)
	Net harvest benefit			296			296			267
Net present value at 8% after tax				$198/ac.			$107/ac.			$78/ac.
Benefit/cost ratio of present values at 8% after tax				3.0			1.6			1.4

[1] Weed control costs and methods described in Table 5. Site preparation and Planting costs are capitalized. Release costs are expensed, thus After Income Tax cost is determined by multiplying Before Income Tax cost by 0.52 (*reciprocal of Ordinary Income Tax Rate of 48%*).

[2] Effective mechanical release treatments are not available, thus manual weed control costs are used.

[3] Before and After Income Tax Revenues determined in Appendix 3.

[4] Before Income Tax Yield Tax determined by multiplying Before Income Tax Revenue by Yield Tax percentage (6.5% for Washington). After Income Tax Yield determined by multiplying Before Income Tax Yield Tax by 0.52 (reciprocal of Ordinary Income Tax Rate of 48%).

APPENDIX 2.—Calculation of Economic Benefits of Forest Management in the Southern Pine Region Dependent on Various Weed Control Methods

		Chemical Weed Control			Mechanical Weed Control			Manual Weed Control		
Stand Age	Revenue or Cost Event	Before Income Tax	After Income Tax	Present Value at 8% After Tax	Before Income Tax	After Income Tax	Present Value at 8% After Tax	Before Income Tax	After Income Tax	Present Value at 8% After Tax
(Yrs)	($/acre)									
0	Site prep. cost:[1]									
	Chemical	(15)	(15)	(15)						
	Mechanical				(50)	(50)	(50)			
	Manual							(60)	(60)	(60)
0	Planting cost	(40)	(40)	(40)	(40)	(40)	(40)	(40)	(40)	(40)
	Capitalized costs	(55)	(55)	(55)	(90)	(90)	(90)	(100)	(100)	(100)
5	Release cost:[1]									
	Chemical	(10)	(5)	(3)						
	Mechanical[2]									
	Manual	—		—	(60)	(31)	(21)	(60)	(31)	(21)
	Net estab. cost	(65)		(58)	(150)		(111)	(160)		(121)
30	Harvest benefit:									
	Revenue[3]	3,000	2,116	210	3,000	2,127	211	3,000	2,130	212
	Yield tax[4]	(150)	(78)	(8)	(150)	(78)	(8)	(150)	(78)	(8)
	Net harvest benefit			202			203			204
Net present value at 8% after tax				$144/ac.			$92/ac.			$83/ac.
Benefit/cost ratio of present values at 8% after tax				3.5			1.8			1.7

[1] Weed control costs and methods described in Table 5. Site preparation and Planting costs are capitalized. Release costs are expensed, thus After Income Tax cost is determined by multiplying Before Income Tax cost by 0.52 (reciprocal of Ordinary Income Tax Rate of 48%).

[2] Effective mechanical release treatments are not available, thus manual weed control costs are used.

[3] Before and After Income Tax Revenues determined in Appendix 4.

[4] Before Income Tax Yield Tax determined by multiplying Before Income Tax Revenue by Yield Tax percentage (5% for Louisiana). After Income Tax Yield Tax determined by multiplying Before Income Tax Yield Tax by 0.52 (reciprocal of Ordinary Income Tax Rate of 48%).

APPENDIX 3.—Calculation of Before and After Income Tax Revenues for Douglas-Fir Management

Weed Control Method	Harvest Volume	Projected Price	Before Income Tax Value	Total Capitalized Costs		Tax	Net Value After Tax	
	(Cunits/ Acre)[1]	($/Cunit)[2]	($/Acre)[3]	($/Acre)[4]	($/Cunit)[5]	($/Cunit)[6]	($/Cunit)[7]	($/Acre)[8]
Chemical	80	260	20,800	95	1.19	77.64	182.36	14,588.80
Mechanical	80	260	20,800	150	1.88	77.44	182.56	14,604.80
Manual	80	260	20,800	180	2.25	77.33	182.67	14,613.60

[1] Based on expected average productivity (1.6 cunits/acre/year) of public (State and National Forest) and industrial Douglas-fir forests in western Washington and western Oregon. Sources of information: Department of Natural Resources, Operations Research Section. 1975. Washington forest productivity study. Phase I Rep. Table 35, p. 116 (156 p.). Beuter, J. H., K. N. Johnson, and H. L. Scheurman, 1976. Timber for Oregon's tomorrow. Forest Res. Lab., School Forestry, Oregon State Univ. Res. Bull. 19. Table A8, p. 94, Management Intensity 5 (111 p.)
[2] Obtained from Appendix 5. (Note that values have been rounded.)
[3] Determined by multiplying [1] by [2].
[4] Sum of capitalized costs (see Appendix 1 for schedule of costs).
[5] Determined by dividing [4] by [1].
[6] Determined by subtracting [5] from [2] and multiplying by Capital Gains Tax Factor (0.30). This analysis assumes that site preparation and planting costs are capitalized, and that release costs are subsequently expensed.
[7] Determined by subtracting [6] from [2].
[8] Determined by multiplying [1] by [7].

APPENDIX 4.—Calculation of Before and After Income Tax Revenues for Southern Pine Management

Weed Control Method	Harvest Volume	Projected Price	Before Income Tax Value	Total Capitalized Costs		Tax	Net Value After Tax	
	(Cunits/ Acre)[1]	($/Cunit)[2]	($/Acre)[3]	($/Acre)[4]	($/Cunit)[5]	($/Cunit)[6]	($/Cunit)[7]	($/Acre)[8]
Chemical	30	100	3,000	55	1.83	29.45	70.55	2,116.50
Mechanical	30	100	3,000	90	3.00	29.10	70.90	2,127.00
Manual	30	100	3,000	100	3.33	29.00	71.00	2,130.00

[1] Based on expected average productivity (1.0 cunit/acre/year) of public (National Forest) and industrial southern pine forests. Source of information: Southern Resource Analysis Committee. 1969. The South's third forest. Report. Table X, p. 42 (111 p.). This estimate of expected average productivity agrees with actual values reported for loblolly and slash pine on medium sites in the Georgia Piedmont. Source of information: Lenhart, J. S., and J. L. Clutter. 1971. Cubic-foot yield tables for old-field loblolly pine plantations in the Georgia Piedmont. Ga. Forest Res. Counc. Rep. 22, Series 3. 13 p.
[2] Obtained from Appendix 5. (Note that values have been rounded.)
[3] Determined by multiplying [1] by [2].
[4] Sum of capitalized costs (see Appendix 2 for schedule of costs).
[5] Determined by dividing [4] by [1].
[6] Determined by subtracting [5] from [2] and multiplying by Capital Gains Tax Factor (0.30). This analysis assumes that site preparation and planting costs are capitalized, and that release costs are subsequently expensed.
[7] Determined by subtracting [6] from [2].
[8] Determined by multiplying [1] by [7].

APPENDIX 5.—Determination of Projected Prices of Douglas-Fir and Southern Pine Sawtimber Stumpage at End of Rotation

Year	Wholesale Price Index	Annual Average Price: Current Dollars	Annual Average Price: 1975 Dollars Constant	Annual Average Price: 1975 Dollars Constant	Five-Year Average Price (Constant 1975 Dollars)	Projected Price at End of Rotation (Constant 1975 Dollars)
		($/MBF)[1]	($/MBF)[2]	($/Cunit)[3]	($/Cunit)[4]	($/Cunit)[5]
			Douglas-Fir			
1971	114.0	49.10	75.33	37.67		
1972	119.1	71.70	105.29	52.65		
1973	134.7	138.10	179.31	89.66		
1974	160.1	202.40	221.11	110.56		
1975	174.9	169.00	169.00	84.50	75.01	
2025						257.82
			Southern Pine			
1971	114.0	52.20	80.09	40.05		
1972	119.1	65.60	96.33	48.17		
1973	134.7	92.68	120.34	60.17		
1974	160.1	90.90	99.30	49.65		
1975	174.9	76.80	76.80	38.40	47.29	
2005						99.19

[1] Sources of information:
Phelps, R. B. 1975. The demand and price situation for forest products 1974–75. U.S.D.A., Forest Service Misc. Pub. No. 1315. Tables 6 and 7, p. 40–41 (85 p.).
Ruderman, F. K. 1976. Production, prices, employment and trade in Northwest forest industries. 4th Quarter 1975. U.S.D.A., Forest Service, Pacific Northwest Forest & Range Exp. Sta. Table 32, p. 44 (54 p.).
[2] Adjusted by Wholesale Price Index to give average price in 1975 constant dollars.
[3] Conversion ratio of 2 cunits/thousand board feet (MBF) used to translate MBF prices into cunit prices.
[4] Five-year average price used as a basis for projections due to large fluctuations in annual average prices.
[5] Projected price based on 2.5% annual increase in constant dollar value of sawtimber stumpage as forecast in:
U.S.D.A., Forest Service, 1973. The outlook for timber in the United States. Forest Resour. Rep. No. 20. U.S. Gov. Printing Office, Washington, D.C. Figure 57, p. 148 (367 p.).

PANEL DISCUSSION

MR. FLAMM: I am going to try to give each of the panelists a fair opportunity and an equal opportunity to make comments and answer your questions.

Dr. Carter's talk was loaded with lots of information. I think it is obvious that some conclusions he has reached, and some of our earlier speakers have reached, are controversial; and not everyone in this room agrees with them.

I think to get things going on the panel I am going to ask Kent (Shifferd) to lead off and respond to some of the major conclusions, particularly those relating to—I think I can characterize the conclusions that the chemical method of vegetative control is the preferred method. Would you like to respond to that, Kent?

DR. SHIFFERD: I thought you were going to read all three conclusions, and I would respond to all three in general.

MR. FLAMM: Okay. The reason I didn't is that the other conclusion was not mentioned in the spoken comments but was in the written comments, which some of you may have observed, the conclusion that the loss of "T" would have serious effects on domestic timber supply.

DR. SHIFFERD: Well, I guess I agree wholeheartedly that those are Dr. Carter's conclusions. If I were going to write a paper defending the present method of management by herbicides, I would certainly want him on my team.

I studied his paper carefully, and he says you can't get there from here. You cannot get to any kind of alternative forest management program from Dr. Carter's conclusions, and I think that is because his approach is not viable.

He says on page 7 that they made a very incomplete analysis, and I agree entirely. What he has done and what he has done traditionally is to adopt and deal with a very few variables.

I think he did well. There are a few clinkers in the cost figures, but I don't want to deal with details. I think he sees very well what he is looking at, but his field of vision is too narrow and the Forest Service and the society at large cannot afford to take this kind of narrow and fragmented view of our larger problems.

I don't think we can afford this kind of specialized approach that doesn't take into account all the variables that make up the forest community and the larger community of which it is a part.

If you start with a narrow stock of ideas and data, then you are not going to come out with any kind of imaginative alternative approach, but Dr. Cutler and the Forest Service and the EPA, I think, are looking for imaginative alternative approaches, and you can't get there from here.

What we need to do is what has been done in the field of energy analysis lately. We need to make biological analyses.

Dr. Carter's paper deals with timber management. We are not talking about only timber management. We are talking about general forest management in terms of the six provisions of the Act. We are talking about the forest being managed to include the well-being of the larger community. That includes timber, but it includes a lot more than that.

What we in the Coalition are trying to do is bring together the jobs that need to be done—the various jobs in the timber management, or some of those jobs—trying to bring together the jobs, the dollars, necessary to do them, and the workers who can do them in order to produce not just timber but stable local economies and a more stable national economy.

We want a healthy society and a healthy environment, so we need to cast our net much more widely than Dr. Carter has cast his net.

I have been in the acamedic world 20 years, and I write these kinds of papers myself. They are narrowly focused and narrowly conceived, but the job that the Forest Service has to deal with cannot be that narrowly focused and narrowly conceived.

He is leaving too many things out of his cost/benefit analysis. The extra dollars that would have to be put in—I think we might quarrel with his figure of $60 million. We have people here who have data on that. But the extra dollars that go in through the Forest Service are dollars that can be and will be added by City Councils and County Boards as value added; their outflow on one part, but their input on another. This is money that improves the local communities. It is represented by money that would be taken out of the welfare rolls.

If we could figure out some way to take the workers that he discussed who are presently, many of them, in urban areas and bring them together with the work that needs to be done in the backwoods—and we think that we have ways to do that. In fact, we have an experience of doing that in some of the National Forests in California.

The creative approach is to use job training programs to retrain unemployed people and put them to work in forestry, not in some old fashioned CCC (Civilian Conservation Corps) "lean on the spade" program. We train them, and they go and compete for contract work in the free market. So they have incentive, because they can make money at this kind of work. We are not talking about a dole and putting the recipients out in the woods.

A more integrated forest management program, I think, is what we are talking about, whereby all the tasks that need to be done in the forest are planned out in advance and are done by labor intensive methods, thereby saving the management costs of letting separate contracts for erosion control and site improvement—we do have experience with that sort of thing.

We have people who would like to tell you about that if they had a chance to be here on the panel. So what we are saying is that we agree with Dr. Carter, that you cannot get there using his conclusions. I think he begins his paper with his conclusions. I am sure he wants to respond to that.

DR. CARTER: Only to the extent that the narrowness of the focus is stated in the program. Timber management was the topic which we were supposed to discuss, and I think my colleagues and I pointed out in the beginning that there were many issues of policy here that we did not intend to address, and that the focus of our paper was on the premise that we are going to produce timber on certain acres of lands, and what are the alternatives. So that is the reason for the narrowness of the focus.

DR. SHIFFERD: I appreciate that. My criticism is not so much of you but the narrowness of the focus of the symposium. It is fragmented, broken down in so many little pieces; we don't get a chance to see how all the pieces might fit together in a different way than the way in which they are being fitted now.

I am reminded of the brontosaurus, sure of his ecological dominance. He thought he was the culmination of all evolution.

We have a certain kind of management of our forests and our agricultural system in general. The message I get here is this is the culmination of all evolution in the industry of forest management and crop management; and there is no better way, and there is no other way, and we don't expect to see any change in the future. We argue that there will be change in the future and we need to find a way to make that change work.

MR. FLAMM: Thank you, Kent. I hope that maybe be the end of the day our pieces will fit together.

I have a couple of questions here addressed to Mike Newton, and I would like to read those and then give him a chance to make a few comments.

The first one asks, what less hazardous herbicides might be used rather than 2,4,5-T?

The other question is, Can you tell me something about the use of glyphosate in vegetation control in the United States?

DR. NEWTON: The question is, what materials are less hazardous than 2,4,5-T? I have several remarks that I would like to make on that subject. May I take the liberty to make some general comments on that question, Barry?

MR. FLAMM: Yes.

DR. NEWTON: We seem to have come into this conference yesterday and again this morning with a preoccupation for the hazard component of the herbicide program, and this fascination has been directed particularly to 2,4,5-T and TCDD.

Meselson, and this morning, Streisinger, have said we don't know about the hazard; and since the matter was brought up, I would like to comment and put the question of hazard in some sort of perspective.

First of all, this specter of hazard has been built on several studies, most of them published by Allen and his co-workers, and there are some corrections I would like to make in the data base that Meselson's story was built on.

I am very familiar with the work of Allen and his co-workers; and I point out that there are several inaccuracies, I believe, in the way that the data was being used.

First of all, the allegation that very, very low levels of subanalytical levels of TCDD are harmful, I think, was not substantiated by his data. His data on toxic fat, in fact, did not relate to TCDD. The analysis of toxic fat did not find TCDD. An assistant suspected that some higher chlorinated material was involved in that, but it was clearly not the TCDD—so it is inappropriate to use it here.

There was no dose-response curve in Allen's rat study and there were no data at all on the fate of his untreated rats, of which 60 percent died from the conduct of his experiments without explanation.

Allen, in reference to minimum dosage levels and their effects on rats, is referring to studies by Cociba and his co-workers, a more comprehensive study on rats, which shows a substantial "no-effect" level for TCDD somewhere between lifetime feeding level of 210 parts per trillion in the food supply.

Again with Allen's work, the reference is made to Allen's monkeys which when fed 500 parts per trillion of TCDD in the diet continuously, five of the eight monkeys died. The presumption on the other three monkeys was that they were not sacrificed. After withdrawal from 9 months' exposure to the high levels of TCDD, the monkeys bore young without any reference to the history of treatment, and those monkeys are in good health today.

Finally, the assumption of a 10 part per trillion level in dietary fat is hardly supportable, especially as it reflects a selectivity of data from "hot spot" sampling. There is a good deal of data that we do have that leads us to the understanding we have.

Controlled forced exposure to 2,4,5-T and TCDD by cattle has produced a maximum of 3 to 4 parts per trillion in body fat and that is only a minor percentage of animals so force fed. None was produced when pastures were used in rotation as required by the label.

When fed on treated forage, the cows did not concentrate TCDD in milk. When we used bioassay indicators of TCDD in forests treated with 2,4,5-T, we don't find it in vegetation at a 1–8 parts per trillion sensitivity or in water at a lower level of sensitivity.

There is evidence that chronic exposure doesn't occur in the environment accessible to animals. Apparently this material breaks down very rapidly. There is evidence of "no-effect" levels. There is evidence that in forests we can find it at extremely low levels and at levels that still give room for food chain accumulation without causing harmful effects on monkeys or rats. In other words, if it is accumulating, we can find it in the environment before it accumulates to harmful levels.

And there remains, of course, the remarkable safety record of forestry registered herbicides for the last 25 years. We don't have this precision of data for any of the alternatives. The phenoxies have the best and the longest safety record of any chemicals in use. They have been used as aquatic herbicides, used in forestry, and used extensively on field crops.

None of the alternatives are documented as well. We haven't looked with that intensity for harmful effects —we haven't looked with intensity for public health effects on alternative chemicals. So I would say, basically, until we have looked with equal precision for harmful effects of various substitute chemicals and of alternative practices, we probably can't say anything about the safety of alternatives.

I would just suffix those particular comments with a statement that I personally bear the scars of 50 stitches that I have sustained while working with alternative methods of vegetation management. I believe that particular record is greater than the summation of documented injury to people exposed to herbicides in 25 years of forest use in this country.

I had one neighbor—I live in a rural area in the woods—and I had a neighbor who was killed by a falling tree 10 years ago. I have another neighbor permanently crippled. He lost a leg with a power saw accident about 5 years ago. This is a very small sampling, but it is damning evidence.

I think I would just conclude with the remark, as far as safety is concerned, that we need to look with equal intensity at the alternatives. We have to turn our magnifying glass up as high a resolution for the alternatives as we do for 2,4,5-T and other chemicals. We have a professional obligation to do no less.

MR. FLAMM: Thank you. Let me sort of get off the chemical toxicity subject for a moment and pose a question to Stevens Van Strum that comes out of Mason Carter's paper.

Mason says it takes more than 5 million man-days to accomplish the same results with manual labor as is done with herbicides, and elsewhere in the paper he says that the labor force is not available. Would you like to address that question?

MR. VAN STRUM: Well, I am only acquainted, really, with the conditions in the Oregon National Forests, and I think that our costs are different there than the ones he quoted.

He talks here about a typical Douglas-fir plantation, 100 acres. The comparative costs are quite different in these National Forests, which is the area I am best acquainted with. Here we have costs given for 100 acres. They give $11,000 by hand, using a figure of $110 a man, that they estimate 100 man-days and $110 a man. They would be content with that figure for manual control, although we feel it might be done for quite a bit less. It depends on your overhead.

You can certainly get workers in our area to work very well and hard for about $64 a day. If you have $60 or $66 of administration costs, then it would get that high.

And the costs given for chemical control here are given as, I believe, $10 an acre. Well, the latest figures from the Siuslaw, the Williamette, and the average for Region 6 runs between $55 and $60 an acre; so, therefore, we would say at best there is a difference of the magnitude of two here.

One thing that has happened in the last couple of years is that we see the costs of manual control coming down and the costs of chemical control rising. Of course, as Dr. Newton and others have said, we really don't know enough about various manual control techniques as alternative techniques of management. If one wonders why that is so, we think of the capital that has been poured through R&D and advertising by multinational corporations into the development of chemical methods, whereas there is no multinational corporation yet that profits from manual methods to the degree where it can pour vast tax-free funds into the development of these alternatives. So it looks like the brunt of the development of the alternatives will fall on the government.

If I may, I would like to make a few statements about the availability of labor. I would like to address it primarily to government-owned lands because the contingencies that the Forest Service and BLM must operate under are quite different from those of either corporations or individual owners.

For example, in the Timber National Forest Management Act it says the Secretary shall promulgate regulations. The regulations shall include specifying guidelines for land management plans developed to achieve the goals of the program which ensure that timber will be harvested from National Forest System lands only where the harvesting system to be used is not selected primarily because it will give the greatest dollar return or the greatest unit output of timber. I doubt that many private concerns would feel that they could operate under that constraint, but the Forest Service is going to have to.

What we want to say is that there are a number of bits of new knowledge that are going to come along that are probably going to make us wish we had an alternative developed available for use.

We do believe in intensive management. We know that forests are going to be managed intensively. However, we believe when you finally manage them intensively it will be done by people.

I will take the Region 6 figures. Right now it is costing $300 an acre to plant, $200 an acre to burn. In Siuslaw it is costing $608 to carry a stand from logging—$608 plus $200 for the burn to carry an acre from the logging to the reestablishment of the stock stand. If we look at that $808, to me that is $64 an acre, and it would mean that we could expect to have 12 man-days per acre to spend on an acre, maybe at best four times as big as this room. At that wage you could have highly trained labor that knows all aspects of forestry. It knows fire fighting, seed cone gathering, weed control, planting, road maintenance, fire breaks, the whole picture; people who are educated, also, not just workers—people educated in their job.

In Lane County we are trying to set up a program in the Community College to teach people the skills, working in the field and the school simultaneously—a week in the field and a week in the classroom.

The best fertilizer is the shadow of the grower. These sites are visited rarely. People that live in these areas see them every day. There are sites that can only be logged selectively and need people examining, working, walking.

I think we should try to see what can be done putting that kind of money, the type of money now spent on herbicide management which moves throughout the whole cycle, people who stay with the work because it is well paid; they enjoy the work; it is good work; it is necessary work.

There is a labor force to do it, certainly in the cost range. There is high unemployment. There are people who love this work. Some of the things that are going to make us wish that we had that may be that there are going to be epidemiological studies of the health of people who live in sprayed areas. They are going to be done carefully, and I think that some people may be very unhappy when they see the statistics of the health of the people in our valleys varying from those in control groups.

The Forest Service is in a very difficult position because it is relying upon the EPA registration. Often we have heard it said almost as if it were an instruction from one government agency to another: "thou shalt use that."

In 1974 the Ad Hoc Policy Task Force all agreed on these conditions. One of the conditions was it was agreed that the label instructions for forest use should be reviewed carefully to assure that it is clear that recreational areas of the forest should not be treated. We not only recreate there, we live there 24 hours a day.

Many people speak of how there is little chance of exposure. They say that nobody will breathe that smoke. We breathe that smoke from treated units 20 days a year at least. Inhalation is probably the major route of exposure of people. It is probably not through water. It is along the roadsides, in back of you. When it heats up, there is volatilization. It affects the crops. That hasn't been looked at. It is difficult for people to grow many things.

This is an aerial photograph of Siuslaw. These are recent clear cuts. There are people living all through these valleys, completely covered, 19,000 acres; 19 acres were slated to be sprayed in the Siuslaw. It is not just a little bit; it is a lot. It is all around us, and we do know the effects. We are concerned enough that we are going to measure them to get facts to show you if you will believe nothing else.

I think the alternatives should really be investigated very thoroughly and honestly. So far, most of the investigations are done by people who are trying to prove it cannot be done, who say nobody will want to do the labor. There are young people who do not feel that way, who would be proud to do the work.

We all know that forest energy is going to be used. It is not just going to be done by whole tree chipping; it is going to change the whole economics. Cellulose is the cheapest, cleanest form of energy that we have, stored energy, and that is going to change things. When large corporations start to develop very efficient wood-burning units that will cook, heat a house, and heat all the water at a high efficiency and low pollution, we are going to worry about the problem of ending up like Europe or India and not having a stick of wood left.

So we somehow have to develop a force of forest workers who are professionals, who stay in the field for a long time, and who are well educated; and starting to use labor for vegetation management is one way to start developing this work force. It is going to be needed for many things.

Intensive chemical use, herbicides, is not selective. They are not accurate. They damage the conifers. We saw the conifer on the screen here, a loblolly pine, and he said it recovers. That is wonderful for a pulp tree. It is not good for timber or plywood, and that is what is happening in the Siuslaw. You can come out and look at the units and look at the trees.

Nobody has even looked at it, but it is well known in agriculture that phenoxy herbicides often cause an increase in the attacks of pathogens upon the protected crop. This has not been looked at carefully in the forest, and I think we can be very sure that it is going on.

Another thing that is going to probably change our whole conception of the problem is that as we see more the relationship between forest management and climate and the CO_2 cycle, especially when talking about using wood as energy. We are going to have to find that forest management is going to begin to have to deal with the climate. You can't change the reflectivity of vast areas without altering the climate. You can't alter the amount of bound carbon in humans too much; this is going to happen. It is happening. Have you seen George Woodwell's article? It is going to be an area of major concern—this kind of natural carbon dioxide policy.

I have a question. In site preparation in northwest Oregon, can a man cover an acre a day? You state $64 per day for a man, versus $56 for a chemical. I used his estimate of $110 a day and his estimate of the work he was talking about of one man per day. It depends on the operation. I think site preparation, probably in many of the cases, if it is done quickly after logging, you could do 1¾ acres a day. Clearing an old brush field is another issue.

The old brush fields are expensive to do by hand. They should never have been allowed to exist, and if we get on top of it we can make sure they don't continue to be produced.

When you combine conifer release with precommercial thinnings so you can combine the two contracts, I think for conifer release maybe three-quarters of an acre per man-day. The sites are very, very different, and it does change radically.

We don't have the type of economic statistics for manual clearance that you have for chemicals. No research has been put into it.

You see something like hack and squirt up there. You see a guy—where we live it is a girdling iron, and you can do that quickly, and you don't have to carry the knapsack.

We don't have the statistics. We have done a limited number of experiments. You will hear this afternoon about experiments done in California under contract with the Forest Service. BLM in the Coos Bay District and the Eugene District are doing experiments. There is a large area in Coos Bay being managed manually by people who want to prove it can be done, and we will begin to get hard data.

We are trying to tell you that you ought to invest in developing this method. The social benefits are great, and we don't have enough foresters. We don't have a steady trained work force for forestry, and we need one for all aspects of it.

DR. SHIFFERD: Could I respond on the use of forests as a fuel reserve and also to Dr. Newton's comments about safety?

MR. FLAMM: I would like to first let the other two panelists comment, and then we will try to make another round here. Ted, do you have any comments you would like to make?

DR. SILKER: Yes. I believe I would like to go back to a comment I heard yesterday regarding our apparent need to look at the elephant in terms of the some 125 people herein the audience and the rest of the Nation. We are all attempting to feel this elephant and determine what it is.

I think we have agreed to come here today, according to the charge of the keynote speakers, to determine what the facts are, what the problem is, and what the approach might be in the future, and see if we can work out the best combination with the resources available to a commitment that will give us our utility needs in the way of what can come from the forest, whether recreation or esthetics, wildlife, or timber production.

Going back to a comment that was made and also referred to earlier, I think I heard at what turned out to be a real fine social session last night (I thought we were going to have directed questions with a question and answer period), I think the social aspect was real fine, but there was a comment I heard yesterday that concerned me that goes something like this: The Federal toxic fatty materials presumably have TCDD in them—presumably—and I think when we come together to feel the elephant, you and I and the rest of the Nation, and think about our future needs, we had better give ourselves a chance to look at facts rather than presumptions and make an approach to problems that can get a team approach. I think that is what the keynote speaker said. The format of the conference is what do we have, what do we need, where are we going to go, and how are we going to get at it.

MR. FLAMM: Dudley, do you have some comments you would like to make?

DR. MATTSON: I would, briefly. One of the things that has not received a great deal of emphasis, I think, in this whole approach to vegetation management, although it was alluded to by several, is the long-time span involved in the activity of trying to manipulate vegetative cover to achieve our ends some time in the rather distant future. This is obvious on a moment's reflection, site preparation related to forestation for specific purposes, and we really are talking about, in most cases, from 25 years on up to 60 or 80, maybe 100 years.

This is a considerable commitment of resources that run into the multi-hundred range on a per-acre basis. The economists, like myself, are accustomed to dealing with time preferences for money and the costs as they accumulate over time when you invest and wait a long period for its return. We can juggle the numbers and come up with the kind of answers that make sense by today's economics. They may not make sense in terms of the wants and needs of the future. Unfortunately, we don't have crystal balls with perfect clarity to see what that future set of needs may be or what our preferences will be 10 years in the future, let alone 25 to 75 to 100 years.

We have limits on how we evaluate the benefits. Even today the benefits alluded to this morning are nebulous benefits except for those that represent fiber or harvestable wildlife or harvestable agricultural crops. These we handle with certain facility, and we can tell you it will be worth so much when harvested.

I wish we had better information on some of the other benefits that are alluded to broadly but are not quantified at all. I wish there were a means to put on a scale the benefits which are maybe social, maybe jobs, maybe amenities, maybe cleaner air. I wish we had ways to measure these benefits and quantify them because in the last analysis our choices today are based upon relative values that we see, that we place on all of these things, and not simply the dollar values that we manipulate with certain facility.

So I guess my plea is for more careful attention to quantifying the benefits from these investments which definitely are long-term.

I don't attempt to address the safety aspects or the use of chemicals or the non-use of chemicals. That is not my forte. I don't claim any knowledge here. I wish, however, that we had a better way to put the other side of the coin into clear perspective. What are the benefits from the choices we have made today?

MR. FLAMM: Thank you. Dudley's comment leads to a question I find very interesting that has been asked. In most of our discussions here, if not all of them, they related to the cost to the producer producing so much wood. Can you re-equate this to how much additional costs a consumer might have to pay? In other words, what are the end product differences in cost over the various methods we are talking about? Would anyone like to try that? Mason, do you have any information on that subject?

DR. CARTER: I am afraid not; no. You are talking about estimating the future cost of wood, or at least production, and then translating that into the final consumer. No, I don't want to join this estimation game.

DR. SILKER: I wouldn't mind taking a crack at it. I think Tom Dierauf brought to our attention, at least he did to me, or focused on it, that we are dealing in terms of the alternative uses in the silviculture, a high utility species in most cases that is in a sub-climation condition in terms of other vegetation with which it grows. And for that high utility species to be obtained or established on the ground so we have sustained yield—that the generation down the road has what it needs for this Nation—there is a point at the start of the rotation to get as many stems on the ground of that species as possible so at the end of the rotation we have complete utilization, or during the rotation we have complete utilization of the site for the maximum production, if we are after timber production. I am not saying that we need to dedicate all the acres in the United States to timber production. There are higher priority needs in the recreational area, watersheds, and the like.

If we are going to take care of timber production as Dr. Carter said, this is the tone assigned to this section of the 2-day meeting, then I think the cost down the road to the Nation would be just as severe, and we have had it brought to us clearly in the last 3 or 4 weeks what the farmer is facing today.

The farmer who raises cotton, sorghum, soybeans, or your corn for your nice, good, or excellent grade steak that you like to eat is operating a mono-climax concept, or he is preparing the ground; he is using herbicides; he is using hand labor; and in quite a few cases he is using machinery to keep the cost down and the production up. I think we recognize how it has been brought to our attention in the last approximately 5 weeks.

Is the small proportion of the Nation that is indebted to the small proportion of workers in the farm field supporting the rest of the Nation, and how dependent we are on this service area.

What I am trying to do is make an analogy that if we limit the efficiency of machinery and the innovation of new machinery to get the job done better, somebody said, who of us wants to be the 50 million that might be looking for better sustenance somewhere down the road. If we are dealing with sub-climax species, the Douglas-fir, the loblolly pine, the short-leafed pine, if you want to go to poplar, if you want to maintain these species, like the farmer—we have to consider a means of getting these on the ground to provide a sustained yield and future production.

No one is saying we are not striving here for what is the best we can look for with the least limit for the greatest interest across the Nation.

MR. FLAMM: We are going to have to complete this panel probably in 5 minutes, so I would like to run through again and allow the panelists to make additional comments, starting with Kent.

DR. SHIFFERD: Thank you. In the Chequamegon National Forest we have had a three-fold increase in fire permits. The Forest Service is killing off red oak to establish plantations. Our utility is now making impressive changes toward burning a mixture of coal and wood. Our oil and gas are Canadian, and they are going to be shut off, not curtailed, shut off in the next 2 years. So we think that these alternative uses that Steve talked about, especially the forest as a source of fuel, need to be preserved.

With regard to safety, I use a chain saw about 300 hours a year, and I am sorry Dr. Newton cut himself. I think it is a dangerous tool. I choose to use that. I am not a fantastic believer in zero risk. I choose to use that tool.

The actuarial tables are frequently cited saying the use of manual methods in forestry is one of the most dangerous kinds of activity. That is misleading because they include bucking and felling. That is where the danger comes in. Most of the methods we are talking about do not involve cutting large trees. We are talking about using a sand pick or some kind of brush action which I use on conifer stands on my own land.

So, if we were to look at the accident rate of people using a sand pick, it would come out differently than an accident rate of people using chain saws.

I choose to pick up the chain saw, and the worker Stevens is talking about chooses to go out and do that kind of work. The person who is sprayed in his garden by a Forest Service helicopter does not choose that risk. When you put dangerous chemical compounds in the environment, you have taken away people's choices, and I think that is an important point.

MR. FLAMM: Mike, do you have something?

DR. NEWTON: There is on the table out in the foyer a handout that I prepared that deals with some of the questions that we have to consider in managing a multiplicity of forest resources, and on page 7 of that handout there is a table which deals with some of the broader issues that we are coming to grips with.

There are lots of criteria for choosing a practice, and when we choose a practice according to the various criteria, we are choosing those criteria which are based in a substantial measure on not just a timber amenity, but water, wildlife, general utility, human safety, various other considerations, and we can't really say what any of these vegetation management tools are going to do to the supply of any of these things or the price of any of these commodities in the future.

We can say with reasonable certainty what those methods do in the way of increasing or not increasing the level of productivity for those uses, and on this table on page 7 this is really the summation of various alternatives and their utility that I have considered throughout this handout, but we deal with safety, we deal with timber growth, we deal with water, wildlife, and, of course, there is also the risk of failure in terms of silvicultural benefit.

The method has got to work not only in whatever management goal we are pursuing, and it has to deal with these other resource values.

I think you make a crossword puzzle, the question came up earlier, what selectivity questions are there. On page 5 of this handout there is a crossword puzzle that deals with selectivity of the herbicides. You pay your money, and you take your choice. Each herbicide has its own pattern of activity, and when you make your choice, you will get what you pay for, so to speak.

The same is true with other methods of site preparation. A bulldozer gives you a different set of consequences. Hand cutting gives a different set of consequences. Hand cutting with herbicides gives you a different set of consequences, and so forth. You have to project what this set of consequences is today, 20, 30, 80 years down the pike.

Okay, we have some information about what these things do. This particular handout is a digest of about 20 years' worth of research in the Pacific Northwest. I don't think we can ignore that. I think we have to add to it, but I think there is some information, and I think it is useful.

DR. SILKER: I would just make one comment on Dr. Shifferd's plea to get us to look at the use of hardwoods in the competitive position with the sub-climax conifers, and I think this is a real commendable goal. I think the forester would agree, if we can help him, he would like us to.

There is a time lag in all things, though. I can give you an illustration—Kansas, of all places. U.S. foresters kid the foresters from Kansas and say, "Has that tree out there died yet?"

We don't think of Kansas as being a forest area and yet southeast Kansas is; and, of all places, Kansas is taking à lead in this effort. Oklahoma is looking at it. We have mentioned it to resource people like Herb McGee, people highly interested in energy. They met with us 4 years back when it was not timely to undertake research at that time at that location, but we are willing, and we would like to help lead the interests in this area, and it will be done. I think I can guarantee you this: the foresters will help find a way.

MR. FLAMM: Mason has a couple of questions here outstanding that he will try to answer quickly.

DR. CARTER. Let me make a quick comment to you. Those of us in Indiana have been suffering in the coal strike in that we are one of the hardest hit areas and the Public Service of Indiana which serves the central part made an announcement that the coal was being shipped in under guard but was not adequate because they burn 27,000 tons a day of coal.

When we started talking about wood as a fuel, I wondered about how extensively we were going to use it as a substitute for coal, anyway. I am not real sure.

There are two questions here that I will try to answer real quickly. Two of them pertain to total tree chipping and if it depletes the nutrient supply. The answer, of course, is yes it will deplete the nutrient supply more so than harvesting the stem of the tree. How much so, we don't know.

There are studies to determine how much tree chipping will deplete the site. We have recharge through rainfall and the biological fixation of nitrogen, so whether the intensity of total tree harvesting is going to result in such depletion of the soil nutrient supply that we will require fertilization is still not firmly established one way or the other, but it is a concern.

The second question I am not sure I understand fully. If timber production is decreased by increased weed competition from a reduction in the use of herbicides, will forestry practices become more extensive or more intensive in order to meet the increasing demand for wood?

That is very hard to say. Again, it is a matter of public policy. The more forest land that is in production or at least is contributing to the raw material needs, the more acres you have, the fewer number of pounds of wood you have to produce from a given acre.

So the real concern for the future is how much of our future forest land base is going to be available for fiber production, and that is kind of imponderable.

You can meet the future needs of the country in either of two ways: by a certain level of production on an extensive percentage of the commercial forest base or with high intensity production on a subtracted or a reduced percentage of the forest base.

I know my colleague was going to jump up on fuel. My only point was that direct combustion of wood as a substitute for coal—there are some questions about it. As a substitute for petrochemicals it has tremendous potential in that aspect of the energy.

MR. VAN STRUM: I wanted to mention that I think there are couple of studies that address the problem and one of them is in Virginia. Malcolm Frazer and Intertechnology Corporation, who have done a large study of the potential of wood as an energy source, calculate that 1/7 of the forests of the United States could, on a renewable basis, meet the entire energy needs of the United States.

Dee, a forest economist at Oxford, wrote a book called *Forest Energy and Economic Development*. He has developed a number of forestry systems in the tropics in India which developed this resource. Also, he is working in British Columbia. There are a number of statistics that are useful in trying to assess responsibilities.

MR. FLAMM: I have the unpleasant duty of bringing this interesting panel discussion to an end.

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POST-SYMPOSIUM RESPONSES TO QUESTIONS SUBMITTED TO THOMAS NELSON

QUESTION: Are timber management objectives mutually exclusive with the objectives of multiple-use management?

ANSWER: No. Timber management objectives are part of the multiple-use objectives on the National Forests. We believe that we can increase timber production, forage production, and wildlife populations of the National Forests and have developed a program for increases. Where timber is harvested, the trees are usually replaced by grasses, forbs, and shrubs which improve wildlife habitat for a period of time. With the proper mix of vegetation, we can grow beautiful, healthy, quality trees and provide food and homes for wildlife.

QUESTION: Are there any indications that the public will support funding for more labor-intensive management of the National Forests?

ANSWER: The public might support funding a more labor-intensive management program for the National Forests. However, at the present we are using labor on those projects where labor is the most cost-effective. There is a large enough need of this kind of work to employ a rather large work force. We would need approval to hire more people and would need administrative approval for additional financing for such a program.

QUESTION: Isn't the Forest Service decreasing the quality of timber in the National Forests, since the best and strongest wood in a tree grows only after approximately 70 years, aren't we growing inferior products for the sake of short-term profits?

ANSWER: We believe we are increasing the overall quality of timber in the National Forests. We are using geneticists to breed superior trees. We are using intermediate cuts to remove defective, diseased, and poorly formed trees. The reason for growing timber on the National Forests is to supply timber for people to use for homes and other purposes. The length of time from regeneration to final harvest varies from 70 to 150 years, depending upon species and the location of the timber stand. At a rate of growth of 6 rings per inch we can grow trees 40 inches in diameter in 120 years.

QUESTION: Are the overhead costs of preparing and surveying an area to be cut by contracted labor included in the bids of that party? If not, isn't the Forest Service in reality competing against private landowners for timber cutting contracts?

ANSWER: This is a complex question that is not simply answered yes or no. Certainly, any time the Forest Service sells timber where there is private timber also available and the supply exceeds the demand, it could be considered competition. In fiscal year 1977 the Congress appropriated approximately $185 million for timber management activities, including sale preparation and administration, reforestation, and timber stand improvements. Receipts, including purchaser contributions for reforestation and timber stand improvement, purchaser road construction credits, and deposits to the treasury were about $860 million—over four times as much as appropriated to finance the sale of timber. This certainly covers overhead costs as stated. In addition, National Forests and their users benefit in many ways from the harvest of timber. Some timber sales are specifically designed to improve wildlife habitat or to enhance recreation developments or to salvage and prevent waste of fire, insect, or disease damaged timber.

The Forest Service supports the principle that the private timber landowner should realize a fair return for his timber. In few instances will National Forest timber sale prices have a negative effect on the private timber landowner. Often, the publicized competitive bidding process for National Forest sales will have a positive price influence on other timber, resulting in higher prices than would have been received had National Forest bids not been public information.

QUESTION: Is America the leader in forest technology? What are other countries doing, and can we learn from them? England is still using 2,4,5-T, and Sweden is a world leader in soil science—can we learn from them?

ANSWER: We can learn from other countries. American silviculturists have visited forests in other countries. Techniques and methods used in other countries are not always applicable in this country. However, we do use seedling lifters that have been developed in other countries, some of the same nursery management practices, and some of the same cutting methods for certain tree species.

QUESTION: The United States Forest Service, under the National Forest Management Act of 1976, Section 2 (7), has been directed by the Congress to "expand its research in the use of recycled and waste timber product materials, develop techniques for the substitution of these secondary materials for primary materials, etc." It has been stated that recycling 60 percent of the paper now used in the United States would relieve by 50 percent the demand on our forest by pulp and paper interests. Would you comment on the need for intensive forestry management and use of herbicides as the management tool if USFS is indeed implementing Congress' mandate to recycle?

ANSWER: The use of recycled paper will help us fill some of the demands for pulpwood. However, we doubt that the use of recycled paper, forest management, or both, will fulfill the future needs of the Nation for wood. The energy shortage has created a new demand for wood. Some of this demand can be filled by material that is left over after logging such as stumps, slash, etc., and by trees that are not merchantable for other products. Wood is being considered as a replacement for oil in fueling power plants and as a mixture with coal to heat schools. Wood mixed with coal gives a cleaner burn and will allow the use of low-grade coal as fuel. There is a shortage of quality solid wood to use in building homes and for other products. Herbicides are used to grow these improved solid wood products as well as to increase the volume of fiber.

POST-SYMPOSIUM RESPONSES TO QUESTIONS SUBMITTED TO MASON CARTER

QUESTION: Seventy-two percent of the commercial forest land in the United States is in private ownerships. How then can you predict that chemical use will increase in the future when the timber "breadbasket" is with private, small landowners who cannot afford to use chemicals?

ANSWER: First, I believe the 72 percent figure refers to the South. The national figure, I believe, is 59 percent of the commercial forest land is in private, non-industrial ownership.

I expect increasing use of chemicals for silvicultural purposes on the private, non-industrial lands. Chemicals are the cheapest tools available for some purposes, and I believe they will be the first choice of many private landowners as timber values rise and incentives for management increase.

QUESTION: If the chemical approach to managing timber forests is so effective and safe, why are there so many citizens living near the sprayed areas so concerned about their health and the effects of these sprays? It seems to me if there were no problems with spraying, then there would be no angry response from the people.

ANSWER: I don't think that there is a relationship between the inherent safety of a product and the reaction of certain segments of the public.

Far more 2,4-D and 2,4,5-T have been used in agriculture than in forestry, but forestry uses seem to cause much more concern in some areas. I didn't say there were no problems in the use of herbicides. Careless applications have resulted in damage to desirable vegetation giving due cause for angry responses. Proper application will avoid such problems.

QUESTION: Dr. Shifferd implies that foresters, specifically the Forest Service, thought we had reached culmination of management. Obviously, he is not familiar with forest research programs of universities, industries, and the Forest Service. Do you have comments?

ANSWER: I'm not certain I understand the question. If you are asking whether we have reached maximum or optimum productivity of our Nation's forests, then the answer is "no." In 1970 our commercial forests were estimated to be producing at about 50 percent of their potential with available technology. Developments in tree improvement; fertilization; insect, disease, and wildfire control; plus improved utilization have raised the potential productivity and will continue to do so for some time yet.

QUESTION: How does a herbicide perform the requirement of "bedding" in southern pine forest site preparation? Is it used on wet soils?

ANSWER: "Bedding" is a soil disturbing technique accomplished with a special plow and tractor. Herbicides are not involved, except possibly as an additional treatment. "Bedding" produces a series of ridges 1–2 feet high and was originally developed for very wet sites to improve drainage and elevate planted trees above standing water. Subsequently, bedding has proven effective on certain well drained sites where it may reduce competition or improve soil properties.

QUESTION: Hasn't the forester's interest in using the "in thing," or the easily applied and inexpensive herbicide, caused him to overlook the possibility of some equally effective and economically comparable alternatives?

ANSWER: This is a good example of a "wife beater" question, since it implies that the use of herbicides is a relative new "fad" and that "effective economically comparable" alternatives are available. Neither of these implications is true. 2,4,5-T has been used in forestry for nearly 30 years, and some of the inorganic materials long before that. They can hardly be classified as the "in thing." As pointed out repeatedly in our paper, there are no effective and economically comparable alternatives to herbicides for accomplishing certain types of vegetation management.

QUESTION: Dr. Carter failed to give cost/benefit figures for fire. What are these figures?

ANSWER: I did not present figures on cost/benefit of fire, but some can be found in the cited literature (see Chen, et al., 1975, 1977). Fire is an effective tool with a good benefit/cost ratio, especially in the southern pine region. But fire is limited by time, terrain, and weather conditions to such an extent that it is rarely satisfactory when used alone. Fire cannot be used to release overtopped Douglars-fir plantations without destroying the planted trees.

POST-SYMPOSIUM RESPONSES TO QUESTIONS SUBMITTED TO MICHAEL NEWTON

QUESTION: This symposium is supposed to focus on the use of herbicides in forestry. Thus far, none has addressed the topic of the kinds of herbicides which should be produced by chemical companies for the future. What kinds and types of chemicals should there be? What should they do and not do?

ANSWER: There are several answers to this question involving forest biology, research and development requirements, and risks of regulatory action in the absence of explicitly defined standards of efficacy and toxic hazard. I will approach them in that order.

A herbicide used in forests must be low in mobility in a watershed system or low in root uptake activity or both. There is little promise for substances moving downstream in biologically active amounts; nearly all herbicides now in use meet this criterion. The chemical also must be low in volatility and have moderate or lower acute oral toxicity to wildlife with short retention time in animals. These criteria either are met by all the presently registered herbicides or else dietary residue tolerances established for human foods are not exceeded by observed animal retention.

The new herbicide must be able to control sprouting hardwoods and shrubs and other presently resistant weeds without leaving a residue injurious to crop tree species. The lack of ability to control sprouts is the greatest deficiency in the presently available materials. Ideally, a herbicide should be able to eliminate all sprouting of species that threaten management goals, yet retain sprouts of species that are valuable for forage. Although this goal would appear to be impossible, there are several products that do this in limited circumstances. The dormant-season application of 2,4,5-T in Douglas-fir is an example. A new product should be able to accomplish similar results, especially under circumstances where present materials are deficient. A perusal of forest-weed inventory data in the various regions will help identify the problems presently not being solved when registered chemicals are used.

The greatest present problem in the forests of the United States is that of low-grade or cull hardwoods. These may be competing with high quality hardwoods or softwoods. There may often be a requirement for selectivity among like species. Some 250,000,000 acres have a serious problem, but the mosaic of forest types will certainly require an array of herbicides if broadcast treatments are to be used satisfactorily on much of it. At present, herbicides are available that will solve some of these problems, especially for site preparation, but available technology is not widely being put to use. This is mostly for reasons having little to do with herbicide technology.

At present the requirements for research and development in forestry are vague. Requirements for wildlife exposure data are unspecified, and procedures for evaluating forest ecological changes are not defined. The number of new regulations relating to endangered species and related ecological matters suggest that the goals for a new chemical may change while research is in progress.

Finally, a chemical company can regard as risky any investment in forestry until regulatory agencies establish specific guidelines which, if met, will protect registrants and users from restriction and litigation.

QUESTION: Are forest animals affected directly by herbicides? How about through indirect effects, such as habitat alteration?

ANSWER: There is no known evidence of direct effects of registered uses of herbicides on wildlife. There are many published reports of wildlife responses to treatment, many of which show a beneficial result on observed species. Most of the studies do not actually investigate the exposures to the herbicides, however. I have conducted two studies of exposure, one with blacktail deer exposed to 2,4,5-T and atrazine, the other with mountain beaver, a hole-dwelling mammal of the Pacific Northwest coastal uplands, in connection with chronic exposure to TCDD. Borrecco, Black, and Hooven, of Oregon State University, have also studied population dynamics of small mammals in large areas deliberately treated to study wildlife responses.

In our study of deer (published in the 1968 Proceedings of the Western Society of Weed Science, Boise) Norris and I evaluated herbicide concenrtations in rumens and numerous organs of animals collected at various intervals after spraying. Norris is continuing work of a similar nature. Our findings showed that routine aerial applications resulted in stomach concentrations of less than ½ part per million of 2,4,5-T at any time, and about five parts per million for atrazine. As a general principle, little more than a part per million per acre-pound of herbicide appeared in the diet. This equates to a short-term exposure level of approximately .05 mg/kg of body weight per day, or less than 1/1000 of the quantity fed dairy cows and sheep by Palmer and Redcleff (1969. U.S.D.A., Washington, D.C.), with no observable effects.

In our study of mountain beaver I collaborated with Dr. Stanley Snyder of the Oregon State University Veterinary Diagnostic Laboatory, and Dow Interpretive Analytical Services Laboratory to determine residues and histopathological effects of 2,4,5-T and TCDD. In short, application of 2 lbs per acre each of the butyl esters of 2,4-D and 2,4,5-T did not have an effect on the gross or microscopic anatomy of the mountain beaver or its apparent health. In searching for TCDD residue after 45–60 days of chronic exposure, there were no clear positive determinations in the livers (the organ most likely to accumulate it) at a resolution of 3–17 parts per trillion. We deduced from the ratios of dietary TCDD to liver concentration in rats reported by Kociba *et al.* (submitted for publication in J. Tox. and Appl. Pharmacology) that the dietary levels of TCDD for these forest animals must have been less than ⅛ part per trillion. This was less than 1/1000 of the lowest level found by Kociba *et al.* to have caused any measurable health effects on rats in a lifetime of feeding and three generations of reproduction. It is therefore my conclusion that there is probably no possibility of demonstrating direct harmful effects from these materials when applied to forest habitats.

The work by Borrecco, Black, and Hooven has demonstrated that there is a close relationship between habitat changes and populations of certain species of small mammals (*Microtus, Sorex*) and little response in others (*Peromyscus, Sorex*). These relations are probably consistent regardless of the method used to achieve the habitat change. As a general principle, one can assume that the greatest changes in food supply and physical surroundings will have the greatest effects on mammals. Understanding that a substantial habitat change for seedling trees is an essential ingredient for successful site preparation or release, the methods causing least physical disruption will almost certainly have the least impact on local wildlife species. It is also germane that the habitats being changed will again eventually be dominated by the trees being established, which are often the species that were present before the brush became established. Thus, the long-term habitats will reflect the dominant forest cover rather than the method used to manage it. This same principle brings into perspective the temporary nature of any wildlife population dependent on a particular seral stage of forest succession. Treatment with herbicide may simply accelerate change.

QUESTION: Are the presently available herbicides (2,4,5-T, 2,4-D, silvex, picloram, dicamba, atrazine, simazine, dinitroanilines, etc.) all that are needed for production of food, fiber, fuel, water, wildlife, etc.?

ANSWER: Most forest management objectives could be accomplished if the presently manufactured chemicals were adapted to appropriate forestry uses. New chemicals could improve the sophistication of vegetation management, but for the present the lack of implementation of good management practices is much more of a problem than lack of appropriate tools. The herbicides currently available do not pose a safety problem and can be used with reasonable effectiveness and cost. When the available materials have been put to sufficiently widespread use so that their limitations can be evaluated more fully, the incentives for new materials will become more clearly defined. I believe the same rationale can be applied to many of our other cropping systems.

QUESTION: How can we find TCDD in the environment before it reaches high enough levels to cause problems? What analytical methods do we use? How practical is this approach?

ANSWER: We can examine the evidence of toxicity and establish acute and chronic toxicity levels and decide what margin of safety is necessary. We can then determine a maximum permissible exposure level and set our environmental monitoring precision to detect an average exposure that exceeds this. Further refinement is of academic interest only.

Looking at the available toxicological evidence, Allen's data with monkeys and rats suggest that chronic exposures of 500 pptr in the diet are too high to be tolerated. Kociba *et al.* have established that a lifetime diet of 22 pptr has no effect on *rats* or two generations of offspring, but that 210 pptr has some toxic effects that are of the reversible type. Only at dosages of 2200 ppt were significant tumors initiated, and these were associated with several general symptoms of chronic intoxication. In view of the large size of the study by Kociba *et al.*, and its agreement with other studies by Kociba *et al.* in 1967 and DiGiovanni *et al.* in 1977, one might postulate that a lifetime exposure of less than 210 ppt would not be likely to induce cancer and would result in no worse than minor health problems.

A factor of 1:100 below lifetime feeding levels leading to "safe" results is often used to determine acceptable levels of exposure, although no formally accepted standard has been published. A much higher level is acceptable for short-term exposures. Under the circumstances some level between 0.22 ppt and 2.1 ppt would be acceptable as an average dietary intake in all food, with higher levels permissible for brief periods provided they are separated by periods of lower concentration. Only the higher of these is detectable with today's analytical methods if analyzed directly; and at this level, quantitative detection has a large error.

Examining the various studies of TCDD accumulation, there appears a close relationship between dietary intake and concentration in the liver. This ratio is consistently about 1:25 at dosages that are not intoxicating to the animals. Symptoms of pathology do not appear until the animals are carrying roughly 5,000 ppt in the livers, which is easily detectable. Thus, by analyzing livers of exposed animals, it is possible to determine if they have been feeding on contaminated forage and how consistent the contamination is. In our paper Snyder and I used this procedure in determining that there was no more than one-eighth part per trillion maximum TCDD dietary exposures to mountain beaver in sprayed habitat.

Using the above procedure, it should be possible to sample human food for determination of TCDD by the technique of rat bioaccumulation. In this procedure a diet of the food sample would be fed to a rat for an extended period, then its liver would be analyzed to determine the average exposure. According to Kociba *et al.* (1976), rat livers equilibrate in about 13 weeks. It is thus possible to capitalize on the very problem that is of concern to us, that of bioaccumulation, to determine reasonably quickly if there is a bioaccumulation hazard. It appears to permit the detection of integrated exposure levels at about 1/25 of present detection limits or at higher levels with improved precision. It also permits detection in a minor item of food before the general contamination in meat reaches that level. The process could be repeated in series to examine any degree of bioaccumulation through several trophic levels.

The bioaccumulation technique is useful for three or more reasons: (1) It looks for low levels of TCDD in the diet and integrates the entire diet over a period of time; this is highly desirable in a study of a chronic intoxicant, (2) it looks for the evidence of food supply contamination in precisely the matrix where it is of concern, and (3) it minimizes the need for continued improvement and specialization in TCDD analysis. I believe further study of the method may demonstrate how it can be used as a general monitoring tool that will greatly reduce numbers of analyses and will provide improved indices of exposure.

QUESTION: Are the same safety standards required of forest herbicides as of alternative methods of vegetation control? Of urban pollutants?

ANSWER: Apparently not. Herbicides are challenged in courts and in the newspapers despite overwhelming evidence of greater safety than alternative methods. If evidence of equal safety were required of non-chemical vegetation control, it would be many years (and perhaps never) before alternative procedures could be used. The requirement of an environmental impact statement for herbicide use on Federal lands is a paradox in that all alternatives, including that of no treatment, may be argued as having a greater long-term environmental impact than herbicides.

If the same standards were applied to urban pollutants, many human activities would be halted pending study of the effects of their actions and by-products.

* * * * * *

INTRODUCTION OF PANELISTS

MR. FLAMM: Time is even shorter this afternoon than it was this morning. We have only 45 minutes each for three panels, and then John McGuire has the difficult job of summarizing the 2 days' activities. I will begin with the introduction of our panel.

Down at the far end of the table is RAY DALEN, Range Improvement Specialist, Southwest Region in the Forest Service at Albuquerque, New Mexico.

Our next panelist is DR. HOWARD MORTON, Research Leader, Rangelands Weed and Brush Control Research Unit in the Arizona-New Mexico area, located at the University of Arizona. I am going to use a word for the first time: he is with SEA, Science Education Administration of the Department of Agriculture.

Next to him is RON KUHLMAN, Chief for Watersheds, Bureau of Land Management, Department of Interior.

DR. JAMES YOUNG, Professor of Range Science at the Max C. Fleischmann College of Agriculture, University of Nevada, Reno, Nevada.

Our last panelist and a newcomer to the panel is STEVE HAGER with the Citizens Against Toxic Sprays.

MR. FLAMM: Our speaker to start our discussion on alternate methods of vegetative management for range purposes is DR. CHARLES SCIFRES. He is a professor in the Department of Range Science at Texas A&M University, located at College Station, Texas. Dr. Scifres will present his talk on "Range vegetation management with herbicides and alternate methods: An overview and perspective."

DR. SCIFRES: Thank you. I have to start by prefacing my comments first, in that I have never felt quite so set-up before. When I first inquired about this symposium, I understood that it was not a symposium covering the very complex issues surrounding the use of 2,4,5-T. It has indeed, as I should have understood, developed into that. This proves stories about Texas Aggies being naive. I prefer the word "naive" over "stupid."

RANGE VEGETATION MANAGEMENT WITH HERBICIDES AND ALTERNATIVE METHODS: AN OVERVIEW AND PERSPECTIVE

Charles J. Scifres

Improvement of rangeland vegetation infested with herbaceous weeds and/or undesirable woody plants is a management problem that must be approached on an ecological basis and within a rather strict economic framework (47). Traditionally, papers of this type begin with estimates of extent of losses caused by undesirable vegetation, especially acreages infested, and impact of the problem related as lost production. Tradition is ignored herein because the problem and its causes have been debated to the point of becoming dogmas; and the benefits, potential and real, associated with proposed solutions have so often been reiterated that they are being interpreted by some as trite justifications for researching the problem. Those of us who work in range management recognize the "weed and brush problem" as being of staggering magnitude, real and, in many cases, without effective solution.

That herbicides have played an important role in improvement of rangelands supporting excessive weedy plant cover is an understatement. Moreover, I expect them to continue to be critically important tools for the natural resource manager. An ever-expanding knowldege base concerning the properties, action, and use of herbicides aids in the continual refinement of our approach to their future role in natural resource management. However, their ultimate utility will depend on a broadening of research attitude relative to herbicide use in range management.

Before discussing the potential of herbicide use on rangeland and associated problems, it appeared advantageous to establish a conceptual framework which might be of value in weighing the merit of the attitudes presented herein:

(1) *Terms such as "vegetation management" and "brush management" should be considered in lieu of the conventional "weed and brush control" when considering range improvement.* Terms such as "eradication," now generally outmoded, have never been of practical utility

in range management. Although the concept of brush management on rangeland is not new (14), the time appears right for vigorously promoting its general acceptance.

(2) *Weed and brush management on rangeland is designed to expedite secondary succession*[1] *in order to optimize the economic output of range products (livestock, wildlife, recreation) on a sustained basis.* Weed and brush management on rangeland cannot be approached with the attitudes underlying weed control in monocultures. The objective of row crop agriculture, highly input-oriented production systems, is to retard secondary succession to maximize income based on production of a single plant species, usually an annual (63). Conversely, diversity of available forages is an attribute for effective range management systems since range animals, domestic and wild, thrive on a mix of vegetation.

(3) *Rangeland is heterogeneous by nature, diverse dynamic plant stands are the rule, and variability is an attribute.* The most logical unit for discussing the merits and weaknesses of any range management practice, including herbicide use, is the range site—the basic vegetation grouping as dictated by soil and climate. Range sites vary significantly in kind or proportion of plant species, or total productivity; and a given management unit (often a pasture) is usually composed of several sites. Understanding this concept is fundamental to "making the most" of any range improvement practice.

(4) *Ultimate success from weed and brush management efforts hinges directly on effectiveness of the natural resource manager.* Effective weed and brush management is readily nullified by mismanagement, especially overgrazing. Rangeland is quickly abused and slow to recover from mismanagement.

(5) *The rate and extent of improvement from range vegetation management, especially on the short term, is highly dependent on weather patterns, particularly rainfall, for that time period* (27). Drought, a factor with which the natural resource manager must persistently coexist, can negate the beneficial aspects of vegetation management efforts for extended periods.

(6) *Brush management herbicides are generally applied to a particular management unit at widely-spaced intervals, usually of 7 to 10 years, as dictated by ecological, management, and economic considerations.* Annual applications are considered only on a few woody species, and then for no more than 2 to 3 consecutive years.

Although undesirable herbaceous plants are of great importance to the range manager, woody plants and their management have been the historic major concern of many, if not most, range managers in the Southwest. Certainly, woody plants and their management have been emphasized in Texas research programs. Therefore, most of the remainder of this paper will focus on brush management to exemplify potential benefits from herbicide use in recognition of some basic, associated problems. This is not an indication that herbaceous weed problems, especially in local situations, are of lesser importance than woody plants. Also, the attitudes espoused in this paper are primarily a reflection of the author's experiences with application of the principles of weed and brush management on Texas rangelands.

EVOLUTION OF HERBICIDE USE ON RANGELAND

The earliest herbicide work on rangeland, not considering use of petroleum oils, probably was accomplished with sodium arsenite (67). Its toxicity at low concentrations to woody species such as honey mesquite (*Prosopis glandulosa* var. *glandulosa*) and its systemic action offered a new dimension to early brush control efforts (18). Other chemicals such as sodium chlorate and ammonium thiocyanate were not equal in effectiveness to sodium arsenite for woody plant control. However, the mammalian toxicity and corrosive nature of sodium arsenite precipitated abrupt reductions in its use as other effective, less hazardous chemicals were developed (43). Probably the single-most important advance in herbicide technology was the discovery of the growth regulating properties of the phenoxyacetic acid herbicides (26, 39) especially 2,4-D [(2,4-dichlorophenoxy)acetic acid] and 2,4,5-T [(2,4,5-trichlorphenoxy)acetic acid]. Related herbicides including MCPA [([4-chloro-o-tolyl]oxy)acetic acid], silvex [2-(2,4,5-trichlorophenoxy)propionic acid], and dichloroprop [2-(2,4-dichlorophenoxy)propionic acid]

[1] Secondary succession, referred to throughout this paper, is the successive occupation of an area by different plant communities progressing from bare soil through an early weed stage to climax or potential vegetation, the most productive stage for any given range site.

have found only limited used. Moreover, 2,4-D and 2,4,5-T continue to have broadest application for general range improvement. The substituted-urea herbicides, monuron [3-(*p*-chlorophenyl)-1,1-dimethylurea] and fenuron (1,1-dimethyl-3-phenylurea) appeared promising in the 1950's but apparently could not compete economically with the phenoxy herbicides. Most recently developed compounds with potential for widescale use on rangeland are dicamba (3,6-dichloro-*o*-anisic acid) and picloram (4-amino-3,5,6-trichloropicolinic acid) (25). Although use patterns for dicamba are similar to those for 2,4-D and 2,4,5-T, it controls a slightly broader spectrum of herbaceous weed species than the phenoxys, may be more effective in some situations such as for control of honey mesquite in the drier portions of its range (49), and is commercially available as a mixture with 2,4-D or 2,4,5-T. Picloram is a highly effective, broad-spectrum herbicide, enters many species via both roots and foliage (dicamba also possesses this characteristic but foliar entry is apparently most important on a practical-use basis) (6), and is more persistent in the environment than phenoxy herbicides but with a low mammalian toxicity (6, 49). Bovey (5) provided a detailed discussion of the properties, activity, and use of these hormone-type herbicides. New herbicides such as karbutilate (*tert*-butylcarbamic acid with 3[m-hydroxyphenyl]-1,1-dimethylurea) (62) have been evaluated for use on rangeland as a result of their activity as total vegetation control chemicals. One of the most recent promising herbicides, tebuthiuron-*N*-(5-[1,1-dimethylethyl]-1,3,4-thiadiazol-2-yl)-*N,N'*-dimethylurea], selectively controls several woody species which are relatively tolerant of conventional herbicides (9, 59).

UTILITY OF HERBICIDES AS ALTERNATIVES FOR BRUSH MANAGEMENT SYSTEMS

Almost half of the U.S. land area is used for grazing and most of this is rangeland. Considering the magnitude of resource involved, relatively few herbicides are available for range improvement (50). A cursory review of herbicides given common names by the *Weed Science Society of America* as listed in the final 1977 issue of *Weed Science* indicated that of about 150 compounds, some 11 have application to range management. After eliminating those with relatively minor uses, such as AMS (ammonium sulfamate) and MCPA, and those which have most applicability to tame pasture management, only four or five (2,4-D, dicamba, 2,4,5-T, picloram, and silvex) are applied primarily for improvement of native range (46).

Development of herbicides for range improvement has lagged behind development of herbicides for monocultures since rangeland is apparently considered a "minor crop" by the chemical industry because of economic constraints facing the range livestock industry. Eight acres of humid rangeland may support an animal unit (1000 pound cow with calf), 20 to 25 acres may be required in humid zones, and 50 to 60 acres may be needed for each animal unit in arid zones (50). Yet, grazing is the best known use for these lands, and only through weed and brush management can their full production potential be realized. Range managers are faced with the challenge of adapting only a few chemical alternatives to cope with a myriad of weed problems plaguing an industry characterized by a high degree of economic risk and uncertainty. The apparent means of improving the land manager's probability of success in vegetation management without shifting traditional land-use practices from range livestock production are:

(1) Discovery of compounds which are highly effective but which can be manufactured and applied at low cost. This hope is idealistic at best when dealing with profit-motivated industries.
(2) Improve the economic framework surrounding the use of presently available compounds by increasing their initial effectiveness (or replace them with more effective herbicides which cost no more to use) and protracting their effective life.
(3) Replace the use of herbicides where possible with economically feasible alternatives.

At present the second and third alternatives appear most plausible from this researcher's view. In my opinion, past attempts at improving the technological base for coping with excessive quantities of undesirable range vegetation have too often been narrow, single-treatment approaches. The natural resource manager must be provided with a set of viable alternatives to effectively deal with his brush management problems. No single approach whether chemical, mechanical, biological, or prescribed burning can be viewed as an ultimate vegetation management practice. Heterogeneity of the resource, production potential, and management objectives impinge directly on selection of the vegetation management alternative. Since range vegetation management is a long-term consideration, it is suggested that practical utility of any method can be exploited only to the extent that it is adaptable into management systems. The systems approach allows the manager to take advantage of unique strong points of several methods while minimizing the impact of characteristic weaknesses of each (44).

Brush management serves as a prime example of the need for application of the systems concept to natural resources. Herbicides have potential of becoming increasingly important components of brush management systems as constraints, especially economic, progressively limit other approaches.

Cost of equipment, labor, and energy historically have limited use of manual and mechanical brush management methods, especially those which require heavy equipment. As the costs of any method continually increase relative to the value of the output, range managers must seek viable alternatives to their use and/or apply the expensive alternatives only to those sites with high production potential. For example, the influence of the poisonous range plant bitterweed (*Hymenoxys odorata*) was effectively limited in the early days by hand pulling. However, reduced availability of labor at low wage rates in addition to the spread of bitterweed now dictates that other methods be employed, primarily spraying with herbicides such as 2,4-D. Since the scope of this paper does not allow consideration of the merits and weaknesses of all brush management alternatives, only the more widely used alternatives will be entertained.

Mechanical brush management alternatives can be categorized by function as those which simply remove the aerial portions of plants (shredding, roller chopping) and those designed to remove the entire plant (grubbing, chaining, root plowing, dozing). Improperly applied, methods of entire plant removal, especially chaining, often function primarily as methods of simple top removal.

Methods of simple top removal offer only temporary brush management benefits. Although the brush canopy is reduced in the season of treatment, canopy cover may actually increase in subsequent years because of the high vegetative regrowth potential of troublesome woody plants. Improvement of wildlife habitat by increasing the availability of high quality browse is a short-term benefit of such practices (14). For instance, huisache (*Acacia farnesiana*) regrowth is more nutritious, palatable, and available than mature growth, but the sprouts may reach half their expected total height within 6 months after shreeding (40). Woody plants often develop a prostrate or "running" growth form following repeated top removal. This growth form tends to spread laterally over the soil surface causing greater reductions in forage production and availability than the upright growth forms. Shredding with conventional equipment is often not effective for controlling plants with basal diameters greater than 2 inches. Also, maintenance costs for shredding equipment used on rugged rangeland terrain are often excessive. Shredding equipment of improved durability has ben developed, but increased equipment costs are simply reflected in treatment costs. However, simple top removal may be employed for short-term forage release and for development of fine fuel in preparation for utilization of prescribed burning on rangeland. In this role roller chopping has proven to be an effective management tool for south Texas mixed brush (17). Roller choppers withstand the rigors of rough rangeland terrain more effectively than conventional shredders and can be used on woody plants with trunk diameters greater than 2 inches.

Physical removal of woody plants, such as by power grubbing, is limited primarily by brush growth habit, size and density, and soil characteristics. Power grubbing is generally effective on stands of 200 or fewer plants per acre with an upright growth habit and of adequate size to be easily seen by the operator. Grubbing is most effective as a "cleanup" method on deep soils following other primary methods of brush management (43).

The recent development of a low-energy, hydraulic grubber holds promise for reducing grubbing costs (65). However, when the woody plant density exceeds 100 to 150 plants/acre, grubbing efficiency is significantly decreased. Alternatives, including herbicide use, should be considered in lieu of grubbing for high densities of species such as honey mesquite. However, the low-energy grubber may have merit for densities which exceed 150 to 200 plants/acre (4) with species such as huisache for which few management alternatives exist.

Root plowing, an effective but costly method, is most applicable to range sites with deep fertile soils and favorable water relations (19). A primary application of root plowing is complete land-use conversion from brushland to tame pasture. Severe soil disturbance by root plowing may actually retard secondary succession on native range. Areas formerly occupied by perennial native grasses may be bared only to reestablish to annuals and to begin the long tedious process of secondary succession. Forage production may be greatly reduced for 2 or more years with 10 years or more required for achievement of optimum forage production (36). Consequently, although a high percentage of the brush is removed, forage production often cannot be maximized without artificially revegetating the rangeland which adds considerable expense to the brush management operation. Also, root plowing may increase the density of pricklypear (*Opuntia* sp.) necessitating followup alternatives.

Dozing or pushing, another slow and costly method, is most applicable to small areas supporting dense stands of large trees. Like root plowing, dozing is most often used in preparation for development of tame pastures or cropland.

Chaining is a relatively low-cost method of knocking down, uprooting, and thinning moderate to dense stands of medium to large trees. Chaining may be most effectively applied in conjunction with herbicides and/or prescribed burning as a component of brush management systems (43). These methods minimize soil disturbance and may be applied in sequences and with treatment timing to greatly improve the native range forage complex (61). Chaining may control a high percentage of tree-type growth but small, limber plants are usually not uprooted. Under environmental conditions for optimum results from chaining, soil moisture adequate for uprooting of the woody plants, pricklypear is usally spread and stands thickened. If the soil is dry, the woody plants may be broken off rather than uprooted leaving intact regenerative tissues to provide regrowth. In these cases application of an effective herbicide and/or prescribed burning are viable, followup alternatives.

With the exception of a few spectacular successes, biological brush management has not advanced technologically to the extent of chemical and mechanical methods. An exception proven to be an effective method of brush management in some areas of Texas and usually classified as a biological alternative is goating. Goats utilize relatively large amounts of browse, probably somewhat more than 50 percent of their diet (28), primarily from low-growing shrubby forms of oaks (*Quercus* sp.), sumacs (*Rhus* sp.), and hackberries (*Celtis* sp.). On a year-long basis one goat is recommended for every 2 to 3 acres of brushy rangeland in the Edwards Plateau of Texas (31). For short-term grazing, a 30-day period for instance, five to eight goats per acre may be required for effective brush suppression. Goating is usually required for 2 to 3 successive years before the brush cover is reduced to the extent that the stocking rate of goats can be reduced. In a study from 1969 to 1974 on the Texas Edwards Plateau, goats reduced the canopy cover of live oak (*Quercus virginiana*) by 92 percent, shin oak (*Q. vaseyii*) by 79 percent, honey mesquite by 77 percent, redberry and ashe junipers (*Juniperus pinchoti* and *J. ashei*) by 97 percent, and pricklypear by 63 percent (31). Overall, the brush cover was reduced by 83 percent during the 5-year period. Economic considerations to consider in addition to purchase of the goats include additional shelter, fencing, predator control, and other practices required for management of the goat herd. This practice holds considerable promise for limited areas but cannot be considered feasible on a broadscale basis. Also, inclusion of goats to the livestock enterprise requires additional managerial expertise to assure maximum production from each kind of livestock. Goating may hold promise for protracting the life of other alternatives, especially mechanical methods which may not result in complete effectiveness. Use of goats to suppress resprouts following methods, such as chaining, should receive more research attention in areas such as the South Texas Plains vegetation area.

As production costs have steadily risen, considerable research interest has been directed toward the use of prescribed burning for brush management. Range burning is a relatively low-cost method of suppressing woody plant growth, is considered by many to be "natural" approach, and offers several side benefits such as improving grazing distribution, improving uniformity of forage utilization especially after burning "rough" plants, and reducing the impact of certain livestock parasites (22). However, burning may be most effectively used as a maintenance practice following other methods. For instance, in heavy, south Texas mixed brush (*Prosopis-Acacia*) two or three successive reclamation burns are usually required for significant range improvement. This time requirement, in some cases, negates some of the beneficial effects of burning. Of critical concern to fire effectiveness is postburn weather, especially the timeliness and extent of precipitation. Dry growing conditions following burning increase the length of grazing deferment necessary to prevent damage to the range. These deferment costs may significantly alter the economic advantage of range burning over other alternatives. Also, deferment prior to burning to build an adequate load of continuous fire fuel must be considered a part of burning costs.

Presumably, the wide acceptance of range burning would present certain potential tradeoffs such as short-term, localized reductions in air quality. Although this area needs more detailed research, range burning applied under the proper meteorological conditions apparently causes minimal air pollution from smoke, visible emissions, and particulate matter. This tradeoff presently appears justifiable in view of the benefits of range burning, especially since areas remote from urban centers are generally the prime candidates for its application.

Recent research on the use of herbicides and prescribed burning in concert have facilitated emergence of effective brush management systems which appear highly compatible with grazing management needs (44). A common misconception is that native range forage should consist almost solely of grasses. In fact, the forage resource should provide a complex forbs and browse in the proper mix with grasses. Cattle, primarily grazers, apparently also utilize considerably more browse than formerly thought by scientists and land managers. Cattle diets at certain times of the year also contain significant quantities of forbs (generally referred to simply as "weeds" by many). Sheep, goats, and white-tailed deer (*Odocoileus virginianus*) depend on availability of quality browse and make heavy use of forbs with only periodic use of grasses. Diet varies also with class (age and/or sex group) of animal within a kind (species or species group). Most herbicides used in range management were purposefully developed to selectively promote grasses and grass-like plants over browse and forbs. Where the forage balance is shifted too heavily toward the broad-leaved components, such herbicides are a wise choice for range improvement. However, some of the more effective herbicides greatly reduce browse availability and diversity and may eliminate forbs, especially desirable legumes, for two or more growing seasons. Reduction of desirable forbs is particularly severe when treating brush problems such as Macartney rose (*Rosa bracteata*), creeping mesquite (*Prosopis reptans*), and the post oak (*Quercus stellata*)–blackjack oak (*Quercus marilandica*) complex which require multiple herbicide applications for effective management. Prescribed burning following herbicide applications may reinstate forbs, especially legumes. This is of particular importance when considering white-tailed deer habitat (3, 64).

Herbicide application, by opening the woody overstory and promoting grass production, serves to build fuel for the application of prescribed fires. In this role the herbicide application may be substituted for at least two reclamation burns. Substantially higher temperatures are generated in the lower 6 inches of the fire front following burning of sprayed Macartney rose–infested rangeland compared to unsprayed areas (44). Also, whereas fire serves to only top kill many species of brush plants especially mature individuals, the herbicide pretreatment reduces the absolute stand density. In addition to the aforementioned attributes, prescribed burning following spraying functions to promote desirable grasses, remove woody debris left by the herbicide application (although standing dead woody plants may serve as screen for wildlife, they are a physical hindrance to livestock management), maintain browse as palatable regrowth with improved access to range animals, and open surviving woody plants to secondary infections (22, 44). Since none of these desirable effects are achieved with herbicides alone, the two methods are complementary in many cases.

Use of fire has reduced the number of herbicide applications for effective brush management. For example, whereas two to three annual applications of 2,4-D are required for control of Macartney rose, a single application of 2,4,5-T + picloram in the fall (when potential damage to adjacent crops is minimized) followed by prescribed burning in late winter or early spring at 2-year intervals has provided greater range improvement at significantly lower economic input than multiple herbicide use (Figure 1.). Yet, it should be emphasized that burning without herbicide use may not result in maximized benefits.

Selection of a weed or brush management alternative depends on effectiveness of the practice for reducing the target species, consideration of any tradeoffs associated with the alternative, and, in many cases, on relative initial cost of the method. Although herbicides are powerful tools for range improvement, there are several disadvantages associated with their use, at least those which are presently available. In previous examples, for instance, herbicide use was cited as the most feasible alternative for heavy infestations of the poisonous plant bitterweed. However, since spraying of rangeland infested with bitterweed invariably kills forbs desirable as forage for sheep production, the tradeoff decision is a choice between reduced production efficiency of the entire herd or death losses due to the weed.

Woody plant communities often occur in mixed stands of several species with varying susceptibilities to any given herbicide. Control of the susceptible species only serves to create the potential for intensification of the herbicide-tolerant species. For instance, application of 0.5 pound/acre of 2,4,5-T to a south Texas mixed-brush stand may effectively control honey mesquite but only slightly damage lotebush (*Condalia obtusifolia*), twisted acacia (*Acacia tortuosa*), blackbrush acacia (*Acacia rigidula*), guajillo (*Acacia berlandieri*), spiny hackberry (*Celtis pallida*), and tasajillo (*Opuntia leptocaulis*)—and may result in no damage to whitebrush, Berlandier wolfberry (*Lycium berlandieri*), Texas persimmon (*Diospyros texana*), and agarito (*Berberis trifoliolata*). Use of herbicide mixtures in Texas, notably 2,4,5-T + picloram, has improved the spectrum of species controlled, but a significant number of problem woody plants resist these combinations applied at economically feasible rates.

As with any range improvement practice there are direct risks and uncertainties associated with herbicide use. Potential spray displacement (entertained in depth in a later section) and volatility damage to nontarget plants, especially economic crops and ornamentals, have traditionally restricted the use of many herbicides. Strict dependency on plant growth conditions seriously restricts

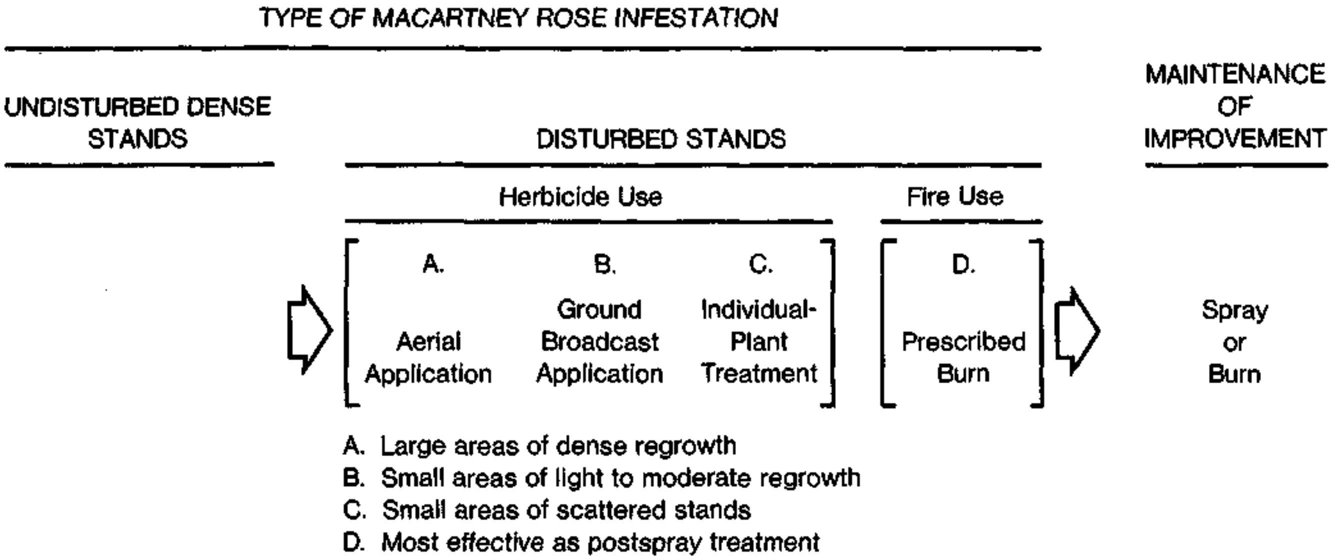

FIGURE 1. Potential improvement systems emphasizing alternatives for increased effectiveness of managing Macartney rose-infested Coastal Prairie rangeland. (Taken from Scifres (44)).

the season of application, and may result in incomplete control if conditions are marginal (15).

HERBICIDE USE AND WILDLIFE HABITAT

Emphasis on quality wildlife habitat in development of range improvement schemes by land resource managers is no longer strictly couched in an attitude of good conservation or simply for aesthetic motives—game management has become an important economic consideration. In some cases Texas landowners are realizing net profits per unit area from hunting leases that approach or exceed those from livestock production (depending on livestock prices). Herbicide use may reduce, maintain, or improve habitat quality depending on range site, wildlife species, maturity of the brush stand, and pattern of herbicide treatment. The basic dependency of game animals upon range vegetation for cover and food can be met, and livestock productivity simultaneously improved, through the wise and judicious use of brush management techniques including herbicide application.

Grass seeds are important dietary components of game birds such as dove (*Zenaidura macoura*), bobwhite quail (*Colinus virginianus*), and wild turkeys (*Meleagris gallopavo*). By preserving key sites for nesting, roosting, and loafing cover and, in the case of wild turkeys, fruits of woody plants as a food source, herbicides can be used to develop the range resource for bird hunting concomitant with increasing livestock production.

In the past broadscale overuse of herbicides on rangeland has most likely reduced quality of habitat for ungulates such as white-tailed deer. Complete treatment of large acreages reduces availability of browse and forbs for at least the season of treatment. However, recent research in Texas has shown that as much as 80 percent of mature mixed-brush stands may be aerially sprayed with herbicides such as 2,4,5-T + picloram without detriment to white-tailed deer habitat. By applying the herbicide in alternating strips, ample browse and cover for deer may be maintained (3). In contrast, spraying entire large blocks of land may result in reduced deer populations for at least 3 years. A critical concern is the interrelationship between forb production and diversity since white-tailed deer exhibit pronounced seasonal requirements for certain key forb species which may be produced only on certain range sites. Many of these forbs are highly susceptible to herbicides such as 2,4,5-T + picloram (3). Strip spraying, properly planned, can be designed to preserve important forb species for white-tailed deer, improve livestock production, and optimize the economic status of the management unit (66).

With the current state of knowledge some compromises may be necessary even with practices such as patterned herbicide application. The close dependency of a game animal on a single food item, for example, javelina (*Pecari tajacu*) and pricklypear, may demand these compromises. Leaving 20 percent of the brushland untreated did not preserve ample pricklypear to prevent reductions in the javelina population in South Texas (3).

HERBICIDES AND THE RANGE ENVIRONMENT

In the early days the ultimate fate of herbicides applied to rangeland, especially private lands, was of relatively little concern if the chemicals were not toxic to grazing animals. As herbicides and their use became more sophisticated and public scrutiny of the use of natural lands became progressively evident, research became responsible to answering queries concerning the fate of herbicides in natural resources including rangeland. This research contributed significantly to the knowledge base concerning herbicide use (6, 47, 56) but did not necessarily provide an adequate perspective concerning herbicide residues. Connotation of the term "herbicide residue" has gone askew over the past 10 or so years. The general attitude that herbicide residues are strictly undesirable has become a detriment to their proper use. Herbicide residues cannot categorically be considered "bad," even in the broadest sense, since residual herbicide in the soil is often required to reach the goals of brush management. It is of great advantage to utilize root uptake of herbicides whenever possible to circumvent factors which limit foliar uptake, especially the timing requirement for application to maximize absorption and translocation. Soil active herbicides can be applied ahead of the period of maximum growth such that residual herbicide is available for uptake at the optimum stage of seasonal plant development. Conversely, excessive residues or residues misplaced can create serious problems. Misplacement can and does occur via physical drift and volatility, too often to the detriment of susceptible plants in non-target ecosystems. The greatest hazard from herbicides is by misuse (37) and, unfortunately, so long as people are the users, some mistakes will undoubtedly be made. However, the concerted research and public education efforts to develop and disseminate technology for minimizing these hazards should be accelerated.

Within the range ecosystem herbicide dissipation is initiated from the instant the chemical contacts target surfaces (Figure 2). The complex of physical, chemical, and biological reactions which govern the rate and extent of herbicide dissipation were discussed by Scifres (47). The relative role of the processes operative in herbicide dissipation depend on specific chemistry of the active ingredient, formulation and rate applied, season of appli-

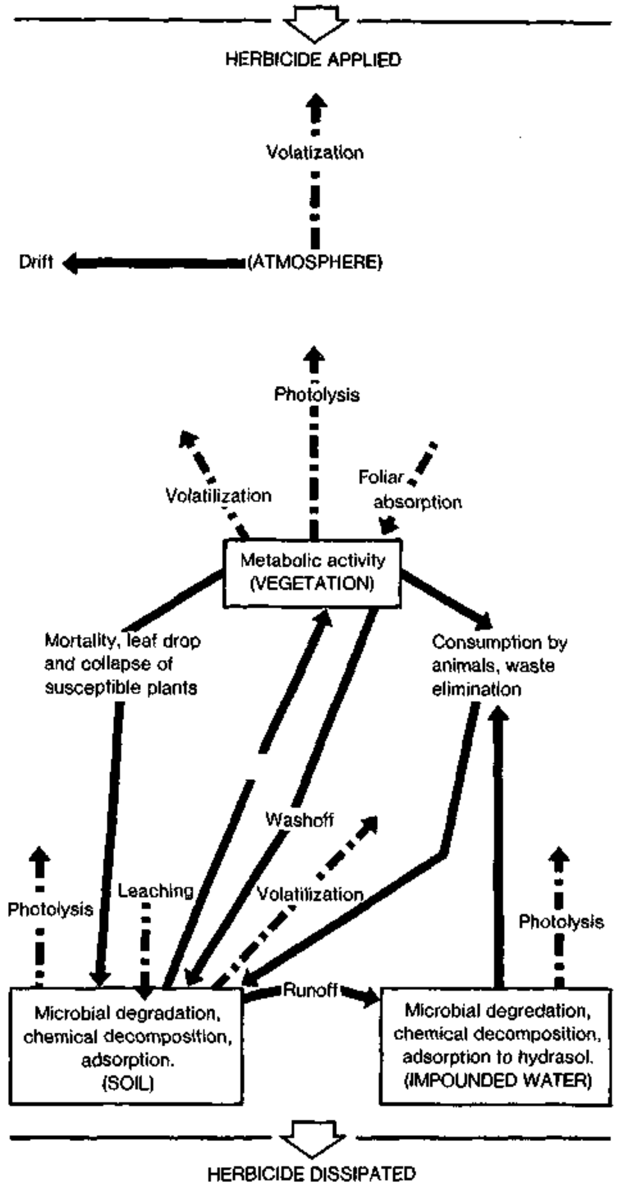

FIGURE 2. Documented modes of herbicide dissipation from range ecosystems and transfer mechanisms of residues among atmospheric, vegetational, edaphic, and aquatic components. (Taken from Scifres (47)).

cation, weather following application, botanical composition of vegetation treated, and soil characteristics.

The ultimate herbicide system would assure the exact placement of the optimum dosage only for the time required for maximum herbicide activity followed by instantaneous degradation into biologically useful components. Although this perfect system has not been achieved, the secondary impacts of herbicides on the range ecosystem appear to be minimal. Most, if not all, of the herbicides used for range improvement are subject to microbiological degradation, at least to a certain degree (54). Phenoxy herbicides are highly susceptible to microbial decomposition and are unlikely to persist into the year succeeding their application at conventional rates (7, 32, 38, 47, 60). Dicamba is somewhat more persistent than most phenoxy herbicides but carryover has not presented problems after its application for range improvement (47, 48). Those herbicides less susceptible to microbial decomposition are susceptible to degradation by other processes such as photolysis (24). Picloram is readily dissipated from soil surfaces but is not highly susceptible to microbial decomposition (47, 68). At rates of 1 pound/acre or higher, picloram applied to dry, cool environments may persist for longer than a year in soils (6, 47, 55, 57). However, adsorption on the clay colloid and chemical decomposition in the soil media apparently deactivate significant amounts of herbicide so that carryover of picloram, especially after application of less than 1 lb/acre to subhumid environments, has not been a problem.

Of major concern is the potential movement of herbicides in runoff water from rangeland treated for brush management to domestic water supplies, especially water used for irrigation of broadleaved crops. Seedlings of species such as cotton, cucumbers, soybeans, sunflowers, and other dicotyledonous crops are sensitive to as little as 5 ppb of herbicides such as picloram in soil (56). Concern over the *possibility* of contaminating domestic water with herbicides used for range management is justifiable, but the *probability* of any such occurrence appears to be low. In general, unless relatively high rates (>1 pound/acre) of herbicide are applied to bare, firm soil surfaces of considerable slope (probably greater than 3 percent) and followed within days by a high intensity storm, the probability of contaminating impounded water from runoff containing significant amounts of the herbicide is minimal (2, 6, 11, 13, 29, 57). For example, when 1.5 inches of rainfall occurred within 24 hours after application of 2 pounds/acre of picloram as the potassium salt, about 3 ppb of the herbicide occurred in first runoff (10). Conversely, after application of 2,4,5-T + picloram as the triethanolamine salts at 2 pounds/acre every 6 months on the same lysimeter in the Texas Blacklands, the herbicide concentration in seepage and well water from the treated area was less than 1 ppb during a 3-year study (13). No 2,4,5-T was detected from drainage samples from the field lysimeter for a year after application of 1 pound/acre of 2,4,5-T + picloram. Picloram was detected in the lysimeter water in relatively small amounts, 1 to 4 ppb, for 2 to 9 months after application. Scifres et al (57) applied 0.25 pound/acre of the 2,4,5-T + picloram mixture to a watershed having a 3 percent slope in semiarid northwest Texas and then applied simulated rainfall at various times after herbicide application. Runoff occurring within 10 days after herbicide application contained 17 ppb picloram, and no residues were detectable after dilution of the runoff in a small range pond. Runoff occurring at 20, 30, or 45 days after application contained less than 1 ppb of picloram.

Herbicides such as dicamba and 2,4,5-T are dissipated relatively rapidly from impounded range water systems (54, 57, 60). Picloram, more persistent than 2,4,5-T or dicamba in impounded water, is dissipated most rapidly immediately after application. Loss rates from a pond aerially sprayed with 1 pound/acre of picloram were 14 to 18 percent/day for the first few days and then progressively decreased to less than 1 percent/day at 100 days after treatment (23). Decay rates were a direct function of rainfall as well as time after picloram application.

Although research accounts are sparse, there is no evidence of herbicides being biologically magnified within the range ecosystem (34). Localizing or concentrating herbicides may occur, but the phenomenon is usually restricted to the abiotic ecosystem compartments and is usually a short-term effect (60). Since most herbicides used for brush management are rapidly eliminated by animals (32, 38), transfer to grazers and browsers within the ecosystem probably contributes only to minor localization of herbicides presently available for brush management (47). Rainfall, growth dilution, and degradation function to markedly reduce the amount of phenoxy herbicide in vegetation within a few weeks after application (33). Picloram residues usually persist longer than phenoxy herbicides in grass with greatest dissipation occurring within 1 or 2 weeks after application, and the residues being maintained at low levels for 8 to 16 weeks (21). Although use of herbicides at recommended rates on rangeland has not resulted in known direct harmful effects on man, his livestock, or wildlife, further research, especially long-term observations, on their possible effects must be continued (5, 47).

BENEFIT/COST RELATIONSHIPS OF HERBICIDE USE ON RANGELAND

One of the most frustrating aspects of herbicide use for range improvement has been a clear assessment of benefits in relation to costs. "Range livestock production requires relatively large operational units characterized by low output per acre from livestock and livestock products but high outpt per man" (1). With the variation in the range resource, it is virtually impossible to consider the overall benefit/cost structure of herbicide use with a reasonable degree of accuracy. Thus, we must depend on isolated cases and then utilize estimates since certain pieces of key information are usually lacking. Assuming alternatives which are technically sound and of which associated initial capital outlay are known, additional information needed includes (1):

1. What are the costs associated with maintenance of the program?
2. What additional returns attributable to program may be expected for the duration of the program?
3. Will returns from the weed and brush management program be as good or better as those from viable alternatives?
4. What are peripheral costs and unexpected returns (benefits) of the program?

The actual economic framework surrounding brush management on rangeland is difficult to characterize because of the interdependency of all parts of the management unit, and because range forage is a perpetual crop that must be transformed into animal products before harvest. However, recent research has begun to isolate the factors attributing to the economics of brush management on rangeland (66). For instance, savings in labor after brush management in the ease of handling and caring for livestock have been valued as much as $1.00/acre annually. Such indirect values can now be considered in addition to animal products for the conduct of economic analyses.

Several of the benefits of brush management which are difficult to quantify are of importance to society in the broadest sense. For instance, water conservation is becoming of increasing concern in States such as Texas. Brush and many herbaceous weed species are highly inefficient moisture users. Scifres et al (58) emphasized the role of herbicidal brush management in improving efficiency of moisture use based on range forage production even in dry years (Table 1).

TABLE 1.—Range forage grasses produced (lb/acre, oven-dry) per inch of precipitation under three herbicidal brush treatments in South Texas (58).

	Grass produced (lb/acre)/inch ppt[a]		
Treatment	Treatment year (26")	Year 2 (15")	Year 3 (19")
None	87	42	36
Sprayed with 2,4,5-T[b]	100	37	39
Sprayed with 2,4 5-T + picloram[c]	126	99	79

[a] Value in parentheses indicates annual rainfall received.
[b] Application rate was 1 lb/acre.
[c] Combination was applied as a 1:1 mixture of the triethanolamine salts of 2,4,5-T and picloram.

Water yield was increased substantially following conversion of chaparral watersheds to grass cover in Arizona (27). The efficiency of conversion for producing extra water apparently improved with annual rainfall to the maximum of 34 inches in the Arizona study. The overall impact of moisture conservation is difficult to assess but has potential of becoming a significant benefit of herbicide brush management to society.

Other factors difficult to quantify in economic analyses include:

1. Livestock tend to be more docile where excessive woody plant cover is not available. This facilitates handling and care of animals, reducing losses from parasites and disease.
2. Fewer breeding males may be required because of increased accessibility to females.
3. The interaction between managerial effectiveness and brush management. Although brush management serves to release increased quantities of higher quality forage, the impact of the brush management is greatly restricted unless management has assured that forage is utilized in the most effective manner by the most efficient animal.

As emphasized previously, treatment life is critical to shifting the benefit/cost ratio in favor of the natural resource manager. The impact of protracting treatment life on economic feasibility of brush management practices may be exemplified by the results of an analysis based on a hypothetical cow/calf operation (Table 2). The projected break-even beef prices ($/pound) were based solely on changes in carrying capacity. The hypothetical average change in carrying capacity from 1 A.U./22 acres to 1 A.U./12 acres (a reasonable expectation for extensive areas in Texas) was assumed constant across all treatment costs to amplify the function of treatment life. No change in calf crop (80 percent) or weaning weights (450 pounds) were considered. Maintenance and opportunity costs (those returns sacrificed from not accepting the best alternative investment) were estimated to total $90.00/cow. This included 8 percent interest on an average cow unit value of $300.00 (including cost of bulls and replacement heifers). An average beef sale price of $0.40/pound was projected for any additional production resulting from brush management. Also, for simplicity of calculation, treatment effect was assumed immediate and constant for the life expectancy of the brush management technique. Of course, such treatments progressively improve carrying capacity of the rangeland, reach maximum effectiveness, and the rangeland then progressively returns to its original carrying capacity. However, the relative comparisons serve to illustrate the importance of treatment-life expectancy based on present value of the treatment.

TABLE 2.—Break-even beef prices ($/lb) for range improvement treatments which increase carrying capacities from 1 A.U./22 acres to 1 A.U./12 acres over various treatment life expectancies.[a]

Present value of treatment (cost $/acre)	Treatment life (yr) 5	10	15	20
	.... Beef price ($/lb)			
5.00	.342	.305	.293	.287
7.50	.388	.332	.315	.306
10.00	.433[b]	.359	.336	.325
15.00	.526[b]	.414[b]	.327	.326
20.00	.617[b]	.468[b]	.422[b]	.400

[a] Table developed by R. E. Whitson, Range Economist, Texas Agricultural Experiment Station.
[b] Break-even prices exceeding $0.40/lb are not considered economically feasible.

From an economic view treatment feasibility is dictated by treatment life as well as initial cost for a given livestock productivity increase. If treatment costs of brush management continue to increase as anticipated, treatment life must be extended for economic feasibility for a given productivity change. Of course, the hypothetical economic structure in Table 2 could be changed drastically by management, and costs remain the same. Management effectiveness can result in increased calf crop and increased weaning weights from livestock grazing the treated areas compared to production from untreated areas. Also, opportunity and maintenance costs may be lower than assumed in the example. However, whatever the decisionmaking framework, technology to prolong treatment life might be one of the most important advances that brush management research can offer.

RECENT ADVANCES IN HERBICIDE TECHNOLOGY FOR RANGE IMPROVEMENT

Technological advances in herbicide use for range improvement the past 10 years have included (a) techniques of application, (b) formulations and mixtures of conventional herbicides, (c) efficacy based on new compounds, (d) understanding of environmental interrelations, (e) techniques for practical economic assessment of herbicide use, and (f) utilization of herbicides as components of more efficient brush management systems. The net result has been potential for overall improvement in the efficiency of herbicide use for range vegetation management.

Standard carrier volume for honey mesquite control by aerial spraying has been 3, 4, or 5 gallons/acre of diesel oil:water emulsions. Based on recent research, many applicators now use only 1 gallon/acre total solution for honey mesquite control. This technique increases efficiency of application by reducing "downtime" and the hauling and handling of carriers (20). Although low-volume application techniques do not presently appear effective for control of heavy stands of layered brush, an avenue for broadscale improvement in efficiency of herbicide use has been opened.

Herbicide mixtures, particularly 2,4,5-T + picloram, developed during the last decade have improved the control of species such as honey mesquite (8, 16, 41) and improved the spectrum of woody species controlled, as contrasted to 2,4,5-T alone. Commercial dicamba + 2,4,5-T mixtures have afforded additional alternatives for range weed and brush management (49).

Development of effective dry herbicide formulations and associated application technology has improved control of some woody species not effectively controlled by conventional sprays, facilitated minimizing the drift hazards, essentially eliminated the volatility problem, and allowed adaptation of soil-active herbicides previously used for industrial vegetation management for selective brush management on rangeland (12). Pellet formulations of picloram, aerially applied, effectively control species such as redberry juniper (42) which resist 2,4,5-T and which are not effectively controlled with reasonable rates of picloram sprays. Individual-plant treatments of picloram pellets also control yaupon (*Ilex yomitoria*), agarito, lotebush (51), Texas persimmon (45), and other hard-to-manage woody species which have resisted conventional sprays.

Herbicides such as karbutilate, formerly with promise only as soil sterilants, can be adapted for selective brush management if applied as large particles (spheres in the case of karbutilate) but widely spaced to correspond to the particle density which would result from placement in a grid pattern on 6-foot centers (62). Using this concept, desirable vegetation is damaged only at the point of application. Movement of the herbicide into the soil results in a series of treated columns in the profile for root contact by the woody species (35). This approach appears promising with another industrial herbicide, "Velpar" [2] (3-cyclohexyl-6-[dimethylamino]-1-methyl-*s*-triazine-2,4[1H,3H]-dione) for management of the oak complex in Texas (53).

Promising compounds developed during the past 5 years include tebuthiuron, a sophisticated substituted urea formulated as extruded pellets or a wettable powder (9). The herbicide appears promising for control of several species which heretofore have resisted broadcast applications of conventional herbicides (59). Whitebrush, for instance, has traditionally been difficult to control (30). One pound/acre of tebuthiuron pellets, aerially applied, have afforded near complete control of whitebrush (59), and over a 4-year study range condition trend has improved significantly on treated sites (52).

Prior to the mid 1960's there was little research activity concerning the fate of herbicides in rangeland ecosystems. Comprehensive research on the residual life of herbicides on rangeland was stimulated by an interest in the relatively persistent compound, picloram (6, 23, 55, 56, 57), scrutiny of established compounds such as 2,4,5-T (7, 60), and interest in new compounds (35, 48). These studies have allowed isolation of the routes and rates of herbicide dissipation from the range ecosystem (47) and aid in understanding factors regulating their activity.

[2] No common name assigned by Weed Science Society of America. Trademark is used for convenience only and does not constitute a warranty or guarantee nor implies edorsement by the compound over any other product suitable for the same purpose by the author or the Texas Agricultural Experiment Station.

POTENTIAL FOR THE FUTURE ROLE OF HERBICIDES IN RANGE MANAGEMENT

The need for safe, effective herbicides will likely intensify in the next 10 years. Efficiency of production is a requisite for the range livestock producer just as for any other segment of agriculture, and the margin of profit is apparently becoming continually more narrow. The rising cost of energy places a real question concerning the future of brush management techniques which require high energy inputs. Also, the energy requirements for meeting the fertility demands of introduced grasses, grown as monocultures, may well shift the emphasis from tame pastures to native rangeland for grazing animals. The use of feed grains for beef fattening may have to be scrutinized more closely than ever before with the potential result being a shift to beef "finished" on native range. As land costs continually increase, expansion of ranches most likely will be accomplished "from within" for the most part; that is, an increased production level realized per acre rather than simply adding new acres to the operation. Thus, economic vegetation management will become more important than ever before.

SUMMARY

Undesirable vegetation and its management on rangeland is an ecological problem that must be considered within a rather narrow economic framework. Excessive cover of woody plants on rangelands poses one of the primary deterrents to optimizing production on an economic basis. The most logical approach to brush management is the systems approach rather than depending solely on single treatments. Demands on feed grains, energy, and land costs and the need to increase the production of red meat protein provide the impetus expanding research on brush management systems. Herbicides may serve as integral components of brush management systems and appear to be particularly compatible with prescribed burning. The unique strengths of each method compensates, at least partially, for the inherent weaknesses of the other. These methods are relatively efficient considering the energy inputs necessary for use of other approaches. Herbicides can be used to promote range livestock production without being detrimental and, in some cases, may be beneficial to quality wildlife habitat. Recognition of potential hazards to wildlife habitat allows planning applications to eliminate detriment to most game species. The greatest potential environmental hazards arise from misuse of herbicides. Herbicides utilized for brush management are dissipated from the environment without biological magnification and minimal biological transfer following proper application. Techno-

logical advancements in improved application techniques, formulation, herbicide chemistry, and understanding of environmental implications will help assure improved efficiency of herbicide use.

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PANEL DISCUSSION

MR. FLAMM: Because of the shortness of time, I am going to change the format slightly from this morning and ask each of the panelists if they have some brief comments while we are checking questions and then we will try to get to those.

Steve Hager, would you like to comment on Dr. Scifres' speech?

MR. HAGER: Yes, I would like to make a few quick comments.

I am an oceanographer and not an expert in range management, but I have been studying 2,4,5-T for about 2 years. The first thing he said which concerns me is the use of spray and burn.

As was mentioned yesterday, the 1977 study shows that if one sprays with 2,4,5-T with one-tenth part per million and then burns it, it is equivalent to spraying with 2,4,5-T with 1.6 parts per million TCDD. That was based on a grass-burning study in the laboratory, but it is a warning that there is at least potential in a range situation for producing TCDD from 2,4,5-T.

The second thing he said which is of concern is that he mentioned a change of emphasis from feed lots to range, and one of the arguments which has been used against the existing data which shows TCDD residues in beef fat is that these animals were not put on the feedlot after they came off the range; and if indeed there is a trend to increase the use of herbicides to replace the feedlot, then we are going to be potentiating that effect. That is, we will not only be removing the proposed clean-out period, and I an not sure it has been demonstrated that beef loses TCDD during the feedlot, but it is possible —but we will also be increasing the use of herbicides.

In my opinion—and those of you who heard Dr. Meselson yesterday, you probably got the point—the data for beef fat from the Dioxin Implementation Plan study were supposedly collected under conditions which represent the beef which the population of the United States is consuming, and they may have done that to a lesser or greater degree. At any rate, if we use Dr.

Meselson's figures, eight of the 25 samples were positive for TCDD.

Of course, this exposure is important only in light of the toxicology. I want to mention here, part of the iceberg that is least understood at this point in toxicology is the effects on the immune system. The early data in the literature on the toxicology of TCDD suggest that the immune system is affected by TCDD, so all of these discussions of mortality which take place under sterile lab conditions are purely academic because the real danger may be to the immune system.

MR. FLAMM: Thank you. Jim Young.

DR. YOUNG: The vegetation type I am most familiar with is sagebrush grasslands, about 90 million acres. As far as use of herbicides in the sagebrush grasslands, I guess we are here to celebrate a wake, because it is non-existent. 2,4,5-T and silvex never had a role in the sagebrush grasslands because there wasn't a valid use for them. There was a valid use of 2,4-D in grasslands to correct an overabundance of shrubs as a result of overgrazing.

Because most of the sagebrush grasslands are under public ownership—in Nevada 86 percent of the landscape is managed either by the Forest Service or the Natural Resource Land of the Department of Interior and the railroad has 6 percent—there is not much left for the private citizen. On these lands the emphasis has gone away from the use of herbicides because of pressure from the environmentalists interested in the quality of the environment.

I think if we are really going to get into integrated pest management, this is a mistake. If we can conclusively demonstrate that herbicides are a useful tool—they are safe to use in the environment—if we categorically deny ourselves the use of this tool, we limit the success we can have with integrated management.

Dr. Lawrence of Weyerhaeuser touched on two of my favorite topics. Many of our wildland communities exist because of the catastrophic stand renewal processes. Many pine ranges in the West are the result of past destructive logging. No one advocates going back to destructive logging and promiscuous burning that produced the lands, but we have to satisfy the same type of seedbed and competition requirements if we are going to reproduce the stands.

The second point he made, that I think applies to sagebrush lands, is you can't stand still. Many communities say, okay, this is an extremely desirable plant community, this meets all of our type requirements, but you can't stand still; vegetation is dynamic. The plant communities reproduce only in the minds of ecologists. Plants reproduce from seed and the process that creates that stand has been to duplicate, or some other treatment done to duplicate it, in order to renew it. You can't preserve things in terms of vegetation. Like humans, plants die, too.

The intensive labor type of alternatives is very difficult to apply to sagebrush range just because of the scale of the area. A portion of our western rangelands is Painted Juniper Forest. It is a transition between the sagebrush or desert lands and the actual commercial forest. We have a study that includes mechanical, fire, herbicides, and intensive labor treatments. I was kind of shocked. I didn't realize anyone else was dumb enough to get involved in intensive labor studies. That is how you find out who your friends are. There is no county agent, herbicide tech man; there is no ranger. They all disappear. After you finish the treatments and you have the wood supply, they all come back. Even the chemist will find something in the truckload to look for.

We approached the study from the integrated pest control basis where we have wildlife specialists, non-game wildlife specialists, water and soils—all gamuts. We are applying it on an American Indian reservation with an 80-percent unemployment level and has labor available for these intensive type things. It is a real lesson in sociology to get involved in such things. I have been trying to interest the sociologists in this type of thing. One of my colleagues told me that the reason why I can't get a cooperating sociologist is that they are all busy being ecologists.

We are interested and are trying to generate concrete data and meaningful economic evaluations to show these alternatives in pest control management on rangelands.

MR. FLAMM. Ron Kuhlman.

MR. KUHLMAN: First of all, I sort of have to say, "me too," to Jim, because being responsible for the administration of public lands, which is another name, the current invoked name for natural resource lands, we do have quite a responsibility here to meet not only the needs of range users for livestock but also the uses of the rangeland for many, many other purposes.

Saying that another way, it means that we have many demands on the same acre and each of these demands has its own requirements.

Now, specifically, as far as the herbicides use is concerned, I just found today that I recognize another benefit of being from Texas, having a Texan's point of view. They don't have the same restriction in the management of their rangelands as the other Western States do, i.e., we have within the Department of the Interior, of which the Bureau of Land Management is a small part, a so-called list of pesticides that are given a category of "prohibited," meaning we cannot use them. We have another list that is called "restricted," which means that there are rigid rules to be applied. What those two lists do is remove the flexibility of using currently registered, EPA-registered pesticides.

Pesticides include not only the herbicides but rodenticides, fungicides, and all other chemical applications to get rid of a pest, be it an animal or a plant. That may not be known, but it is a real fact, and it does definitely hinder the area of consideration for the application of pesticides.

Another statement I would like to make on the basis of that is that, contrary to Dr. Scifres's comments that he sees an increase in herbicide application, we do not see an increase. We do not see an increase primarily for two reasons. One of them is that the continued use of the public lands has different demands, and those demands have created public opinion that must be recognized; and in the process of that recognition, we are involved, for instance, in lawsuits, very many of them, very expensive, that do hinder the application of the herbicides.

We also see that the question of economics is not the same from a public point of view, public land manager's point of view, as it is a rancher's. For instance, instead of the cost being the cost actually involved in the application or treatment, we must include the costs associated with the prior planning. That includes preparation of environmental impact statements, preparation of environmental analysis records, the simple fact of legal fees of fighting in the court of law the situation that will permit or deny us the application of herbicides.

Now, those things do, then, generate a situation whereby you have got to look at these from many, many different points of view, which we are doing and which the paper, as presented, recognizes. For instance, there is a lot of application of the mechanical treatment. There is also use of the biological treatments. There is somewhat an emerging use of fire and the pesticides themselves; and each of these has its own niche, and each must be considered. As a result of that we identify that there is a relatively small part of public lands that actually is treated with pesticides.

I think we noticed from our earlier talks that each of the speakers, I believe, have percentages less than 5 percent of treatments actually involving pesticides. So, while it may be important to a segment of the population, in total it may not have that same degree of importance. That is all.

MR. FLAMM: Thank you, Howard.

DR. MORTON: I don't have too many disagreements or arguments with Dr. Scifres's paper. I think viewed from the perspective of Texas versus the public land States of the West that we have certainly more flexibility and the objectives of a particular unit of land certainly can be accepted in focus easier than it can in the Southwest where we have multiple-use concepts to consider such as the watershed, the wildlife, the recreation, etc.

Our research in the Western States is concerned with providing land managers with the tools with which to provide people with the service that they wish. If you wish to develop a wildlife habitat, many of the brush stands that we have, whether they be juniper or mesquite, are relatively sterile as far as providing cover for wildlife species. Through the use of herbicides, we can develop a better habitat for wildlife.

You have to define what you want in terms of wildlife. Are you looking for a game bird? Are you looking for a song bird? Our role in research is to provide the kind of vegetative cover that people want, and this makes it much more difficult; but we are developing, as Dr. Young indicated, more of a systems approach to vegetation management.

We are also trying to serve the rancher and the farmer so that he can provide food that is necessary. We see herbicides integrated with other management practices as an important step in this. Such things as water havesting or perhaps water retention, both of which are techniques used in the Southwest, have been used for centuries in all parts of the world. I think we will see more of this kind of management in the future, and I think they will be applied to our Western range.

MR. FLAMM: Thank you. Ray Dalen, in addition to your general comments, I have a question. Can you comment on the relative effectiveness of techniques available to minimize drift of aerially sprayed herbicides, or can we put it where we want it?

MR. DALEN: We hope that we can. Being on this panel here, I am a range improvement specialist in a Forest Service Region, and I agree with Dr. Scifres's paper.

I am not familiar with the vegetative types in Texas. However, I believe the principles are the same.

These past 2 days we have heard a great deal of conflicting, controversial, confronting type of information, and it is difficult for me, because as a worker on the ground it is my responsibility to take some of this information, filter it, and give it to our people on the ground, particularly our line people who are responsible for making these decisions in such a way that they can utilize it to the best extent. And this really isn't easy.

We have to go through an environmental analysis report, the NEPA process described this morning by Dr. Tom Nelson, and we honestly believe that in this process the information does get properly filtered. I would be naive to say we do not make mistakes, but we also try to do the best with the information that the experts or critics, the public, give to us. We have to utilize this information properly because it is our responsibility.

Now, where I am from in the Southwest in Region 3, range management on the National Forests is really a management problem. We have around 13,000,000 acres of rangeland. We also have approximately 2,000,000 acres or what we call deteriorated rangeland. That was brought on by passive use many years ago We, go through a process of range allotment analysis.

Management of ranges is a key item. However, as part of management we must have structural improvements. After this we move into vegetative manipulation. In this process, particularly in Region 3 of the Southwest, we have a wide variety of vegetative types to consider. We need a complete arsenal, everything that we can use to manipulate vegetation. The figures brought out yesterday indicate that maybe we are not doing enough. I don't know.

The use of herbicides by the Forest Service on rangeland is quite low compared to other uses. We have had problems in drift on National Forest projects, but many of these—I guess they are still happening—but many of these have happened in the past. We use current technology to mitigate this problem.

Dr. Scifres didn't mention it, but in Texas low volume applications of 2,4,5-T on mesquite have been developed. Technology today—using proper nozzles, proper pressures, the various forms of drift control, understanding the principles of atomization and droplet sizes, using spray cards and proper monitoring—enables us to do the project correctly. We feel it is our responsibility to do it correctly, and I think we are doing it.

MR. FLAMM: We have a couple of questions for Dr. Scifres.

DR. SCIFRES: I would like to respond to a couple of the panelists' comments first.

We are not quite as lucky in Texas as we would like to be. I don't know which is harder, facing an individual rancher in Texas or the public over public lands. We do have a system for regulating the use of hormone-type herbicides which is very strict. They can be used only by permit from the State Department of Agriculture.

Also, on the comment concerning burning, if you listen closely—and I am not completely familiar with the lab studies that involve the application of 2,4,5-T followed by burning—as I recall, the burning was accomplished fairly shortly after treatment. If you will recall, I indicated that we needed a time lapse of 2 to 3 years from treatment to burning for the system to work out. That is because the herbicide is critical in building fine fuel and nature won't give it to you without two or three growing seasons even when you do a good job in brush control.

What are the hazards of herbicides to wildlife? I don't know. We don't have a comparison. A gut reaction to it would be the risk from pelleted herbicides would be perhaps reduced. I hate to leave the attitude that there is a risk with the sprays. If I say "reduced," it becomes relative. I was asked once, do quail, for instance, eat the little beads of herbicides that you put out for mesquite use? Well, I don't know whether the quail eat the beads or not. I understood in the lab they had to forcefeed them to get LD-50 data, so I assume that is not a problem. They are not available for injection by the animal. A resident animal within an ecosystem isn't contacted by the herbicide as it probably would be with the spray. From those standpoints we feel dry herbicides offer advantages.

Do you spray in Texas during the deer breeding season? The slide gave the times of herbicide application that we have to use; and from the standpoint of the very strict phenol requirements relative to susceptibility of the woody plants, we are confined to spraying during about a 40- to 90-day period each year and that is it—and certainly not during the deer breeding season. We have to apply the herbicides during the spring when the foliage is developed and under conditions such that we can get adequate control of woody species. We would be wasting our time and the deer's if they were trying to breed.

Do you have studies of field research after sprays, I assume, on mesquite? Yes, we do. There is a paper in the *Journal of Range Management* that covers the white deer. There is an individual who is interested in bird and mammal counts before and after spraying. We tried to work with wild turkeys and bobwhite quail. We don't have enough data to be conclusive, but there are studies that have to do with responses to spray. I would say peruse the *Journal of Range Management,* and you should run into what you need.

MR. HAGER: Grass-burning studies were with limited oxygen available and thus resulting in incomplete burning and why do I believe the results mean anything in terms of range management? That is a good question.

I shouldn't have cited it as a quantitative thing. I was with grass instead of with, for instance, brush or mesquite or something. It merely indicates that we really don't know to what extent TCDD is produced. It was produced, I believe, 13,000 times in a test tube, 13,000 times when it was originally in the 2,4,5-T, and certainly that isn't applicable to the field situation. But whether 1.6 ppm equivalent is higher or lower than would be achieved in the field situation, I can't say.

MR. FLAMM: Thank you very much.

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POST-SYMPOSIUM RESPONSES TO QUESTIONS SUBMITTED TO CHARLES J. SCIFRES

QUESTION: Are there any cost data available on manual control (of woody plants) on brushland? If so, what are the costs per acre?

ANSWER: Manual control, as a broadscale practice, was abandoned years ago because of labor and cost requirements. Therefore, I have no current cost data.

QUESTION: Has TCDD or 2,4,5-T caused any adverse health effects on people or animals on rangeland?

ANSWER: To my knowledge, 2,4,5-T, when applied for the intended purposes under the label directions, has not caused any adverse affects to human health or to the health of domestic livestock in Texas.

QUESTION: Do you categorically claim that there has not been a single instance of damage to any species of wildlife as a result of the use of herbicides in your experience?

ANSWER: Biologists with experience do not make "categorical claims" . . . they interpret responses in nature based on the state-of-the-art of biological knowledge. I must interpret the meaning of "damage" as being indirect or direct detriment as a result of herbicide use. In my opinion use of herbicides without considering habitat requirements of resident animals can result in detriment to wildlife by altering food availability or by manipulation of wildlife cover. I mentioned the possibility of these indirect effects in my paper in reference to my cooperative research with wildlife scientists on white-tailed deer responses to aerial spraying of brushlands in Texas. As to direct effects, I have no knowledge of direct damage to any wildlife species in Texas when conventional herbicides were applied for their registered use(s) under directions on the label.

POST-SYMPOSIUM RESPONSE TO QUESTION SUBMITTED TO HOWARD L. MORTON

QUESTION: To what extent has removal of sagebrush with the chemical 2,4-D altered antelope and grouse populations?

ANSWER: The antelope is basically a plains animal but does occupy large areas of the sagebrush type in the Western United States. Reeher (1969), of the Oregon State Game Commission, reported the results of a 6-year study conducted in Oregon on the effect of sagebrush spraying by the Bureau of Land Management. In this report it was found that antelope do not use extensive stands on big sagebrush. His data concerned with production of antelope on native rangelands as compared to treated areas (using 2,4-D) showed the production of kids per 100 does on treated range as compared to production on native ranges was not significantly different. Killing of big sagebrush and other woody species by spraying does not make an area attractive to antelope; however, results of a survey of ranchers in Wyoming suggested that there was no decrease in range use by antelope following spraying of sagebrush. In fact, there were numerous accounts of increased use by antelope in spring and summer and some reports of increased use by antelope in fall and winter. Antelope populations were not changed drastically by spraying with 2,4,-D even though you might find lower populations on the sprayed area.

Sage grouse has a dependence on sagebrush. Sagebrush constitutes between 60 and 80 percent (on an annual percent basis) of the grouses' diet and nearly 100 percent in winter. Generally, no grouse are found in the sprayed area immediately after spraying, but grouse population will usually start to build back up between 1 and 1½ years after spraying. The effectiveness of a spray treatment affects the length of time before an area will recover sufficiently for nesting. A longer time is needed where a high level of control is obtained. Klebenow (1970) suggested that controlling tall, dense sagebrush and allowing the native forbs and grasses to recover their former productivity could benefit sage grouse. Since he found that between 17 and 18 percent brush cover is best for nesting and strutting activities, something less than complete control of sagebrush would be desirable. A good sage grouse habitat would be an open stand of sagebrush with a scattering of other shrubs and an understory of perennial grasses and forbs. Carr and Glover (1970) and Autenrieth (1969) report that spraying strips of sagebrush with alternate strips left unsprayed had no obvious effect on the distribution or movement of adult grouse, but broods fed and roosted on sprayed strips while unsprayed strips were used for shade, loafing, and escape cover.

Autenrieth, R. E., "Impact of Strip Spray on Vegetation and Sage Grouse Use on Summer Habitat," 6th Biennial Western States Sage Grouse Workshop. pp. 147–157 (1969).

Carr, H. D., and F. A. Glover, "Effects of Sagebrush Control on Sage Grouse," 35th North American Wildlife Conference, pp. 205–215 (1970).

Klebenow, D. A., "Sage Grouse vs. Sagebrush Control in Idaho," J. *Wildlife Range Manage.*, 23(6), 396–400 (1970).

Reeher, J. A., "The Effect of Large Scale Livestock Range Rehabilitation on Game Species," Final Report, Project No. W60K01-5 (September 1, 1963–June 30, 1969). Oregon State Game Commission, July 1, 1969.

POST-SYMPOSIUM RESPONSES TO QUESTIONS SUBMITTED TO RAY DALEN

QUESTION: Can you comment on relative effectiveness of techniques available to minimize drift of aerially sprayed herbicide?

ANSWER: There has been considerable research and development directed toward finding practical ways to reduce spray drift from target areas on pesticide application projects. Even though much of this effort has been on agricultural cropland areas and aerial insecticide application of forest lands, the information is useful for herbicides application on forest and range lands.

The spray droplet size is related both to potential drift and plant coverage. Through the proper selection of spray nozzles, the orientation of the nozzles in relation to the airstream, proper boom length in relation to the wing span or rotor, proper pressure, and limiting the spray operation to the optimum local weather conditions, spray drift off the target area can be significantly reduced.

Drift control adjuvants are available; however, the above factors must still be considered.

Several types of specialized spray booms have been developed such as the microfoil boom. According to tests conducted by Dr. Norman B. Akesson, University of California, Davis, the microfoil boom provided very good drift control. However, it produces 800 micron droplets which may not provide sufficient coverage for some plant species on rangelands.

QUESTION: What other effective control can be implemented in the immediate future if 2,4,5-T is banned?

ANSWER: The herbicide 2,4,5-T is the primary herbicide used to improve the production of forage species in the chaparral, shinnery oak, and mesquite vegetative types. There are alternative methods being used. They include other herbicides, mechanical clearing, and prescribed fire. Often the most effective method is a combination of several techniques. The application of 2,4,5-T has generally proved to be the most cost-effective method. Even though 2,4,5-T is only moderately effective in the chaparral, it is the standard treatment over much of the shinnery oak and mesquite range. Should the option to use 2,4,5-T and related herbicides such as silvex be taken from the land manager, his ability to improve forage condition in the most cost-effective manner will be limited over much of the chaparral, shinnery oak, and mesquite range.

QUESTION: 2,4,5-T and TCDD are said to be dangerously toxic. Have you observed or heard of any examples of the ecological disasters which should be happening if these chemicals are really dangerous?

ANSWER: The term "ecological disaster" has different meanings depending on a person's viewpoint. However, in working on herbicide application projects for about 20 years, I am not aware of any major ecological problems. There have been reported cases of damage to crops and other nontarget plants, most of which have apparently been caused by drift or misapplication.

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INTRODUCTION OF PANELISTS

MR. FLAMM: Our panelists are: at the far end of the table is DANIEL CASSIDY, Landscape Specialist, State of California, Department of Transportation.

Next to him is Dr. William Byrnes, Professor and Assistant Head of the Forestry School at Purdue University.

Next to him, a new panelist, JEFFREY DAVIS, Office of Environmental Programs at the Public Service Commission, Albany, New York. He is substituting for Dr. Frank Egler.

Our next panelist is HYLAND JOHNS, President of the Asplundh Tree Expert Company, which activities include right-of-way management nationwide for various utilities, highways, and so forth.

MR. EDWARD GRASSEL, Acting Head of Transmission Line Maintenance for the Bonneville Power Authority in Vancouver, Washington.

Our speaker, DR. WILLIAM NIERING, will address us on "Right-of-Way Vegetation Management and Evaluation Techniques and Alternatives."

Dr. Niering received his bachelor of science degree in Biology at Penn State in 1948 and a masters at Penn State in 1950. Subsequently, he received his Ph.D. in Ecology from Rutgers University. He has written a number of important books and papers on ecology. In 1967 he received, jointly with Dr. Rupert Whitaker, the award of the National Ecology Society for the best paper of the year.

DR. NIERING: It is a pleasure to be here and share some thoughts on right-of-way management, a subject close to my heart for 20 years. I seem to have gotten an inkling today of a broader "wholistic" view in looking at the use of herbicides. I would like to make a couple of general points before I start the presentation, which I would like to point out that the economists attempting to evaluate the cost/benefit values should take into account several basic ecological principles difficult to evaluate.

One is the whole problem of energy as a non-recycling resource. We have seen this here today by the use of a cup, a petroleum product in short supply, a product that should be substituted as soon as possible with paper, especially at this kind of conference. I am not putting the blame on anybody; it is part of the system.

Herbicides are also petroleum products. They are high-energy producing products in terms of production. We should put a cost on that. The material of this cup has to be disposed of someplace. There should be a cost put on that. Paper would disintegrate because it is recycled. Ecological principles, basic to any conference, have to be considered.

The third is ecological diversity—diversity systems, not one system. We are not here to sell herbicides for anybody. We are here to see how herbicides fit into a total systems approach to preserve maximum biotic diversity. That is what they are all about. They are highly diverse systems and, in general, the greater the diversity the greater the stability, realizing that Dr. May's models rebut this to some extent.

RIGHT-OF-WAY VEGETATION MANAGEMENT: AN EVALUATION OF TECHNIQUES AND ALTERNATIVES

William A. Niering

INTRODUCTION

Rights-of-way across our Nation represent a large land area under management. In a Nation consuming one-third of the world's electrical energy, there are over 100,000 circuit miles of transmission lines representing more than 4,000,000 acres (U.S. Dept. Int./Ag. 1971). This figure may expand to 7 million by 1990 (U.S. Fed. Power Comm. 1971). Natural gas pipe lines traverse more than 1,000,000 miles, four times the distance to the moon. By 1990 there may be over 18 million acres committed to natural gas pipelines (U.S. Fed. Power Comm. 1974). In addition there are over 3.2 million miles of roads in the United States which require some type of right-of-way maintenance. Since rights-of-way represent such an extensive acreage of natural or semi-natural landscape, every effort should be made to manage this land resource with the best ecological knowledge available.

Sound right-of-way vegetation management has matured slowly in this country. The initial era, following the advent of herbicides, might be referred to as a period characterized by the indiscriminate spraying of "brush." Although this approach is still widespread, there is a strong core of ecologically oriented managers who have progressed to the concept of selective vegetation management. The difference between those two approaches is not merely a semantic one, but in reality there is a basic difference between those concerned with managing a mosaic of plant communities along a right-of-way versus the mentality aimed at suppressing, or controlling "brush." This dichotomy is probably related to the fact that the pre-herbicide era was concerned primarily with periodic hand-cutting supervised by personnel with limited training. The industrial evolution of herbicides in the '40's and their commercial application in the '50's exposed managers to new tools and forces. Thus, the industrial promotion of weed killers, combined with the lack of ecological expertise, set the stage for an era of indiscriminate broadcast spraying with little or no regard for the plant communities being treated. The pseudo-scientific and the sociopolitical nature of this indiscriminate era has been documented by Egler and Foote (1975) and Goodwin and Niering (1962). It was a rather undistinguished period in the history of herbicidal usage in this country. In fact, it can be argued that currently we are overcommitted to indiscriminate brush control techniques in right-of-way management. In an era when the safety of certain herbicides is being seriously questioned and legislation is even being proposed to ban the aerial use of 2,4,5-T (Senator Peter Behr pers. comm.), it would seem prudent that every attempt be made to apply herbicides as selectively as possible.

The Northeast Forest Experiment Station and the Eastern Region Forest Service were among the pioneers in advocating the sound use of herbicides in managing the vegetation along transmission and roadside rights-of-way crossing Federal lands under Forest Service jurisdiction. It is, therefore, a pleasure to see this topic receive national recognition in such a program jointly sponsored by the U.S. Forest Service and Environmental Protection Agency. However, before launching into the alternative methodologies in right-of-way vegetation management and their various ramifications, I shall attempt to outline from an ecologist's point of view what I feel should be the overall objectives in any right-of-way vegetation management program. Then we will be in a better position to evaluate various techniques and alternatives.

LONG-RANGE MANAGEMENT OBJECTIVES

Vegetation management on rights-of-way should involve only the selective removal of that plant growth which is deemed undesirable in terms of accomplishing the services rendered (Egler 1954a, Nat. Acad. Sci. 1975). By such an approach there will occur a multiple set of values including (1) the potential development of a relatively stable mosaic of plant communities which will tend to resist future tree establishment, (2) preservation of desirable wildlife and game habitat (Cavanagh et. al. 1976, Mayer 1976), (3) preservation of the native flora and fauna, and (4) creation of an aesthetically diverse set of naturalistic landscapes with high outdoor recreation values (Goodland 1973, Randall 1973). It is also recognized that in many areas current productive land use practices, including crop farming, grazing, nurseries, and Christmas tree plantations, should be encouraged as long as these activities are compatible with the utilities involved.

The Eastern Region of the Forest Service (R–9) has recognized the special management requirements for the more than 35,000 acres of rights-of-way that occur within their Region. In their manual *Vegetation Management for Rights-of-Way* (U.S. Forest Service 1966) they recommend that all rights-of-way be managed under a Special Use Permit involving the application of selective maintenance of the vegetation in accordance with a plan prepared by the Forest Supervisor. This manual could well serve as a model for the entire Forest Service.

For the thousands of acres under private ownership it should be noted that the actual owners of the right-of-way have the right to demand the very best land use practices in terms of vegetation management. Often the land owner is unaware of his rights in this regard concerning the utilities' use of this natural resource. Now let us turn to some of the specific types of rights-of-way and outline a set of sound management objectives.

Roadside Rights-of-Way

Roadsides include those strips of natural or semi-natural vegetation along roads, including town and rural roadsides and the extensive network of State and interstate highway systems. These roadside verges serve as a buffer zone between the road and the adjoining land and serve a number of utilitarian values including conservation of wildlife (Way 1967, Michael et al. 1976). In all situations only those plants that obstruct vision or interfere with other highway functions or are deleterious to human health should be removed. On most town and State roads this should involve the selective removal of undesirable tree growth that interferes with sight line conditions as shown in Figure 1 and the development of a perennial herbaceous cover in the mowed strip next to the road. Such a cover will reduce or eliminate ragweed as a potential problem since it is favored by open exposed soil conditions. Non-selective broadcast sprays are ecologically unsound. A classic case, in the early 1960's from a New Jersey roadside, involved 19 foliar applications with phenoxy herbicides destroying attractive broadleaved flowering plants (forbs) and resulting in

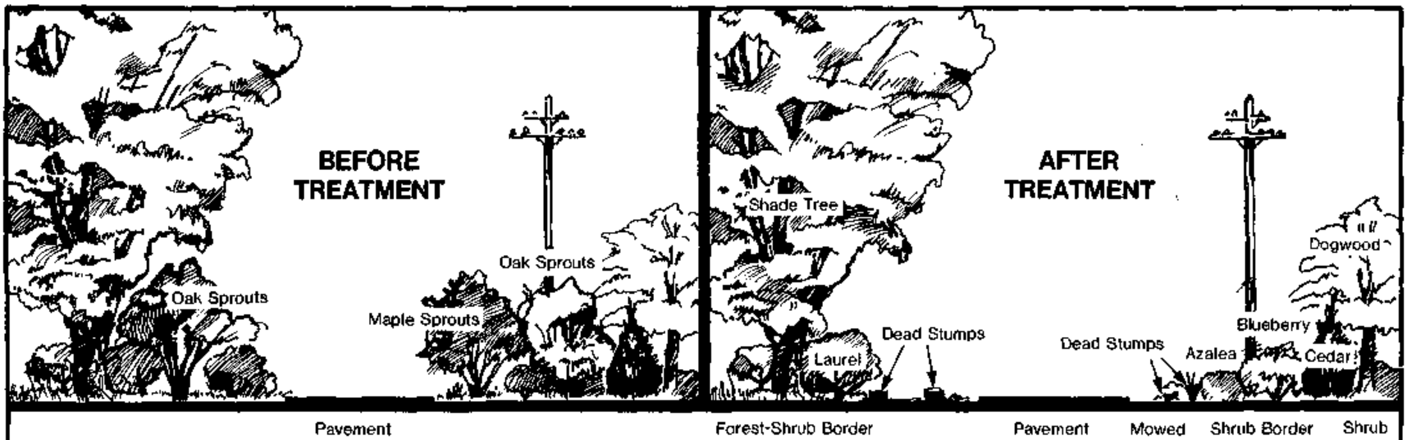

FIGURE 1. Diagrammatic bisect of roadside vegetation before treatment showing tree sprout clumps and shrubs, some of which will be removed; and after treatment with the undesirable woody plants selectively removed by herbicide treatment. Attractive native shrubs and wildflowers remain. Tree species which would grow into the wires of the utility lines have been removed. Shrubs underneath the wires and small trees adjacent to it have been preserved.

relatively spray resistant cover open to tree invasion and requiring continuous maintenance (Dill 1962–63). On a town roadside that was foliar sprayed through the wooded Connecticut Arboretum, drift of phenoxy herbicides affected unsprayed trees up to 300 feet from the roadside (Niering 1959). Affected oaks showed a characteristic weeping effect as the new growth developed. More specific details on sound roadside management and effects of broadcast sprays can be found in Conn. Arboretum Bulletins 11 and 13 (Goodwin 1959, Goodwin & Niering 1962).

In agricultural areas Crafts (1975) indicates mowing, burning, discing, blading, howing, seeding to grasses and legumes, and chemical treatment as among the techniques available to control roadside weeds. Although it is recognized that weeds (plants out of place in a given area) may pose a problem in certain situations, there is no ecological justification for their nationwide elimination, especially along the extensive grassy swaths of our interstate highway systems. Many of these so-called weeds are attractive flowering plants. In fact, our native grasslands comprise a rich mixture of both grasses and colorful flowering forbs. In order to maintain a weed-fire firebreak along State and interstate highways, Crafts further indicates chemical sterilization as a widespread tool. Although there may be localized situations where sterilization is needed, I highly question the extensive use of this technique in roadside management. Would not periodic burning be a feasible alternative in maintaining a firebreak? The potential role of fire in right-of-way management will be considered in a later section.

Railroad Rights-of-Way

Railroad rights-of-way offer another challenging opportunity for the selective use of herbicides where over the past decades broadcast sprays have been widely used. In the Connecticut Arboretum the Central Vermont Railroad right-of-way has been indiscriminately sprayed at least twice in the past 2 decades. On one occasion several hundreds of dollars were collected for plants damaged beyond the right-of-way on Arboretum property. Although selective vegetation management may be more difficult along high-speed rail systems, there is no ecologically sound justification for indiscriminate broadcast sprays. Such treatment on the Arboretum right-of-way resulted in unsightly brownouts, inadequate root kill of unwanted woody species, and accelerated erosion on the steep gravelly roadbed due to excessive removal of ground cover species. It is recognized that local broadcast use of chemicals may be relevant directly on the railroad bed if no vegetation can be tolerated. However, beyond this zone the sides of the right-of-way should be managed in a selective fashion similar to that outlined along roadsides.

Transmission, Telephone, and Gas Rights-of-Way

On transmission, telephone, and gas rights-of-way vegetation management should begin with initial construction. Only that vegetation which is deemed undesirable, such as tall growing trees that will grow into wires on transmission and telephone lines, should be removed. On gas pipelines low plant cover should also be preserved. Often much of the existing ground cover is unnecessarily destroyed or seriously disturbed by bulldozing the entire right-of-way—a technique still too widely employed. Following such an operation and the installation of the facilities, the line is then turned over to another department for future maintenance. If the clearing operation is initially coordinated by the two departments, greater conservation values will occur. Such is the current policy of Northeast Utilities. and Tillman (1976) also describes such an approach in southern New York. Northeast Utilities specifications dated March 31, 1975, state, "The objective of woody vegetation control is to *selectively control* that woody vegetation which is or will be interfering with the line which occupies the right-of-way. However, all herbs, most shrubs, and some low mature height trees are normally considered desirable, and they shall be preserved and encouraged to grow." By this approach one utilizes the existing plant cover to the maximum as an aid in decreasing future maintenance costs in addition to other values previously mentioned.

In setting forth a management design for a typical right-of-way, most managers agree that an access road is needed and that relatively low plant cover should be maintained around the towers or poles. Elsewhere, however, a diversity of shrub cover can be tolerated in a variety of site situations. Such a pattern has been created on the Connecticut Arboretum right-of-way demonstration area at Connecticut College (Niering and Goodwin 1974) and elsewhere in Connecticut under commercial management. In looking at a bisect across an idealized right-of-way, the height of the plant cover may vary forming a valley-like effect with low growing shrubs toward the center or directly under the wires and taller shrubs and low growing trees along the edges (Fig. 2). The rationale for preserving the low ground cover, especially shrubs, is based on their ability to arrest tree invasion.

The approach recommended in this paper contrasts sharply with that mentioned by Crafts (1975) where aerial sprays are used to convert woody growth to grasslands. Such treatments can result in a less stable and diverse plant community (Carvell 1976). In Alabama aerial sprays have also been compared with mechanical techniques for initial clearance. Aerial spraying is reported to result in a more diversified wildlife habitat than that created by mechanical clearance (Carter et. al. 1976). It would appear, however, that the mechanical clearance referred to here is not selective as advocated in this paper but rather bulldozing out most of the vegetation. Therefore this comparison is not valid. Regardless, aerial use of herbicides is not advocated as an initial vegetation technique on rights-of-way.

The Stability of Shrub Communities—Rationale for their Preservation

Although traditional succession concepts suggest that in highly disturbed forested areas there is often a relay from herbaceous to shrubby to tree species in somewhat of a step-like manner, this is obviously an over simplification of the process. In fact, there is considerable evidence that initial vegetation floristics is also often operative, which implies that the vegetation development is greatly determined by initial site conditions (Egler 1954b). Open or sparsely vegetated sites are frequently most favorable to the establishment of woody seedlings. However, once the site is heavily vegetated, especially by dense shrubby growth, seedling establishment is more difficult.

That shrub communities can exhibit remarkable stability has long been recognized by foresters since thickets are often a deterrent in forest regeneration. Mountain laurel (*Kalmia latifolia*), great laurel (*Rhododendron maximum*), scrub oak (*Quercus ilicifolia*), Japanese honeysuckle (*Lonicera japonica*) and snowbrush (*Ceanothus velutinus*) are among some of the shrubs that have been reported to arrest tree establishment (McGee and Smith 1967, Wahlenberg and Doolittle 1950, Little 1961, Yawney 1962, Zavitkovski et al. 1969).

The Connecticut Arboretum shrub stability studies show a diversity of shrub types as exhibiting stability (Niering and Goodwin 1974). Among these are huckleberry (*Gaylussacia baccata*), green brier (*Smilax rotundifolia*), and lowbush blueberry (*Vaccinium vacillans*). Egler (pers. comm.) also found the following communities relatively stable for nearly 50 years—meadowsweet (*Spiraea latifolia*), highbush blueberry (*Vaccinium corymbosum*), lowbush blueberry (*V. angustifolium*), arrowwood (*Vaccinium recognitum*), sweet fern (*Comptonia peregrina*), common juniper (*Juniperus communis*), and others of both native and introduced species. Elsewhere in Connecticut the following cases have been reported with varying years of stability: nannyberry (*Viburnum lentago*) for 45 years (Niering and Egler 1955); gray dogwood (*Cornus racemosa*) 2 decades (John Emery pers. comm.); witchhazel (*Hamamelis virginiana*) 40 years (Goodwin pers, comm.); and alder (*Alnus rugosa*) stable for 20 years.

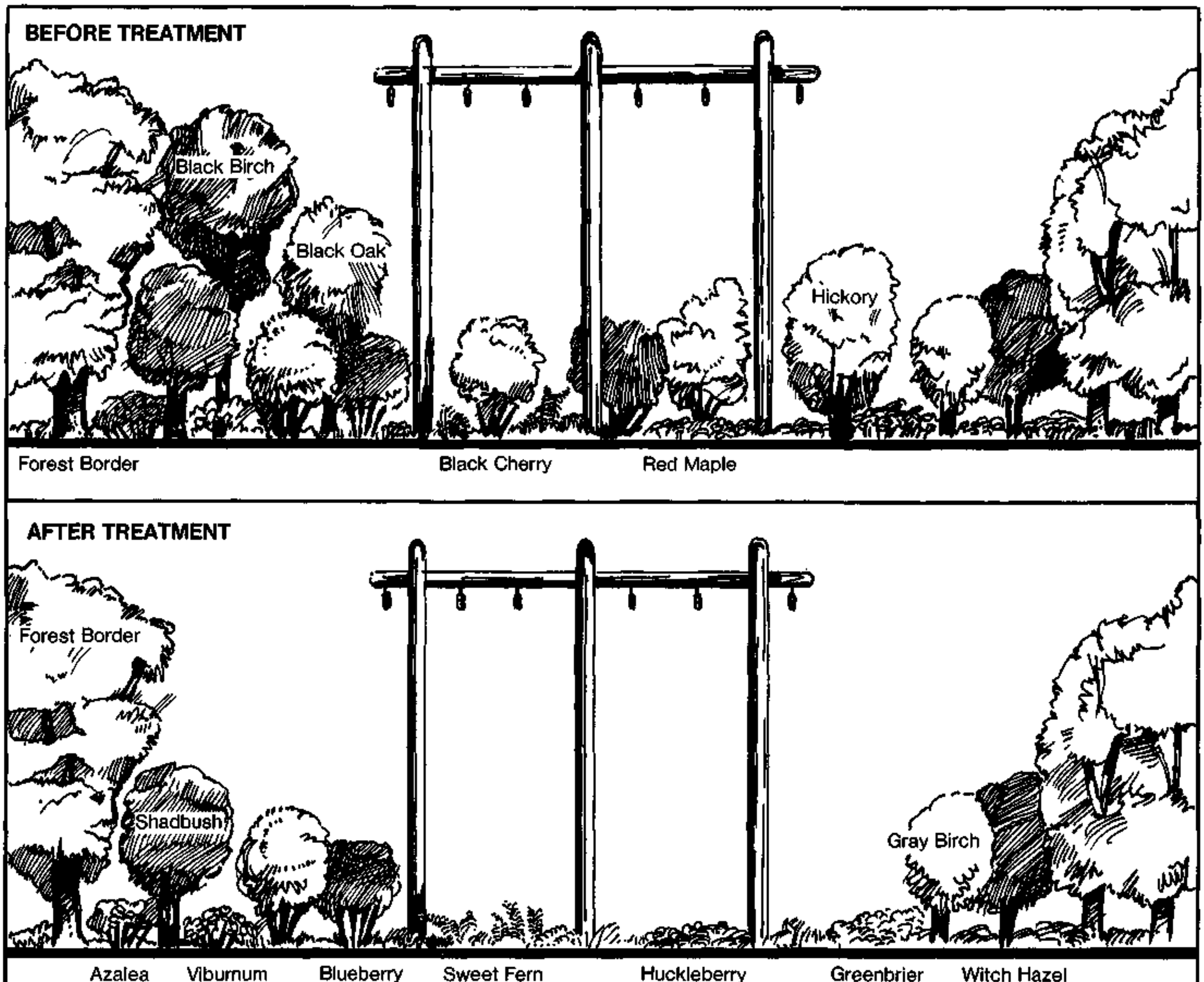

FIGURE 2. Diagrammatic bisect of an electric transmission right-of-way showing tree and shrub vegetation prior to and after selective herbicide treatment. Shrubs and low-growing trees have been preserved where they do not interfere with the utility operations.

In addition to relatively stable shrub communities certain grasses and forbs can exhibit considerable stability. In the Connecticut Arboretum little bluestem grassland (*Andropogon scoparius*) on well-drained sites tends to resist tree invasion (Niering and Goodwin 1974). Bramble and Byrnes (1974) found meadow fescue (*Festuca elatior*) to be remarkably stable, and Richards (1973) reports red fescue (*Festuca rubra*) with similar attributes. Dense stands of goldenrod and asters have been shown to exhibit allelopathic effects on woody invaders, thus showing a resistance to tree invasion.

This marked stability of dense ground cover types, especially shrub communities, further documents why every effort should be made to preserve the existing diversity of plant cover on rights-of-way, removing only that which interferes with management objectives.

MANAGEMENT TECHNIQUES AND ALTERNATIVES

Cutting and Mowing

Prior to the advent of herbicides clearcutting of woody growth or brush was the main technique employed in right-of-way maintenance. Although labor costs were much lower at that time, periodic reclearing was still necessary since most deciduous woody species resurge following cutting. The tremendous advantage of herbicides as a management tool has been our ability to root-kill undesirable growth, so that one can manage the vegetation toward the development or preservation of a mixed grass-shrub-forb vegetation. Therefore, even where cutting is still employed without herbicide treatment, only undesirable tree growth should be removed. Although cutting adds to the cost of maintenance, it is often necessary along certain roadsides in order to maintain adequate sight line conditions. However, it is usually followed by herbicide treatment.

In the Pacific Northwest conifer forest region mechanical cutting is also carried out along the forest roads. Although somewhat unsightly, it is feasible where non-sprouting species are involved and aesthetics are not of major concern.

On interstate highways hundreds of miles of roadsides are periodically mowed. Here mowing tends to arrest woody growth and decreases the fire hazard. However, there is a tremendous expenditure of fossil fuel in maintaining this vast acreage, especially in an era when energy conservation is being advocated as a national policy. A viable alternative such as prescribed burning may eventually evolve, realizing that certain management problems would have to be resolved.

Stump Treatment

When unwanted woody growth that has the ability to resurge is cut, it should be treated with herbicides. Stump treatment involves the application of the herbicide, usually in an oil carrier, to the cut stump—preferably immediately after cutting. Currently, cutting and stump treatment are extensively employed along roadsides not only for maintaining sight line conditions but also for preventing potential tree growth from growing into utility lines paralleling the roadsides. The actual removal of the undesirable growth is also aesthetically more desirable since basal sprays, especially in summer, can result in brownout.

Along roadsides such as those in our National Forests the stump treatment technique advocated by McQuilkin and Strickenburg (1961) nearly 2 decades ago is still ecologically sound. This basic approach is applicable to all roadsides where undesirable tree growth should be removed.

On transmission lines in southern New England, Northeast Utilities also employs the stump treatment on either side of their rights-of-way where they cross public roads. This is done primarily for aesthetic purposes even though the remainder of the line is selectively treated by basal sprays. Costs for such treatments range from $139.00 to $723.00 per acre depending upon stem density and chemical employed. The average cost is $347.00 per acre using Tordon 155 and $464.00 using 2,4,5-T. These data are for rights-of-way within the central and transition hardwoods forest region of Connecticut and northern Massachusetts. The stump treatment, although more costly than the basal technique, is an ecologically sound selective technique which results in good root-kill.

Basal Bark Technique

The basal technique involves the application of the herbicide, usually in an oil carrier, to the lower 12″-15″ of the stem base. Trees up to several inches dbh (diameter breast height) can be effectively root-killed. On trees 5″-6″ dbh or over frilling the base of the trunk prior to application increases the effectiveness. Over the past 2 decades research on the Connecticut Arboretum right-of-way demonstration area (Niering and Goodwin 1974), the Pennsylvania State University area (Bramble and Byrnes 1974), and elsewhere (Carvell 1976) has documented that the existing ground cover is best preserved by this selective approach. At the Arboretum a mosaic of relatively stable upland and lowland shrub communities and grass forb types have been produced by basal and stump applications. In Pennsylvania an ericad-dominated shrub type has been especially favored. Of even longer duration has been the 40-year-old shrub complex on a right-of-way in southern New York where the Civilian Conservation Corps physically removed tree growth in the 1930's on a section of right-of-way resulting in the preservation and perpetuation of a mosaic of relatively stable shrub types (Pound and Egler 1953).

In commercial application this technique has also proven to be economically feasible. Ulrich (1976) reports that Metropolitan Edison in Pennsylvania has been employing basal applications since 1955. In the mid-1960's the Eastern Region of the U.S. Forest Service (1966) set forth a sound selective vegetation management policy for rights-of-way. More recently Northeast Utilities has moved to a selective basal technigue. The specifications may be among the most rigorous in the Nation demanding a 90 percent root-kill of unwanted free growth over 6′ high. In commercial operations such specifications are obtainable and economically feasible. Costs range from $74.00 to $221.00 per acre with an average around $130.00 using Tordon 155 (picloram, 10.3 percent, and 2,4,5-T, 41.3 percent). Northeast is currently on a 4–6 year spray cycle but this will expand to a 6–8-year interval or longer depending upon the stability of the ground cover (Robert Smuits, pers. comm.). Tordon has proven to be more effective on root suckering species than 2,4,5-T alone. However, considering its potential killing impact on desirable plants as well as its toxicity to fish, the dormant stem broadcast applicataion included on the manufacturer's label is not recommended. Although there is general concern about the safety of herbicides, Barnes (1976) in a rather thorough recent review concludes that the major groups of herbicides display no significant effect on mammals, and there is little published on the toxic effects on wildlife. The main hazard arises from the effects of herbicides on vegetation acting as habitats and food losses such as can occur with broadcast spraying. There is also a sound physiological basis for employing nonfoliar application. Only small amounts of the phenoxy herbicides are actually moved from leaves to stems in woody plants and movement to roots is negligible (Hay 1976). Therefore, placement of the chemical on or near the root collar is highly desirable if root kill of unwanted growth is desired. In fact, picloram when applied to the roots moves to the shoot tips and young leaves where it accumulates.

Stem-Foliar Treatment

In transmission rights-of-way vegetation management there may be so-called sensitive areas where the right-of-way crosses watershed land or comes close to agricultrual lands where certain chemicals are not desirable. For example, some crops are especially sensitive to picloram. In such situations selective stemfoliar sprays of Ammate XNI are currently being used on watershed lands in Connecticut and Massachusetts. Here on localized areas Ammate is considered safer and more desirable by Northeast Utilties. Such foliar applications run $255.00 per acre, whereas stump treatment with Ammate runs as high as $850.00 per acre. It could be argued that if phenoxy herbicides cannot be used, then only Ammate stump treatment should be employed to get the maximum selectivity. Although the initial cost of the latter is several times greater than selective Ammate foliar sprays if effective root-kill is obtained, the more expensive technique may well be more economical when pro-rated on a long-range basis.

Foliar or stem-foliar sprays can be applied from the ground as well as aerially and both techniques are indicated on manufacturers' labels or handbooks issued by industry. Although selectivity is often claimed as feasible, it depends upon your management objectives and your meaning of selectivity. Those employing such techniques in a widespread manner are tending to manage "brush" not vegetation. Their objective is usually the suppression or total elimination of woody growth and the creation, hopefully, of some type of herbaceous cover, often a grassland.

Among the limitations of stem-foliar sprays are (1) lack of selectivity, (2) loss of desirable ground cover, (3) potential for inadequate root kill, (4) opening site conditions and often favoring a vegetation type more prone to tree seedling invasion, and (5) drift of chemical spray off the right-of-way.

Broadcast sprays applied from the ground or aerially can drastically affect ground cover species. Carvell (1976) has found in a nine-State study that eventually spray resistant species dominate. Some of the common plants include perennial grasses, hayscented fern (*Dennstaedtia punctilobula*), bracken fern (*Pteridium aguilinum*), sweet fern, and whorled loosestrife (*Lysimachia quadrifolia)*. He also notes that summer and fall wildflowers are adversely affected unless the more soil persistent picloram has been used. Asters, strawberry, goldenrods, and vetches are also more effectively eliminated by picloram (Tomkins & Grant 1974).

Although foliar sprays are still widely employed in "brush" control, costs can run $100.00 to $124.00 per acre compared to an average of $130.00 for selective basal applications--a more effective and environmentally desirable approach.

Burning

The use of prescribed or controlled burning is now recognized as an important management tool in forest and wildlife management. It has also proved to be applicable in managing the vegetation on rights-of-way in the South. Arner (1976) and his associates have used fire on rights-of-way which had been cut and sprayed over 2 decades to achieve a dominantly grass-forb cover. In Alabama and Mississippi they found that winter burning could be effectively used on the upper Coastal Plains, Interior Flatlands, and Southern Prairies. Apparently the initial herbicide spraying removed most of the woody growth favoring the present herbaceous cover dominated by various grasses and forbs. With burning, the herbaceous cover was further favored as game habitat. Burning combined with fertilizer significantly increased desirable annual food plants for quail and turkey. Since the maximum temperature recorded 12 feet above the ground in winter was only 148°F, this technique would not appear to be hazardous to overhead lines on most rights-of-way. Effective summer burns were obtained in certain areas, and here increase kill of sprouting hardwoods also occurred. Burning on a 3-year cycle is recommended. Winter burning was most economical ranging from $3.60 to $15.40 per acre. This compared with up to $96.24 for selective basal sprays during the initial period in the removal of woody growth (Arner 1976).

On steeper terrain, however, where plowing fire lanes is too difficult, selective basal spraying is recommended to develop a shrub dominated community. In this Southern region burning on relatively level terrain combined with selective basal sprays on steeper topography offers two possible approaches in developing a diversity of plant communities. It appears that prescribed burning might also be possible along much of the eastern Coastal Plain where the relief is low and the creation of adequate firebreaks is feasible.

The use of prescribed fire on the grassy swaths along our major highways will probably also increase in the future as fossil fuel costs continue to rise. Actually a combination of mechanical mowing and burning will probably be employed. At the Connecticut Arboretum we have been maintaining old field little bluestem grasslands by either annual or biennial burning (Niering et al. 1970). With spring burning, minimum width fire lanes are needed, herbaceous cover is favored, and woody growth is suppressed. Thus with burning, the same general objectives can be achieved as occur with periodic mowing. It is recognized that air pollution may be considered a problem in terms of smoke or decreased visibility. However, often this can be kept to a minimum depending upon moisture conditions.

In Australia burning is employed in railroad right-of-way management, as I have observed between Melbourne and Canberra where much of the line traverses pasture land. Controlled burning probably offers one of the most challenging potentially energy-saving techniques of the future.

Other Alternatives

Among other alternatives that may be employed in right-of-way vegetation maintenance are growth inhibitors, herbicide pellets, herbicide injector tools, and certain new chemicals. Growth inhibitors, which arrest meristem elongation, have been used by Chappell and his associates (Chappell 1976) in Virginia, where they found that the growth of grasses and woody species was noticeably reduced. They report growth reductions as much as 90 percent on some woody species using diethonal amino salt 3-triflouromethysulfonamide-p-acetetoluidide (Sutar) or maleic hydrazide (MH-30). Complete inhabition was achieved by late season applications of ammonium-ethyl carbamorylphosphonate (Krenite). In fact, most woody species treated with Krenite (6–8 pounds per acre) died, and annual ground cover growth in the spring was not affected. The potential advantage of Krenite is that no brownout occurs. However, its control of root suckering species such as sassafras in both Virginia and Connecticut (Robert Smuts pers. comm.) appears limited. As a foliar spray selectivity in application may be a further limitation. Its use should be restricted to those situations where more selective techniques are not feasible.

The use of herbicide pellets impregnated with picloram has also proven to be effective in controlling woody species. Apparently they can be selectively applied or spread indiscriminately over the entire right-of-way. Where spread throughout, Carvell (1976) found that spring wildflowers were eliminated due to the long persistence of picloram. Therefore, such superficially innovative techniques should be used with extreme caution. Selective placement of the pellets in order to remove only the undesirable growth is recommended.

Special injector tools loaded with concentrated herbicide are effective in the selective removal of unwanted tree specimens without damaging adjacent plants. This tool would be most effective in the removal of larger trees along the edges of rights-of-way that might otherwise fall into the lines.

Although there are adequately effective herbicides available to selectively manage woody growth on rights-of-way, new chemical formulations are continuously evolving from industry. Most of the formulations currently used contain 2,4,5-T in some form and since certain States have banned the use of 2,4,5-T, new formulations of 2-4D derivatives such as Weedone 170 (2,4-Dichlorophenoxypropionic acid and 2,4 Dichlorophenoxyacetic, butoxyethanol esters), effective on woody species, may provide an effective substitute for 2,4,5-T. It is toxic to fish and must be kept away from ponds, lakes, and streams. Certain farm crops such as tobacco, beans, tomatoes, and cotton are also sensitive.

***Electromagnetic* Pollution vs. *Underground* Transmission**

The possible health hazards of electromagnetic radiation (Bankoske et al 1976, Becker and Marino 1978) and air pollution (Young 1976), primarily ozone associated with extra high voltage transmission lines, may result in an increase in underground transmission.

Although underground transmission is expensive, about 1 percent of the lines mostly in highly urban areas, are now underground. G. Frank Miller (1976) of the Federal Power Commission feels that installation of underground cable will increase rapidly in the future especially around densely populated areas where extra high voltage and ultra-high voltage lines will not be permitted. If it is documented that there is a real health hazard, the rate of underground installations will probably increase in the future. Even with underground lines buried to 3–4 feet in depth, shrub dominated communities are still compatible as long as an access road is maintained under the lines.

IN CONCLUSION

In conclusion it appears the Nation's rights-of-way offer a tremendous potential in terms of an open space land resource which can serve a multiple set of land use values, if properly managed. There must be a recognition by the chemical industry and the utilities that they are dealing with a mosaic of plant communities rather than just "brush." As long as the brush control mentality persists, broadcast foliar sprays will tend to dominate the scene rather than the selective approach with its multiple values to the utility and the public at large.

And finally, what relevance does sound right-of-way management have to the U.S. Forest Service and Environmental Protection Agency? Today, in an increasing environmentally conscious society, it is prudent that Federal agencies utilize and promote the most environmentally sound techniques available. Within the Forest Service the National Forests represent a vast natural resource where forest roadsides require periodic maintenance and transmission lines crisscross vast acreages of Federal lands. Sound techniques should be employed such as those advocated here and already set forth by Forest Service personnel. On the vast acreage of utility rights-of-ways crossing federally owned lands, only sound management techniques should be permitted by the utilities.

For the Environmental Protection Agency concerned with nationwide environmental quality, policy statements concerning sound rights-of-way vegetation management, rather than "weed" or "brush" control as used by industry, will further emphasize the scientific ecological aspects of the problem. Federal agencies should set the example and recommend guidelines for selective rights-of-way maintenance. In so doing, those concerned with managing this resource may come to recognize the broad spectrum of environmental values and also recognize the economic feasibility when figured on a long-range basis.

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PANEL DISCUSSION

MR. FLAMM: Thank you very much for an excellent presentation.

I would like Hyland Johns, if you would, to start off our panel discussion. Would you like to respond to the speech?

MR. JOHNS: For my 3 or 4 minutes I would like to compliment the speaker for those of you in the audience who have not had a chance to read this paper. I would urge you to do it when you get the proceedings. It is a very comprehensive review of the subject as it was originally charged to us. There are a few differences or questions I would like to raise and a couple of additions in the time that permits.

First of all, nobody has said in respect to rights-of-way, "no action," and I would, for the record, like to say that when you are talking about highways, pipelines, communication, electric, and railroad rights-of-way, that alternatives to the methods that have been discussed today would be economic and social chaos. We cannot do nothing with our rights-of-way; there is no question about that.

When you get to the paper, you will find most of the alternatives that I am aware of.

There is a new one, and I think it may have some promise, although strictly in the development stage, and that is the electric shock technique for treatment of undesirable weedy plants.

Bill, I would say I think we all get your message on minimal use and selective application of herbicides, but I would like to push the door open a little more and broaden this a bit and make several points that I think need comment.

First of all, in paraphrasing, you stated the Forest Service should require utilities to employ only selective techniques on rights-of-way on Federal lands. If you include other than selective basal, I go along with that. There is selective oil-water, semi-basal, selective leaf stem foliage.

You stated that EPA should set guidelines on management of these public and private lands. I don't believe for a minute that it was the intent of Congress to allow or to have EPA get into this. They have too many other things to do, and they are behind on their deadlines with these, and I don't think it is the appropriate place to determine guidelines for right-of-way management.

I believe you stated the aerial use of herbicides is not advocated as an initial vegetation clearing technique. Sometimes, I hold, it is; and as an applicator working across the country, I feel from experience in performing this work and supervising 8000 other people doing it, based on other experiences—when you are talking about weedy plants over 8 feet high that have to be eliminated—you can do it safer from the air with thickened or other application systems and formulations that will control drift better than some of your ground applications in certain areas.

Aerial application of 8- to 10-foot-high weedy plants is like treating a forest. You are going to have the overstory, and the chemical does not get to the ground layer. After an initial treatment you find the next year, if done by the proper prescription, you find a tremendous regrowth of the species that you saw on the slides, that we are trying to achieve.

I think you have to look at your figures again, at least I would question the figures, and I will put it in the record. I don't think there is time to go into the cost figures on selective basal versus various foliage and cutting and other alternatives.

The figures you used for Northeast Utilities, and we work for them, certainly cannot be extrapolated for the rest of the country and the tremendous variety of conditions you find there. I will put in the record other figures that might be more broadly applicable.

Lastly, you made a point that the few formulations may provide an effective substitute for 2,4,5-T. This may be possible, but I don't see it with the compounds you mentioned or some of the others being proposed as "T" substitutes, because what will happen if you use a less effective chemical may be that you will have to use a higher concentration, greater quantities, and you will have to have more frequent applications, perhaps, until you reach the ultimate of plant community takeover and control. So, it has to be evaluated in terms of their ecological effect in addition to cost and and other considerations.

I would like to conclude by saying that less than 10 percent of our company's sales and profits come from herbicides. We can use anything, and if we had to go to these other alternatives our sales and profits probably build up tremendously.

We are interested in herbicides because not only are they more economical, I think they have less impact on the environment when properly used, that means, according to the label. This is a labeling, it is a legal document, and it has to be followed according to the certification of the States in which you are working, and these are good things; and if followed, I think it will help avoid some of the abuses—although I don't think the abuses are as bad as has been painted.

Our record over the past years of use of herbicides on millions of acres and the damage resulting from careless accidents or negligence or something else—and everybody has an accident, I don't think any of us are free from those little errors—but our experience shows that our claims and accidents have cost less than 10 cents per acre per year. We are hoping to get below 5 percent, and we are getting close to that, but we can live with that while we are trying to make it better.

I would like to conclude by saying, from the standpoint of occupational hazard, I have figures from the States showing that the States and the insurance companies all look at spray applications as being far safer than tree and burn control, contrary to some of the statements we heard this morning. Sharp tools, mechanical, hand cutting tools, power saws, are far more dangerous to the men, and I have records to prove this, compared to the chemical treatments.

I would like to conclude by saying, in support of Bill's general thesis, take a thing that needs to be here to conclude with, and that is that we need prescription programming. The *Journal of Forestry* in January talked about the tree, the decision tree. We made one of these 15 years ago to show that prescription programming is the way this thing should be approached. It means identify and inventory the resources on the right-of-way, which includes the undesirable, the sensitive, all of these other things, and in the framework of the objectivities of the area whether agricultural, recreational, water yield, and others, to then prescribe the right treatments, supervise them carefully, follow up, and monitor.

These are the things that have to be done to ensure good jobs with safety to the public and the worker and long-term economical maintenance of our rights-of-way.

MR. FLAMM: Thank you, Mr. Johns. Next, Ed Grassal.

MR. GRASSEL: Thank you, Barry. I would like to state that Bonneville Power has adopted a selective vegetation management policy and all of our right-of-way management standards reflect that philosophy. We have been working at this for quite a number of years. We are trying to promote a low-growing vegetation under our lines to help control the growth of taller species, and we are trying to implement this the best we can.

We are in the process of writing standards to control the use of herbicides indiscriminately. We couldn't live, I think, without the use of herbicides. We have some 12,000 miles of transmission line that we have to keep the lights burning out there, so it is very important that we have a plan which gives us the highest degree of reliability of transmitting that power, and at the same time using right-of-way management tools which will be the least damaging to the environment.

There are some 200,000 acres of right-of-way in our system, which covers Oregon, Washington, Idaho, Montana, and a little part of Wyoming. We have about 84,000 acres of land which reqiures vegetation management. We feel that the best way to manage those lands is to let the individual landowners take care of the management the best possible way, rather than us have all the headaches, but, of course, we can't always do that.

We hold very little land in fee which we have to control. We would prefer that this land be managed by others. We do use a helicopter spray. We control it very well. We limit the time at which the spray can be applied to the early morning hours when it is calm. We don't permit spraying when it is over a 1 or 2 mile-an-hour wind, a maximum of 5, but mostly within 1 or 2 miles an hour, very calm. We put out control cards to see that there is no overspray off the right-of-way. We use thickeners. We do the best we can in controlling the indiscriminate use of herbicides.

We have used contracts in clearing our rights-of-way—those which we have control of. We have issued contracts to minority groups. We have used small businesses, and we have found it works fairly well, so that I think we are integrating all the things that I have been hearing today into managing our rights-of-way to the best way we know how to fit in with the ecological philosophy.

MR. FLAMM: Thank you, Mr. Grassel. Next, Jeffrey Davis.

MR. DAVIS: Thank you, Barry. To those of you who know Dr. Egler, I am sure you must be somewhat disappointed to see me sitting here rather than him. However, he would like to be involved, and if you have any questions that you would like to direct to him, submit them to the symposium chairman—and he will do his best to answer your questions in writing for the printed proceedings of the conference.

I would like to focus on a subject that Bill brought up in his talk, and that is the decision between brush control and vegetation management. I think once this distinction is fully understood, the role of herbicides as a tool will be less controversial.

Brush control is our legacy in this field. Brush control is what has been going on from the beginning of powerline maintenance. It is a simplistic concept: simply keep the tall growing brush out of conductors and do it as cheaply as possible.

Today, brush control has moved from rather indiscriminate stem-foliar applications to selective applications. More thought is now given to the types of vegetation being sprayed and how they are being sprayed. In other words, utility companies are changing.

Vegetation management is a more complex concept, but it has far more potential for realizing the goals of vegetation management. You don't get something for nothing. Vegetation management is both an art and a science that is ecologically based, as Dr. Niering pointed out. It considers a multiplicity of values and resources. It has as its goals the maintenance of reliability and security with minimum adverse impact at the lowest cost to the rate payer for the most years with the highest conservation values of the resultant plant communities.

Now, at the risk of sounding somewhat esoteric, let's explore this a bit further. Vegetation management depends upon a knowledge of what the vegetation was for a given ecological geographical context, what it was, what it is, what it could be under various management strategies and tools, and what the vegetation values are. With the development of this knowledge we are then, and only then, in a position to truly meet our goals and not just give them lip service. I am constrained to say that that is the state-of-the-art today.

The companies are dedicated to keeping the brush out of the lines over the conductor, but the lowest cost for the most years for the highest conservation values, with few exceptions, lip service.

Vegetation management is a long-term proposition. It is an investment in the future. It is no overnight panacea. It will require a modest investment in R&D, perhaps a larger investment in I&E. It will require a gradual phase into operations. It need not disrupt operations as most managers fear when they talk to characters like me. The main barriers to it, in my opinion, are psychological and social. They are not economic nor are they the result of a lack of scientific information.

So, in my opinion, we are still in the era of brush control—1978. Today's brush control is somewhat more selective. It is doing less damage. But the values of right-of-way vegetation have yet to be appreciated; with a few general exceptions, that proves the rule.

MR. FLAMM: Thank you, Jeff. Dr. Byrnes.

DR. BYRNES: Thank you very much, Barry. I appreciate the opportunity to be here today. In many ways I feel like I am reliving my youth because I have been involved in vegetation management on transmission and direction rights-of-way for 27, almost 28 years.

Twenty-five years ago we went through the same process that we are going through today, and people were expressing the same concerns and posing the same questions, that is, use of herbicides versus mechanical methods of vegetation management, what kind of treatments, broadcast versus selected basals versus other and various and sundry methods that have been developed through the years.

So my associates and I, in collaboration with industry and university and State agency people, initiated a study in the Allegheny plateau in the upland oak forest type in Pennsylvania, a study celebrating its silver anniversary this year. It has been maintained now for 25 years, and our objectives in this study have not changed over those years—and those objectives relate to the questions that are being posed here today. How well can you control the target species that you want to remove? What effect does this have on the non-target vegetation, the low-growing shrubs and grasses and herbs and other tree species that may be tolerated on some parts of the right-of-way? What effect does it have on wildlife habitat? Does wildlife use these areas after herbicides have been applied?

So in this study—and it was a design study—we incorporated the commonly used methods for vegetation management that were inherent in the early 1950's. This included broadcast treatments. Most of our herbicide work was with 2,4,5-T. In addition, ammonium sulphate—we hear there is some use today, not as much as at that time—was used. So we had two broadcast systems, an intermediate which we called a semi-basal, and then two selective basal treatments, a summer and a winter basal treatment. In addition, we also included a manual treatment, that is, hand cutting of the brush. And I use "brush" because that is what it was called at that time. We were going through a trial and error period.

I fully endorse Dr. Niering's concepts which he put forward: that we talk about vegetation management, that we use ecological pinciples. There is nothing magic about this. Progress has been made. Many Federal agencies and State agencies have employed competent professional people trained in the biological sciences, and it doesn't stop there. The utilities have hired these kinds of people and the custom applicators have, so we have greater inputs of professionalism. Professionalism from the standpoint of their ability to understand plant community development, the process of succession that Dr. Niering talked about.

In turn, these people are capable of setting up the plans and training those who are going to be involved with the land management aspects in the field Progress has been made, tremendous progress, and I think quite often we are too impatient. The environmental era did not start yesterday in Washington. As far as I am concerned, it started back in late 1949 and the early 1950's.

Dr. Niering had two slides of the study I referred to, and I think we will defer on those and not show them. We have been able to show with the broadcast treatments that there is greater disturbance of the non-target species. This disturbance lasts for a very short period of time; in our case, within 1 year the areas were revegetated. Depending on the kind of chemical used you had a difference in the type of vegetation that came back. Where we used the selective stem foliage or selective basal treatment, we minimized disturbance to the non-target species, so we have maintained the same plant species for 25 years.

The wildlife used the areas. There were species of plants available there, used for nutritious food for wildlife and good cover. On the control areas that were hand cut, the same thing. We maintained the original vegetative cover, the low, desired ground cover, for 25 years.

The slides that we have available, which I won't show, are panoramic views of three of the treatment areas on this right-of-way. One is a broadcast treatment, one is a selective basal treatment, and the third is the intermediate, the stem foliage semi-basal treatment.

When you look at this area today, you cannot see any difference. Within 15 years the desired woody shrubs were back in the areas that received the broadcast treatments. Granted, they were missing for 15 years; although on the selective basal treatments, they were maintained throughout that period.

However, all of the area has pretty much reverted to the original composition we had to begin with. It is a stable community, a diverse community, the typical mosaic Dr. Niering is talking about.

Some components are highly resistant to invasion of tree species. There is one grass that resulted from the broadcast 2,4,-D plus 2,4,5-T treatment which is the most resistant. So we can't generalize here. When you are talking about resistant communities, we have to say what species because there is variation here as well.

I solicit that there has been progress made. There will be more progress made, and we are well down the road in preserving our environment and doing the job.

I solicit, too, the thing we proposed years ago and that is prescription selective vegetation management programs on utility rights-of-way. At this point in time you cannot agree that we limit managers to one option and if that option is going to be strictly a selective basal type treatment; I think he needs more options than that to get the electric power to us who need it. Those options include broadcast treatment in remote areas where nothing else can be done. Some patches are so dense, even if you go in with a selective basal treatment, it is still a broadcast. In many instances they have no ground cover when they reach that treatment. The selective basal treatment is excellent, and you can do an excellent job under the right conditions. Mechanical—I think the same way.

It is being incorporated in selective programs today along roadsides, streams, this type of thing, where they have selectively cleared the right-of-way. No treatment is being used in some of these programs where you have deep ravines today, and these are the most sensitive areas. They don't need to control brush there, the tall growing trees, if you will.

I solicit this type of program, a selective vegetation management program with a number of options, if used responsibly.

MR. FLAMM: Thank you. Dan Cassidy will have the opportunity of concluding the panel this afternoon. We won't have time to answer your questions; I am sorry.

MR. CASSIDY: I would like to state that there is a difference between the plant growth in California, and certainly, we plant trees on the roadsides in California. We have to care for them by watering them throughout the drought in the summer to try and get them to grow. We try to use alternative methods to chemical spraying wherever we can.

The question was asked this morning; we do not use 2,4,5-T—we have not for 7 years in California. Dry sulphate does seem to be a suitable material to use.

Our policy in California is to use alternative methods whenever possible and to use only the safest possible materials.

Our biggest problems are noxious weedy types of growth, such as the introduced species into this country, such as Russian thistle, yellow thistle. These types of materials lend themselves to biological control.

We have a number of contracts going. Is another method of controlling vegetation possible?

POST-SYMPOSIUM RESPONSES TO QUESTIONS

QUESTION: Why is grass cover not desirable on rights-of-way?

DR. NIERING: It depends upon the grass type. In forested regions annual grasses are unstable and permit tree seedling invasion. Most perennial grass cover is less stable than shrub cover and offer less wildlife food and cover. However, certain grasses like little bluestem and fescues may be relatively stable and should not be destroyed if present on rights-of-way.

QUESTION: You made a statement that foliage spray presented a drift hazard. Is this to imply that selective basal does not present a drift hazard?

DR. NIERING: Yes, selective basal sprays do not pose a drift problem and the root kill is usually more effective than foliage spray.

QUESTION: Do you see any role in *urban* rights-of-way for growth regulators (e.g., maleic hydrazide) as vegetation management (those chemicals that *retard* growth rather than kill it) for trees on private land over which utility lines pass?

DR. NIERING: Yes, growth regulators have a potential role in rights-of-way vegetation management. Any chemical techniques that will keep the vegetation at a desired height may be effective. My paper deals briefly with this subject.

QUESTION: Do you agree that vegetation management is both an art and a science? If you do, shouldn't the use of herbicides be left to the exclusive use of specialists and not given to the general public with label instructions? If you don't, then why have landscape specialists like yourself?

MR. CASSIDY: The amended FIFRA laws that require certification of applications is a good law in my opinion. The proper testing and certification of applicators will assure that the general public is protected from indiscriminate use of herbicides.

INTRODUCTION OF PANELISTS

MR. FLAMM: *Will the next panel come to the head table?*

The first panelist is FRED ARNOLD, Acting Branch Chief, Special Projects Branch of the Special Pesticide Reviews Division, Office of Pesticide Programs, EPA.

The next panelist is MARY BURKS of the Alabama Conservancy. Mrs. Burks organized the Alabama Conservancy and was its first president. She has been active in a number of environmental issues.

Our next panelist is GERALD MOORE. Jerry is an assistant to the Director of the Special Pesticide Reviews Division, Office of Pesticide Programs, EPA. He is a fish and wildlife specialist working in liaison with the Wildlife Service and Commerce Department.

Our next panelist is GERALD MACKIE, president of HOEDADS, Incorporated, from the University of Oregon.

Our last panelist is DR. CHARLES WALKER, Senior Environmental Scientist, Division of Habitat Research, Fish and Wildlife Service, Department of Interior. He is on a special half-time detail with EPA.

Our last speaker was given the most difficult job of covering the rest of the ground; but after looking over his paper, I think you will agree with me that he is taking a unique approach to it, and I am sure you will enjoy reading it in advance.

DR. ANDRES: *I see we are a little pressed for time here so I will try to go through this fairly quickly and allow the panelists a chance to comment.*

First of all, the title of the paper is different than what appears in the program. The title is now "The Role of Biological Control, Intensive Skilled Labor, and Controlled Fire in Achieving Realistic Vegetation Management."

Since my experience is only in the area of biological control, I asked Sean Swezey, a graduate research assistant at the University of California, involved in the labor intensive approach to vegetative management, to help me and Richard J. Vogle, a professor of biology with experience in working with controlled fire.

THE ROLE OF BIOLOGICAL CONTROL, INTENSIVE SKILLED LABOR, AND CONTROLLED FIRE IN ACHIEVING REALISTIC VEGETATION MANAGEMENT OBJECTIVES

Lloyd A. Andres, Entomologist
Biological Control of Weeds, USDA, SEA, Albany,

California
Sean L. Swezey*, Graduate Research Assistant
Division of Biological Control, University of California, Berkeley

Richard J. Vogl*, Professor of Biology
California State University, Los Angeles

**Did not partipicate in symposium*

INTRODUCTION

Although this symposium focuses on the question of herbicide use on Forest Service land, to resolve it we must answer a question of more fundamental importance —how much is man a part of nature; how much is he apart from nature? Since every action against a plant, plant community, or area, triggers a sequence of reactions throughout the ecosystem, how much and by what means can we alter the forest environment without jeopardizing its long-term productivity as well as our own well-being? Just what are the full consequences of our activities on the forest ecosystem? To avoid unwanted repercussions, care should be taken towards setting realistic utilization objectives and the methods employed to attain them. Utilization plans geared to getting more for less, whatever the "less" happens to be at the moment; e.g., man-hours, money, or energy, must be tempered by an ecological appraisal of the potential sustained productivity of our forest resources. The economic justifications for our decisions must be ecologically sound to avoid short-term gains at the price of long-term imbalance. Selective and non-disruptive vegetation management techniques should receive priority consideration to avoid unnecessary environmental repercussions.

In addressing this particular assignment—alternative methods of vegetation management as they relate to wildfire and the optimization of forest land productivity, wildlife, recreation, and watershed—we recognize the limitations of our own experiences and have focused our comments on those three techniques we know best, i.e., biological control, intensive skilled labor, and controlled burning. We note some of the advantages and limitations of each method, leaving it up to the resource manager to determine their applicability in vegetation managment programs. The minimally disruptive or "soft" cultural techniques which we describe offer a distinct advantage over other methods in that they allow the manager to retain the option of using other management practices if they are needed.

GENERAL CONSIDERATIONS IN APPROACHING THE PROBLEM OF VEGETATION MANAGEMENT

Ecological

Two ecological concepts basic to sustaining resource productivity in a vegetation management program are: (1) in nature no plant exists in isolation and (2) the plants present in an area are forever responding to the changing climatic, edaphic, and biotic factors of their habitat.

Plants enter into varied and complex interactions with many other organisms, serving as food and shelter as well as competing with other plants for essentials. Thus a cultural practice which obviously impacts on a particular plant may eventually initiate repercussions throughout the entire system of organisms dependent upon or competitive with that plant species. For example, the encroachment of weeds and other plants non-palatable to cattle is one of the more obvious environmental responses to the cultural practice of overgrazing. However, the subsequent and more covert shifts in faunal composition and microbiota, erosion, rainfall runoff, etc., often go unrecognized and unrecorded.

The frequent and widespread use of an herbicide is a cultural practice that poses another danger in the fact that "They can affect vegetation over very wide areas in a short period of time, thus eliminating 'reservoirs' of wildlife and wildlife habitat that would have otherwise survived." (Way 1969). The problem here may not be so much a toxicological one as it relates to wildlife but an ecological one in terms of scale and intensity of use. Thus the total destruction of a small area of vegetation on one occasion might be less serious for the wildlife of a region than the selective destruction of vegetation over a wide area at regular intervals. Non-cultivated lands are becoming increasingly important (as urban centers expand) as genetic and biological reservoirs of the various forms of life on which we depend for sustenance (Mellanby 1967; Evanari 1969).

Changes in vegetation are occurring continuously and are a natural response to ongoing environmental changes. Failure to understand fully how these changes influence the rate of plant growth and mortality limits our ability to subtly, yet intelligently, influence the rate and direction of plant succession. What are the forces directing the formation and dissolution of plant communities? Basic studies and new ways of viewing the plant environment are needed.

A reluctance to incorporate these two concepts into our forest management thinking can lead to unnecessary expenditures and environmental upsets.

Administrative

The setting of realistic objectives is perhaps the most important responsibility of an administrator. For example, in vegetation management the objective behind the purposeful alteration of the vegetation creates and defines the problems to be faced and the "pest" species to be controlled. We must recognize that the terms, "pest" and "problem," are both mental and social constructs and as such are a direct result of our desire to attain an objective, otherwise they do not exist. When our goals are realistic and take into account the potential productivity and condition of an area, they can often be achieved with relative ease. Unfortunately, the question of purpose is not easily solved and is only rarely faced.

Since the basis of our objectives rests on a continually changing set of cultural values, we must exercise caution in which plants we name as pests. Today's pest may be tomorrow's food. A plant labeled a pest under one set of circumstances or by one group of people may be considered of value by others. A good example here is the introduced phreatophyte salt cedar, *Tamarix pentandra* Pall., which forms such dense stands over washes and stream beds of southern Arizona, southern New Mexico, and parts of Texas that it impedes waterflow. As a result this plant causes flooding during the rainy season, while transpiring large volumes of water from the underground water table during the remainder of the year. The Forest Service has interest in controlling this plant. However, salt cedar is valued as a nesting site for the white-winged dove, *Zenaida asiatica* L., a favorite game bird in the areas, and is also an important source of nectar for honey bees (Andres 1977). Clearly the potential values of this introduced plant must be weighed against its noxious qualities, but by what criteria?

When it comes to judging the 'weediness" of native plants, we must be especially careful since they are a natural and integral part of the landscape. To call them weeds is strictly a subjective valuation that fails to acknowledge their role in the plant community. For example, brush species such as *Ceanothus* spp., *Cercocarpus betuloides* (mountain mahogany), and *Alnus rubra* (red alder) fix atmospheric nitrogen and contribute to forest soil fertility on sites where they occur (Gratkowski. 1967; Tarrant 1961; Tarrant and Miller 1963; Tarrant et al., 1969). It has been recognized that the presence of red alder in Douglas-fir forests of the Pacific Northwest limits the growth, spread, and economic importance of the laminated root rot *Phellinus* (Poria) *weirii*, a forest disease responsible for widespread losses of both young and mature Douglas-fir (Nelson 1968; Trappe 1972). Chemical control objectives and classification of these species as "weeds" may ignore their ecologically important functions in maintenance of forest soil fertility and stand vigor.

In California three other plants considered weeds in many situations by the cattle and agricultural industries, *Opuntia* spp. (prickly pear), *Adenostema fasciculatum* (chamise), and *Centaurea solstitialis* (yellowstar thistle), are considered beneficial by wildlife managers, soil and water resource specialists, and beekeepers (Huffaker, 1957).

In this instance the problem to be discussed is a reexamination of the use of herbicides on forests, range, and other non-agricultural lands. Herbicides are used to release timber from competing vegetation, to remove weeds from rangelands in order to speed the development of more desired forage plants, to maintain firebreaks to minimize fire losses, and many other uses. That herbicides can do these things and do them efficiently in terms of worker-hours and present-day economics is well recognized, but this is not the only consideration. Of equal importance is whether the use of chemicals (i.e., the type of herbicide, the amount, the methods of application, frequency of use) is inconsistent with natural processes taking place in the areas we wish to exploit. If they are, what substitute alternatives do we have available or could we develop to manage the plants, and what are their advantages and limitations? Biological control, skilled labor, and controlled burning are three alternatives.

NON-CHEMICAL METHODS OF VEGETATION MANAGEMENT

Biological Control

It is recognized that the presence and abundance of a plant in an area is a product of that area's history and the ability of the plant to reproduce under existing climatic, edaphic, and biotic conditions. Variations in soil, water, and disturbance of the habitat influence the abundance and the species of plants present by influencing the ease which which the plants fulfill their growth requirements. Relatively minor alterations of the environment can sometimes selectively stress a particular weed or plant species to the point that abundance is reduced. The biological control specialist tries to reduce weed abundance by increasing the stress placed on the weed by its natural enemies, either by manipulating the natural enemies already present or, more commonly, by seeking out and introducing to the problem area those natural enemies that are associated with the weed in other areas of its range. To be most effective, the new biotic stresses imposed by the biological control specialist should complement existing climatic, edaphic, and biotic stresses on the plant.

The agents used for weed control can include any organisms that curtail plant growth or reproduction (Huffaker 1964). However, in weed control what is needed are organisms that will effectively stress the weedy plants but will not attack plants of recognized value. Insects, due to their size, high reproductive rates, and host specificity, have received particular attention as biological agents for the control of weeds. Interest is now also focusing on the use of plant pathogens as host-specific control agents. However, natural control agents and competitors other than insects and plant pathogens may also be useful in non-crop situations. Here may be included goats, sheep, cattle, herbivorous fish, and competitive plants. The latter may be selectively planted in a problem area to close the environment to undesirable species.

Which agent to use in solving a particular problem depends on the host specificity of the control organisms, the number of weedy plant species involved, the size of the problem area, the habitat, and the level and timing of control desired. Host-specific feeders are effective where a single weed species is to be removed from the plant community without hindering the development of desirable species. Where a complex of plant species must be controlled, the more polyphagous feeders (i.e., goats, herbivorous fish) may be used but only when they can be confined to the area where the weeds are to be removed. Management is essential here. In the case of host-specific agents (e.g., insects, plant pathogens) no effort is made to restrict their spread once they have been placed in the environment.

There are several methods and steps in implementing biological control and which may further aid in adapting a particular organism to a given problem. The first step in a biological control program is to assess the existing natural enemies associated with the weedy plants and determine their potential for providing control. If suitable natural enemies are already present, efforts may be directed towards conserving them or enhancing their action against the plant. For example, the defoliating moth, *Aroga websteri* Clarke, that attacks *Artemesia tridentata* Nutt. (giant sagebrush) has been studied from time to time in order to capitalize on natural outbreaks which can devastate thousands of acres or in some way trigger artificial outbreaks to cause dieback of the plant wherever it is weedy (Henry 1961). In South Africa a low dose of DDT was applied to the weedy prickly pear, *Opuntia megacantha* (Salm-Dyck), to kill a predaceous ladybird beetle, which was in turn feeding on the *Dactylopius* spp. scale imported to control the cactus. Once the ladybirds were killed back, the scale destroyed the cactus (Annecke et al. 1969). Deer will often browse on plants in firebreak areas, helping to keep them low. In fact, deer can control browse plants if the amount of plant regrowth is kept in proper proportion with deer numbers and feeding capacity. However, if the regrowth is too extensive, deer feeding impact becomes erratic, making effective utilization impossible (L. Green, personal communication).

Where natural biological controls are lacking, new ones may be introduced. This approach has been employed many times, especially against introduced weeds that are present in the problem area free from their normal complement of natural enemies. Here several notable examples can be cited: the control of *Hypericum perforatum* L. in western North America with weed feeding insects (Huffaker 1967), the control of alligatorweed, *Alternanthera philoxeroides* (Mart.) Griseb. in the southeastern U.S. by insects (Coulson 1977), the control of prickly pear cactus (*Opuntia* spp.) on Santa Cruz Island, California (Goeden et al 1967), not to mention the outstanding control of other *Opuntia* spp. on 60 million acres of land in Australia (Dodd 1940), the control of *Eupatorium adenophorum* Spr. in Hawaii (Bess and Haramoto 1972), to name a few. A number of other promising projects are underway, the outcomes of which are not yet clear (e.g., tumbleweed (*Salsola iberica* Sennen et Pau) in California and Arizona; rush skeletonweed (*Chondrilla juncea* L.) in California, Oregon, Washington, Idaho; field bindweed (*Convolvulus arvensis* L.) in California). The rust fungus, *Puccinia chondrillina* Bubak and Syd., has proved effective against the introduced rush skeletonweed, *Chondrilla juncea* L., in Australia (Hasan 1972; 1974). All of these are examples of host-specific agents that were introduced to control specific weed species that occurred in relatively pure stands and over extensive duced to control several species of plants is the herbivorous fish, *Ctenopharyngodon idella* (Val.), brought in from its native Amur River (which flows between China and the U.S.S.R.) to control a mixture of submersed weeds in Arkansas (Bailey 1975).

When introduced or indigenous natural enemies are present but ineffective for some reason, their impact on the plant may be augmented by periodically reintroducing given numbers of organisms at times critical to plant survival. A good example here is the artificial culture and periodic application of the indigenous fungus, *Collectotrichum gloeosporioides* (Penz.) Sacc. f. sp. *aeschynomene*, to control the weedy jointvetch (*Aeschynomene virginica* [L.] B.S.P.) in rice in the southern United States (Daniel et al. 1973). The periodic stocking of irrigation canals in southern California with the fish, *Tilapia* spp., to clear submersed weeds is also an example of augmenting the effectiveness of non-host-specific feeders (Legner et al. 1975).

Here can also be included the possibility of stocking areas with goats for brush control. Goats are good brush feeders and have been used effectively to limit regrowth of woody plants following other control practices. In Texas where goats were included with sheep and cattle and grazed in various combinations, a greater range of plant species was utilized and, where grazing rates were not excessive, the range showed marked (10–20 percent) improvement (Merrill 1975a).

Since 1973 the U.S. Forest Service, the University of California, and livestock producers have been involved in a cooperative project to determine the feasibility of using goats to eliminate brush or reduce fuel loads in fuel breaks. Goats are being utilized as part of the 7900-acre firebreak maintenance program in chapparal areas of the Cleveland National Forest in southern California (Green, pers. commun.). Following construction of the break with bulldozers, burning of the debris, and reseeding with grass to provide ground cover and competition to brush plants, periodic grazing by goats holds back brush regrowth. (In one large-scale test program workers have not had to use herbicides. The test has been underway 2 years.)

Two types of goats are being studied, the Angora, which produces both meat and hair, and the Spanish goat, which provides meat only. Both goats exhibit feeding selectivity among plants, but this is minimal when the plant growth is young (L. Green, pers. commun.). Selectivity also varies with the season and the growth condition of the plant. In general Spanish goats are felt to be better brush feeders than the Angoras, primarily because they are a bit hardier (L. B. Merrill, pers. commun.). Present research is aimed at determining the number of goats required for various levels of brush suppression (Merrill 1975b; Merrill and Taylor 1976).

Preliminary studies using goats to maintain already cleared firebreaks in Southern California are underway (Hughes 1976a) at an estimated annual cost of $5.00/acre (Hughes 1976b, Environmental Analysis Rept. prepared for the Cleveland National Forest). This annual cost when extended over a 10-year period comes out to $85.00 (at 6 percent), which was considerably lower than other methods of brush control (e.g., herbicides, $185; mechanical, $210; burning, $125; hand clearing, $875). Detailed economic data is needed to clarify the practicality of this method.

The chief advantage of using goats on brush is that they will feed on a wide variety of plants (brush species, forbs, and grass—the order of preference changing with season and palatability) converting the plant energy into a useful product. However, if not handled properly, non-preferred plants can become a problem. Thus, to optimize the use of goats, management is needed (herdsmen, fencing, water, perhaps supplemental feed) to assure each area is cleared properly without overgrazing (Jones, personal communication.). Heavy goat traffic can cause soil compaction, denudation of vegetation, and the development of "dustbowl" conditions. In fact, if goats are held on an area too long, they may even kill trees. Goat escape should be prevented to avoid the establishment of feral herds that could compete with native browsers and cause unwanted brush damage.

Some ranchers in California are even using brush as a crop, periodically running the goats through the area to harvest the regrowth (Plaister and Dal Porto 1976). Grazing by livestock may also prove effective against some emergent aquatic weeds (i.e., grasses, sedges, rushes, reeds, etc.) (USDA, 1976). Care must be exercised to avoid erosion of bank soil which is often unstable.

Proper livestock management (i.e., where grazing pressures are controlled) may allow seral stages to occupy the area leading to "replacement control" of the problem plants. This method has been successful in controlling Russian thistle (*Salsola iberica*) in some areas and may be properly considered a type of biological control (Piemeisel and Carsner 1951).

The chief limitation of using host-specific agents for biological control is their inability to control a complex of plants. If the problem involves two or more plant species, the unstressed weeds (those not attacked by the host-specific agent) will continue to develop and may even increase. Non-host-specific feeders (fish, goats, etc.), on the other hand, can control complexes of plant species, but because they often prefer some plants over others must be managed carefully if they are to be effective with a minimum of side effects.

In the case of the smaller organisms (insects, pathogens) it is almost impossible to limit them to specific areas of the hosts' ranges. Thus, if the host plant has actual or potential value, conflict interests should be resolved prior to release. Such conflicts can sometimes be resolved by keeping in mind the limitations of biological control. Unlike chemical or mechanical control of weeds biological control generally effects only a gradual reduction in plan abundance; eradication over large areas is rarely, if ever, achieved. If sufficient of the weed's virtues can be retained despite a lower level of plant abundance and as part of a more diversified plant community, there may really be little or no conflict of interests.

Several authors have dealt specifically with the economics of biological control (DeBach 1964; Simmonds 1967; Huffaker et al. 1976) noting an overall cost: benefit ratio of $1 to $30 based solely on the results of classical biological control programs (i.e., the introduction of foreign natural enemies to control introduced insect pests and weeds). However, it should be remembered that the benefits to be derived from any form of weed control are proportional to the productive capacity of the area occupied by the weed. In a rich or potentially highly productive area the exchange of weedy plants for useful plants can produce considerable benefit.

Based on the benefits that have resulted from several biological control of weeds attempts, further support and development of the classical or introduction of new natural enemies approach is economically justified. The 11.5–12.5 SY (scientist year) cost of developing a project ($900,000–$1 million overall cost at $80,00/SY, estimated USDA figure 1976) can often be recouped within a few years once effective natural enemies have been established (Andres 1977). The costs and benefits of developing and implementing a biological control program through the periodic release or manipulation of natural enemies may not be so clear. The added costs of periodically obtaining and releasing the organisms will partially offset the expected direct benefits. The cost of continued surveillance and management to assure effectiveness and minimize unwanted side effects will likewise act to offset the benefit from using polyphagous feeders (e.g., goats, herbivorous fish) but should not preclude their use (Andres 1977). The economic case for biological control will certainly be strengthened as the methods of estimating the indirect losses resulting from the use of chemical, mechanical, and other controls are improved.

An important, but less recognizable, benefit resulting from the use of host-specific, weed-feeding organisms is the subtle, non-disruptive manner in which they control their hosts, adding to the overall stability of the ecosystem. Likewise, the community balance provided by naturally occurring indigenous biological controls frequently goes unrecognized and uncredited. Perhaps the increased understanding of natural population balance and control gained through the study and implementation of weed-feeding natural enemies will in the long run prove to be the greatest contribution of biological control to society.

Although we frequently limit our thinking to economics in performing a cost-benefit study, Gilliland (1975) notes that energy, the one common commodity in all processes, can also serve as a physical measure or assessment of the environmental and social aspects of man's future or past actions. Bayley and Odum (1973) combined both energy and economics in evaluating water management alternatives in one portion of river system in Florida, noting that money measures only the work of people excluding that work done by nature. They further added that a region that makes use of the tasks that nature performs for free will have an economic advantage over another area that uses money and energy to perform these same tasks.

Integrating weed biological control into a management program is a relatively new area of study. In most instances where biological control has been attempted, the control agents have either been sufficiently effective by themselves, that other controls were not needed, or the potential productivity of the weedy area was so low that other controls were economically impractical. Perhaps as the number and variety of available natural enemies increases along with their increased use in situations were precautions to protect the environment from disruption are more stringent, more attention will be devoted to integrating biological control into weed management programs.

Intensive Skilled Labor and Utilization

Manual conifer release for reforestation has received little experimental attention since the 1930's when manual scalping around seedlings planted in non-stocked brushfields was practiced. Since that time hand cutting or grubbing has been thought of as economically unfeasible except in small scale brush removal or thinning operations. However, beginning in 1977, an organized group of volunteer forest workers in California (representing the public interest organization, G.O.A.T.S.[1]) is showing that conifer release, which presently uses herbicides as a major tool for accomplishing control objectives, *may under many circumstances, also be carried out* with intensive, skilled manual labor.

Working in conjunction with Six Rivers National Forest Service personnel (Lower Trinity Ranger District), G.O.A.T.S. is carrying out a pilot conifer release program on 33 acres of National Forest land. Crews operation under Forest Service specifications are integrating chainsaws with brush hooks and other manual tools (as well as protective equipment) in cutting competing vegetation down to 10 inches in height and within a 5-foot radii of all potential crop trees. To assist in obtaining maximum growth and yield of Douglas-fir trees, specifications also include thinning of conifers and spacing of released crop trees 8–10 feet apart. The competing plants (ceanothus, tan oak, madrone, manzanita, and other brush species) average ¼″ to 4″ in diameter and 6″ to 20′ in height, depending upon the age of the site. Cut vegetation is placed close to the ground around crop trees. This encourages conservation of soil moisture, promotes rapid breakdown and incorporation of nutrients into forest soil, and prevents erosion of exposed soil surfaces. Although slash is produced in the vicinity of each crop tree, in comparison in the increase in standing dead vegetation following aerial application of herbicides for tree release, manual release may actually *reduce* fire dangers in many cases by preserving live vegetation between the released trees.

Like other skill-intensive techniques, this manual release method minimally disrupts forest material cycling and trophic structure. It is highly selective of vegetation treated and guarantees release treatment to small crop trees not ordinarily released by aerial spraying. The method may be programmed to meet precise specifications and control objectives, taking into consideration

[1] Group for Organic Alternatives to Toxic Sprays. Information presented here was obtained through personal field experience of one of the authors (SLS); consultation with Robert B. Rhode, Resource Ecologist; and cost analysis prepared by G.O.A.T.S. staff (G.O.A.T.S. 1978).

the fact that all release situations are different—requiring flexibility in tools and techniques. It is versatile in that many sites not accessible to aerial application of herbicides (due to steep terrain, physical obstructions such as large snags, mature trees, or geographical features or environmentally sensitive sites (e.g., near rural water supplies and dwellings)) can be effectively released. Reliable, long-term control of competing vegetation will result if job specifications incorporate the biological and development characteristics of the vegetation to be managed. Monitoring is required to assess the duration of control obtained (i.e., levels of resprouting) with this type of manual release procedure.

The costs of manual release will vary depending upon previous site history, time of year, variations in slope and aspect, amounts of old slash residue on the ground, and density and comparative age of both competitive broadleaf canopy and conifer stock. To achieve maximum efficiency, labor-intensive techniques should be employed early in the successional sequence of the stocked brushfield before competing vegetation has become too dominant and difficult to cut.

In the project described, cost estimates were approximated on two sites (total 33 acres) aged 12–18 years after clearcutting. These were clearly sites of mixed suitability for effective chemical release due to topography and age and extent of brush regrowth. On the more difficult site (Salyer 4) the area released varied from 0.3 to 0.75 acre/person/day. Based on this work rate and hourly cost calculations of $12.12/person/hour ($5.02/hour take-home pay and $7.10/hour employer-paid benefits, administrative, and equipment costs), release costs ranged from $129.32–$323.30/acre (G.O.A.T.S. 1978). On the second site (Hennessey) the area released varied from 0.5 to 1.0 acre/person/day, and release costs ranged from $96.96–$193.92/acre. It is anticipated that these costs will be reduced significantly on plots where brush regrowth is between 5 to 10 years of age or at a time when the neighboring plants have served their protective function to the crop tree and before their competition for resources hinders tree growth.

Release techniques, whether manual or chemical, should not be employed as a "catch-up" procedure on older "back-log" sites, if cost-effective and efficacious treatment is desired. In one study in which chainsaws were used to provide conifer release as well as complete brush control on sites logged 15 to 30 years previously with brush 5′–10′ high (85–100 percent crown closure), the costs ran from $556 up to $1268/acre (Bernstein 1978).

The Task Force on the Use of Herbicides, sponsored by the Society of American Foresters (SAF 1977), listed manual release costs as consistently over $100/acre in a table representing "all geographical locations," while the costs of herbicide release ranged from $10 to $40/acre. The Task Force Report went on to identify the need for an objective cost analysis of noncropland vegetation management programs. Certainly the variable manual release costs cited by G.O.A.T.S. and other workers in a variety of forest vegetation types indicate that the economics of manual conifer release should be more fully investigated. Hoedads (1977) encountered costs in excess of $189.94/acre working on a 14-year old rehabilitation-release site (Alsea). This site was characterized by steep topography and dense stands of vine maple, big-leaf maple, red alder, salmonberry, and thimbleberry. The site was further characterized as "a problem unit not comparable to other younger, less-developed brushfields." Herbicides had been previously used unsuccessfully to release the site. At a second, younger site ranging 2 to 10 years in age since planting, release costs ranged from $32 to $56/acre to control big-leaf maple. Work rates ranged from ⅓ to ½ acre/person/hour. These data indicate that release treatments applied to younger brush can be efficient and cost effective. Any attempt to generalize concerning per-acre costs of manual conifer release should be viewed with caution.

The preliminary expense estimates cited in the G.O.A.T.S. pilot program above include not only the cost of release but also thinning treatment costs to ensure proper spacing between young crop trees. Thinning is presently an additional expenditure incurred later in the management cycle of Douglas-fir. Manual conifer release can efficiently accomplish both release and thinning objectives simultaneously and substantially offset future thinning costs.

To implement the labor-intensive approach, the potential work force must also develop administrative procedures for obtaining and negotiating contracts and work out the logistic problems of transportation of equipment and personnel, field supply needs, and especially worker training. For safe and effective participation workers require from several hours to several days of initial on-site training, depending on individual competence and the poblem to be handled.

Worker competence on the G.O.A.T.S. pilot project has also been assessed. Of a sample of 83 leave trees on released plots subsequently inspected by Forest Service personnel for specification compliance, only 7 (8.4 percent) were unsatisfactory due to worker damage, poor growth form, or insect and disease damage (G.O.A.T.S., 1978). By comparison, Bernstein (1978) cited data on "complete" vegetation control-conifer release tests indicating 31 percent of all seedling class conifers intended for release were damaged or covered with slash by workers on older brushfields in Josephine County, Oregon.

Manual release and other labor-intensive forest management alternatives are being investigated by other organizations in California, including the Center for Education and Manpower Resources (Ukiah, Mendocino Co.) (Wawona 1977) and the Redwood Creek Renewal Project (Briceland, Humboldt Co.). Preexisting Federal and State conservation programs in California, such as the Youth Conservation Corps (YCC) and the California Conservation Corps (CCC), can also be used to test feasibility of labor and skill-intensive reforestation.

The success and expansion of experimental manual release projects depends on Federal agencies developing management procedures and guidelines for contracting labor-intensive conservation programs (including firefighting and general resource improvement) on public lands. Federal and State employment programs should also emphasize and support labor-intensive methods in forest areas where high local unemployment and an available labor force exist or in areas where environmental restrictions preclude disruptive, non-selective, or enegy intensive opetions. This would be in line with the present Federal Administration's repeatedly stated intent to remedy high unemployment and welfare costs with Federal employment programs. Notable among such programs are proposals for funding civilian conservation labor forces for protection and improvement of renewable natural resources. The value of intensive control strategies becomes more apparent if socioeconomic criteria are used to evaluate weed control programs.

In seeking economically viable alternatives to the use of herbicides in the management of "weed trees," particularly relevant is the useful harvest of these "weeds." In California, for example, the wood of the tan oak, *Lithocarpus densiflorus* (Hook. & Arn.) Rend., considered a weed by many foresters, can be chipped for other fiber products, or used for a variety of finished wood products such as furniture, cabinetry, flooring, pallets, tool handles, and a wide variety of other wood products. Tan oak can also be harvested as fuel wood on a commercial basis and represents a renewable energy source more compatible with many domestic heating uses in timber counties than non-renewable, fossil fuel energy sources.

The status of tan oak and other "weedy" hardwoods associated with Douglas-fir in northern California, including chinquapin, madrone, big-leaf maple, manzanita, and laurel, should be critically reevaluated in terms of potential utilization rather than otherwise being wasted. In 1968 the United States Department of Commerce completed a study of the feasibility of hardwood utilization on the Hoopa Valley Indian Reservation in northern California and concluded that a hardwod sawmill, kilns, and manufacturing plant could be profitably established, using hardwood forest resources of that region (USDC, 1968). The Mendocino Co. Woodworkers' Guild is investigating the feasibility of cooperative agreements with private timber companies and State forestry officials in Mendocino County, California, for the cutting and processing of useful hardwood species.

Hardwoods and brush slash manually removed in release or timber harvests may also be utilized for the construction of contour wattles, checkdams, and other erosion control devices similar to the practices of the Civilian Conservation Corps (CCC) in California in the 1930's (Kraebel and Pillsbury 1934; Kraebel 1936). Again, locally organized, skilled labor crews can perform this conservation work in conjunction with manual harvest or release operations. In Humboldt County, California, the Redwood Creek Renewal Project, a locally based conservation organization, has performed such conservation work and has received Federal funds to continue labor-intensive soil and watershed conservation projects. The project emphasizes maximum utilization of forest residues and training of crew to become economically self-sufficient units, capable of independently contracting for conservation work and selling forest by-products.[2]

In Mendocino County, California, the Center for Education and Manpower Resources (CEMR) has evaluated the need for labor-intensive watershed repair in the Redwood Creek Basin and has found that many situations exist in which on-site vegetation may be utilized in the construction of erosion control devices (Wawona 1977). In a region in which declining timber inventories and mechanization continue to create unstable employment conditions in the forest products industry, labor-intensive watershed repair could supply much-needed jobs while conserving the forest soil for critically needed reforestation.

The use of aquatic weeds as soil additives, processed livestock and poultry feed; pulp, paper, or fiber products; source material for biosynthetic fuels; agents of wastewater treatment; human food; and other purposes

[2] Information supplied by Gerald Meyers, Project Coordinator, Redwood Creek Renewal Project.

(NAS, 1976) suggests utilization possibilities for aquatic weeds on Forest Service land.

CONTROLLED FIRE

Natural Role of Fire

Most North American vegetation types are naturally adjusted to fire, containing organisms that have developed recovery mechanisms or other fire adaptations or require fires to complete their life cycles. In some ecosystems or vegetation types the fires were infrequent, occurring once every 100 to 500 years, simultaneously terminating and initiating the dominant plant species. Fire-initiated plants are typically shade intolerant and require mineral soils, minimal competition, and a post-fire period free from severe fires, all of which were achieved by the infrequent, catastrophic fires. Fire-initiated systems are common in temperate and boreal regions. North American examples include eastern and western white pine, eastern and western hemlock, eastern white cedar, western red cedar, eastern and western larch, Douglas-fir, Jeffrey pine, and red pine (Vogl 1977). As these fire-initiated species mature, they are frequently joined by more mesic and fire-independent species until terminated by the next inevitable fire.

Other plant communities are dependent upon frequent (annual to once every decade), light fires to maintain the communities by preventing excessive fuel buildups and controlling the plant invasion-succession which would otherwise result in severe fires that destroy the vegetation (Biswell et al. 1973; Weaver 1974). Fires in these types serve as the principal decomposing agents since the fuel composition and prevailing environmental conditions deter decomposition by the usual bacteria, fungi, and invertebrates. These frequent, light surface fires reduced or eliminated the occurrence of destructive crown fires by selectively thinning and pruning the standing crop and controlling the invasion of the more mesic and fire-intolerant species. The nature of the fuels, climatic conditions, and the geomorphology are conducive to frequent and widespread fires. Maintenance fires were once common in Southeastern pine forest; the early successional stages of eastern deciduous forest and northern pine-hardwoods; the oak and pine savannas bordering the Great Plains, Intermountain West, and the Southwest; redwood forest; giant sequoia groves; ponderosa pine savannas/forests; various temperate grasslands.

Fire-dependent systems possess organisms that require fire to complete life cycles and to maintain health, vigor, and growth (Vogl 1977). Some of these species have reproduction structures (closed cones, capsules, pods) that are stimulated to release seeds upon exposure to fire. Some species' seeds will not germinate unless treated by fire. In others new growth is stimulated by fire. Fire-dependent ecosystems in the temperate zone include many grasslands (which will stagnate and become brush fields without recurring fires), lodgepole pine which dominates much of the Rocky Mountains, jack pine of the East Coast, pond and sand pines of the Southeast, the closed-cone pines and cypresses of California (Vogl et al. 1977), aspen in the West and Lake States, and chaparrel of the Southwest.

Fire-independent vegetation types, those systems with organisms and environments that are naturally free from fire, and fire-free communities, occupy a lesser number of sites. Most of these vegetation types are of relatively minor commercial importance. When fires do occur in these fire-free systems, they act as catastrophic forces, destroying the existing vegetation directly and the associated animals and soils directly or indirectly (Davis 1959).

Fire As a Management Tool

Fire can be used in a number of ways to perform a variety of management tasks. The literature on the techniques and uses of prescribed burning and the effects of fire is extensive (Kozlowski and Ahlgren 1974) and can only be reviewed briefly. Many agencies and regions have published controlled burning handbooks.

Fire can be used to control or regulate the vegetational development or plant succession. A basic premise of plant succession is that the vegetation is dynamic or that plant communities are characterized by constant or continuous change (Oosting 1958). Fire is normally a retrogressive agent or successional check in that it usually retards or temporarily stops the vegetational development or sets back plant succession to an earlier and either more zeric or hydric vegetational stage. The fire initiates a secondary successional sere or a recovery replacement series which again moves forward through time to the same mesic species endpoints. In order to understand the role of fire, one must understand the original vegetation under natural conditions. Fire can be used naturally and effectively to hold the vegetation at some stage considered to be desirable for man or wildlife or to set it back to some earlier stage beyond which it has advanced.

Fire can also occasionally accelerate or promote the vegetation development by creating conditions that encourage a more rapid replacement series of plant species (Vogl 1969). In communities maintained by frequent fires, each fire serves as a renewal agent that perpetuates the vegetation cycle. In this way fire functions as the necessary or key force in energy, fuel, and vegetation recyling. Fire-adapted plant species are favored over unadapted species, natives over exotics. Conifers are selected by fire over hardwoods. Grasslands are favored over shrub or brush species with repeated burning. The more xeric or hydric stages of early vegetational development are selected over the later and more mesic plant species with burining. The selective nature of fire is largely controlled by the skill of the manager in manipulating the frequency of fires, the time of the fire (season and hour), and the kind of fire used (how the fire is applied). With this approach even fire-adapted species can be reduced and unadapted species favored. All species have times and places when they are vulnerable to fire.

Fire can be used as an effective thinning agent in many forest stands, reducing competition and stand stagnation, releasing growth, culling inferior trees, and reducing the fire hazard. Normally fire is far more objective than labor in eliminating the weaker and slower-growing individuals. Even when thinning is done by hand or herbicides, the cuttings or killings must still be disposed of to reduce the fire hazard. Fire also serves as an inexpensive pruning agent, removing shaded and dying lower branches thereby reducing the chances of crown fires by removing the "fuel ladders" and improving the quality and growth of trees.

Fire can be used to clear areas of vegetation for fire breaks, clearings, etc. The destructive force can be controlled by varying the frequency, the precise time of the fire, and the kind of fire.

Fire also stimulates new growth. Recently burned areas are often more productive with plants growing more vigorously with more flowers, fruits, and seeds (Vogl 1974). Animal life also increases in response to the fire-stimulated productivity, improved palatability, and better nutrition.

Fire can also be used to prepare seedbeds for pioneer species. It creates open sunlight conditions and the necessary mineral soils by converting the accumulated litter to usable ash and nutrients. It sometimes increases soil nitrogen by increasing the soil pH and creating a blackened surface that collects solar heat which results in fungal "blooms." Grassland fires help to build grassland soils. Fire also breaks seed and bud dormancy in a variety of species and creates conditions conducive to germination and plant establishment.

Fire can also be used to create plant diversity since it is a variable tool. It appears that under natural conditions, areas with high fire frequencies had pronounced mosaic vegetation patterns. Natural fires probably often burned under marginal burning conditions which tended to emphasize this age and composition diversity. Most controlled burns are surface fires which tend to vary in intensity and effects more than the crown fires common to most wildfires of today. In many pristine landscapes a mosaic of young and old vegetation existed, which has been largely replaced by extensive mature/overmature forests, brushlands, and rangelands overloaded with fuels. These types can only result in severe burns that reduce the species diversity.

The use of fire in land management is an art, not a science, involving experience, knowledge, and sensitivity. Fire must be related to all other factors and components of the ecosystem (Kilgore 1976). Most controlled burning is best conducted by a small number of competent personnel and a minimum of equipment. Preburn preparations often go hand-in-hand with traditional fire-control measures, and costs and efforts can be shared. The most important ingredients of a successful controlled burn are a well-thought-out plan and the ability to pick or create the right time and place.

For example, in chaparral areas of southern California crushing or spraying the green brush may sometimes be necessary to dry it sufficiently for a safe burn. On the other hand, older brush will burn with a minimum of preparation. Although fire can be used as a tool in any environment with fuels to burn, fire is not just a tool in fire-related systems (Mutch 1976). Here knowledgeable ecologists consider controlled burning essential to an ecologically sound management program if we wish to restore the natural balance of these systems for the benefit of man (Kilgore 1976). It is because of this that fire cannot be replaced and that herbicides cannot be considered as a substitute or the ecological equivalent of fire, which is implied when fire is thought of only as a tool.

Costs of Burning

Costs of controlled burning are usually much less than other management practices. The initial fires are the most expensive because of the preparations that must be made to ensure control. As the excessive fuels are reduced and experience and confidence are gained in burning, the equipment, manpower, preparations, and costs are reduced.

Costs of burning are usually lowest in grasslands, savannas, and open woodlands and increase with the burning of dense types and brushlands. Using fire to maintain firebreaks or to do specialized tasks usually costs more than the general burning of blocks of vegetation. Although costs of burning are variable, forest, brushland, and rangeland burns in areas previously set up for controlled burning are currently being conducted for less than $1.00 per acre, even with burns of under 100 acres in size.

The burning of large tracts (several thousand acres) reduces the costs per unit area. On the Fort Apache Indian Reservation, Arizona, for example, the cost of burning large forest areas every 6 years was about $0.13 per acre with the yearly cost of fuel reduction coming to only slightly more than 2 cents per acre (Biswell et al. 1973). In contrast, if the total costs of suppressing wildfires on the same area in just 1971 ($2,774,987) were applied to controlled burning efforts, this money would permit a controlled burning program to be conducted for 255 years on a 6-year rotation.

Private pine forests in the southeastern U.S. are being burned annually for timber and wildlife production for under $0.10 per acre (E. V. Komarek, personal communications). Crex Meadows Wildlife Refuge, Wisconsin, was burned annually for $0.05 per acre in the early 1960's (Vogl 1967). At that time burning in various Wisconsin vegetation types ranged from $0.05 to $8.00 per acre, including the costs of manpower, equipment, and firebreaks.

The initial controlled burns in Whittaker Forest and Redwood Mountain, Sequoia National Park, California, cost from several hundred to several thousand dollars per acre because of the heavy fuel accumulations and the necessary preparations and precautions needed to protect the giant sequoia trees (Harold Biswell & Bruce Kilgore, personal communications). Subseguent fires or reburns of these areas have been or are expected to be greatly reduced. The National Park Service believes that all these costs are negligible when compared to the value of the resources and the comparable losses of the irreplaceable sequoia groves by wildfires. Current costs of small scale (5–10 acre) controlled burns in coastal redwood forests are $74 per acre (Greenlee 1977).

Again it should be noted that the practicality and cost of controlled burning will vary with the terrain and problem at hand (e.g. rough terrain may limit burn size and increase back-up fire control needs in the event of escape, etc.). In those parts of the U.S. where the terrain is more open (i.e., Southeast) burns can be carried out over large areas, while in the denser forests and rougher areas (i.e., Sierra Nevada Mountains, California) burns must be more limited in size and application and as a consequence are more costly.

Fear of Fire

One of the basic problems of using fire in resource management is the fear that most people have developed as a result of the one-sided propaganda that has taken place in the last 50 years (Vogl 1973). We have been told that fires are dangerous; destroy watersheds, wildlife, soils and resources; and cause air and water pollution. Even if some of these things are true, controlled burning and its effects are not generally comparable to the effects of our present-day wildfires.

The relationships between fire and soil erosion have often been exaggerated or misrepresented. Although fires in nonfire systems and those out of natural sequence in fire types can cause extensive erosion, natural fires occurring under normal circumstances produce minimal or no erosion (Viro 1974). Most accelerated or heavy erosion can be traced to man-caused fires in vegetation types in which they would not naturally occur or in those that are extra-severe because of abnormal fuel buildups and vegetation decadence as a result of fire prevention. Fires in many grasslands, for example, actually contributed to soils until man-caused fires, overgrazing, and vegetation deterioration reversed the process (Vogl 1974).

The use of fire in resource management cannot be ignored. The U.S. Forest Service, commercial lumber/paper companies, and private landowners now control burn on a 1–3-year rotation on much of the Southeast pine forests (Mobley et al. 1973). Where they can burn with a low intensity, this fire prescription reduces the fuel buildups to where destructive crown fires have been largely eliminated and wildfires are more easily and cheaply controlled. Efforts should be made to further the training and familiarization of personnel with controlled burning in order to better realize its potential as a management tool. Prescribed or controlled burning is a cheap way of working with nature.

SUMMARY AND CONCLUSION

Three points should be kept in mind when looking for alternative vegetation methods: 1. In nature no plant exists in isolation; an action directed against one plant will often trigger reactions in associated plants and organisms. 2. Plant communities are continually changing in response to changing climatic, edaphic, and biotic factors of the habitat; to stop or objectively alter this normal succession requires varying energy commitments. 3. The terms, "pest" and "problem," are mental and social constructs, reflecting society's current values and objectives; new problems and program redirections originate with changing values. To avoid unnecessary environmental reactions and energy commitments and conflict with redirected programs, the forest manager should employ cultural techniques that are selective; i.e., can be directed against specific plants or limited to specific areas and are minimally disruptive to those processes favoring balanced growth and sustained productivity.

The selection of a management technique will depend on the problem at hand (i.e., type and number of plant species involved, are they native to the area, the topography, size of problem area, potential productivity of area) balanced with the advantages and limitations of the several methods available for use. The more extensive the problem area, the greater the environmental heterogeneity and consequent need for a range and sequence of techniques.

Whereas economics has been, and will continue to be, the most immediate and basic consideration in selecting forest management alternatives, improving methods of assigning economic values to such ecologically important items as community balance, natural suppression of pests, pollution, and sustained productivity, plus the gradual introduction of these assigned values into the decisionmaking process should eventually favor the implementation of more highly selective or "soft" management techniques. The equating of economics with sound ecology will also foster studies to improve the selectivity of existing techniques (i.e., hand application of herbicides to specific plants and areas rather than broadcast use).

Biological control is best known for its high degree of host plant selectivity and its self-perpetuating capabilities, especially when weed-feeding insects or plant pathogens are used. In the case of insects they seek out and stress the target plant, reducing its competitive role in the plant community even in otherwise inaccessible areas. The object of biological control is to strike a new balance between the problem plant(s) and the more desirable species, while enhancing the natural condition of the area. When non-specific plant feeders are used (e.g., goats, herbivorous fish), proper management is essential if objectives are to be achieved without unwanted side effects. The wide host range of the non-specific feeder makes them adaptable for solving some range management problems involving complexes of plant species, i.e., firebreak maintenance and watershed management. Both the specific and non-specific plant feeders derive their energy from the plants themselves, recycling this energy to a higher level in th ecosystem or converting it to food energy useful to man.

Biological control with host-specific natural enemies has provided effective and economical control against specific target weeds in relatively stable plant communities (i.e., pasture and rangeland areas). The use of non-host-specific feeders to manage a complex of plant species is still in the experimental stage but holds promise in many situations.

Skilled manual labor is also a highly selective plant management technique. Since our objectives and consequent problems are social constructs, people can be trained to cut or otherwise alter vegetation in whatever way desired and in almost every conceivable situation. For example conifer release, a silvicultural practice for which herbicides are commonly used, can also be accomplished by skill-intensive labor. The method is selective, causing minimal disruption to the environment, and when properly integrated into the forest management program, can be cost-effective. Where the vegetation offers a harvestable product that can be utilized (i.e., the use of "weedy" tan oak for lumber, fuel wood, by craftspersons for furniture and implements), labor-intensive costs may be substantially offset. The labor force can also carry out watershed repair practices utilizing the hardwood trees, brush, slash, and young trees thinned from timber areas. The social benefits of full employment resulting from the use of labor and skill-intensive options are also considerations which have received very little objective attention.

Fire is a natural element in the environment to which most U.S. vegetation types are naturally adjusted. Controlled burning can selectively alter and upgrade many plant communities that have become unbalanced, unproductive, and prone to destructive fires because of fire control and mismanagement. Herbicides are used extensively in these fire types but are seldom effective replacements for fire or are equivalent to fire in their effects. Fire is an inherent part of these systems, producing no alien substances, controlling dangerous fuel accumulations, stimulating growth, increasing plant and animal productivity, regulating vegetational development, and creating diversity. Controlled burning does not usally produce soil erosion, wildlife mortality, and air or water pollution. The practicality and cost of controlled burning will vary with each problem (i.e., topography, type and age of vegetation). The method is used widely in scattered areas throughout the country.

Although each of the above methods surpasses existing alternative methods for solving certain Forest Service problems, there is the difficulty of finding and matching specific approaches to specific problems within the present economic framework. However, these difficulties should lessen as the value of each method becomes apparent and as ecological considerations enter more and more into the decisionmaking process.

That chemicals are used on Forest Service land is not our main concern but more how they are used and the quantities used. Like man, most organisms in nature also use a variety of strategies to maintain their status, including their use of chemicals. Allellopathic compounds, pheromones, kairomones, alkaloids, etc., all selectively aid species survival. These chemicals are released in limited quantities in the environment and provide an advantage for the producer. However, the production of these chemicals requires the use of energy by the producing organism. In some respects our chemical pesticides can be likened to these naturally occurring, biologically active chemicals. As Southwood (1977) has noted, pesticides require time and energy on our part to produce and provide us with a powerful tool for managing vegetation. They should be conserved and used with caution only in those situations where other methods are ineffective. As noted earlier, it is to our advantage to capitalize on those services provided free by nature (i.e., natural control organisms, controlled fire), using our manmade resources only when necessary (Bayley and Odum 1973).

As the author of a book on physiological botany noted, "Plants are not just troublesome complications in the formula of environmental chemistry and physics and a roadblock to our utilization of the habitat, but they are a living part of the environment on which our lives depend" (Bannister, 1976). As such they demand our study and respect.

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PANEL DISCUSSION

MR. FLAMM: I am going to ask Dr. Walker if he would start our panel discussion.

DR. WALKER: Thank you very much for this opportunity. Over the past several years, about 10 years, I have been associated intimately with the program funding elements in the Federal system using pesticide programs and pesticide programs, per se. I am very troubled as I have over the last several years come to understand the concepts of integrating pest management and particularly where it applies to what I feel are some of our very precious natural resources in Federal lands.

I have been asked to specifically address the problems associated with fish and wildlife habitat and, most specifically, the problems concerned with management of aquatic habitats. Let me touch upon several things that concern me deeply.

One is the incompatibility I have seen with the management programs that have been prescribed in those areas that I have reviewed for the program review panel of the Federal Work Group on Pest Management, and in the many impact statements I have reviewed in the last several years, that is the compatibility of chemical control methods with biological control methods, the compatibility of mechanical and cultural tools, and the various aspects of looking at the ecosystems with a long-term goal or objectivity. Very often it is at the expedient moment that one does control a weed problem or a pest problem and we do not think to the future, what is going to happen.

Nature abhors a vacuum and, unfortunately, when we look at aquatic situations we are often tempted to clean up what appears to be a problem in its entirety, hardly realizing that in a short period of time nature will, of course, be well on its course to replacing those plant species which have been controlled with others.

I have a number of questions I have to ask from the standpoint of benefit to wildlife. When we do control certain species of vegetation we often leave a void of primary productivity for a span of time, sometimes relatively short. We are often not concerned about what happens to the substance we have used in the way of a herbicide—what its eventual fate might be.

I have also been concerned about the registration of some of what we call minor use chemicals ,aquatic herbicides, some of them quite desirable, I might add, in their beneficial effects to fish and wildlife. Unfortunately, we have been unable to muster the kind of effort to, in my judgment, place before the Environmental Protection Agency the kind of information on which they can make a good judgment relative to their safety and at times even their utility.

Thus, I would leave you with my concern in detail relative to the objectives for the control of the aquatic vegetation or even those types of vegetation and forest habitat relative to the best interests of the public as a whole.

I would also add in my few objections that I have been able to make from the audience, that we don't look at the energetics of an ecosystem in a correct sense. For example, much of the organic matter that comes into a headwater stream contributes energy to running that system. Upwards of 99 percent of the energy coming into a small brook, for example, in a forested watershed there may be all locothus matter, that which is transported from the watershed as compared to a lake or pond where 99 percent of the energy comes through primary productivity or the photosynthetic pocesses.

When one sees this, we have to be concerned about the availability of that organic matter coming into those systems and also what happens to the energetics and the organisms or food chains that are developed.

These are a few of the considerations relative to the food chain and food web relationships we must address, whenever we use a biocidal material. Pest management invites a number of opportunities in the aguatic vegetation area that perhaps aren't available in the terrestrial stream of aquatic vegetation. We have water level fluctuation, freezing, and thawing as a technique, the delimiting factors of light into water. There are many things we have to explore in combination with various other tools, including biological means of control. However, this is going to take a great deal more expertise in many instances to apply, thus the reason that we have the very unique position, I think, of largely researching an area at this moment and moving into an opportunity for application of integrated pest management and schemes that I feel terrestrial management areas have not been able to attempt.

MR. FLAMM: Thank you very much. Mary, would you like to go next?

MS. BURKS: Yes. It may surprise some of you to know that the forest industry calls the South the wood basket of the world, and we are expected by the year 2000 to provide the major amount of wood products of this Nation. I am sure those of you from Oregon may be surprised, but I am quoting from a publication of the *Forest Industry of the Southeast*. Therefore, the citizens of the area are extremely concerned about vegetation management in the South.

We found that what usually happens in the South is that we have management with selected softwoods in a culture. A good deal of the South is hardwoods, and this means species conversion. This is where the herbicides come in. I do not believe, at least not in Alabama, that we use anything like the amount of herbicides, certainly not from the air, used in other places. I talked to a private consulting forester and asked him the latest information on herbicide use, and he said we were discontinuing it. We did use a great deal of herbicides 6 to 8 years ago from the air, but not now. We use it to control Kudzu and hardwoods. This is in the Coastal Plains region, and he suggests an alternative method he considers by far the most profitable—natural stand management.

Many Southern foresters along the Coastal Plain are returning to the longleaf pine which we had so much of in the early days of our country. With mechanical site preparation we lose the wild grass community associated with the longleaf pine, and these longleaf pine producing areas along the coast of the South are disappearing to the extent that the communities will be an irreversible and irreplaceable loss of the source. If we don't stop mechanical site preparation, some of the things we do will kill those communities. We are using fire as the control method. In North Alabama we do have hardwood stands, and we do have species conversion.

I want to read a statement by Steven Boyce, Forest Ecologist of the Experimental Station in Ashville, North Carolina. He says, "The challenge is multiple benefits on coniferous and hardwood forest products, solitude, clean water, and opportunities for all plants and animals."

I want to bring one more thing in, and then I am going to stop. We haven't mentioned why we have to have expensive forest management. Is there anything we can do so we don't have to have such management? Not a word was said about the recycling of paper. If we could recycle 60 percent of the paper used now, this would relieve the demands on the forest by 50 percent. We would not have to have such intensive forestry management. We would not have to have the killing of the hardwoods and the extensive use of herbicides. Thank you.

MR. FLAMM: Thank you, Mary. Would Jerry Moore like to go next, please?

MR. MOORE: I would like to say we have a recycling program at the EPA and can be identified in the outside world by the presence of the light-brown paper we generate. It is an economical process.

I am involved with the Office of Endangered Species in the Department of Interior as liaison to that group on pesticides which meet or exceed criteria in FIFRA. Also, we have an obligation to coordinate with the Department of Commerce and National Marine Fishery Service. We have set up several meetings and have a process underway with the Office of Endangered Species (OES), and we have four pesticides currently within that group being evaluated in terms of its impact on endangered species. The regulations are pretty clearcut, Section 7 of the Regulations of the Endangered Species Act, as to how Interior will operate with other agencies which have activities which may impact upon threatened or endangered species or their habitats.

We have had a lot of cooperation and foresee no procedural problems. We have established a standard operating procedure to cooperate with both of those agencies, and, as I said, we anticipate no operational problems at all in the future.

MR. FLAMM: Gerald Mackie, would you care to go next, please?

MR. MACKIE: I guess I will start with a question. By the way, I am not presently president of HOEDADS, although the program says I am. To those who don't know. HOEDADS is not a Federal agency. We are a cooperative with some 300 members. We have an annual payroll of about $1,200,000.

The question here is in regard to the alternatives. Very recently the Siuslaw National Forest awarded a contract for manual brush control the cost of which was $450 per acre. Why is this so high?

I haven't been bidding lately, so I have to say I imagine it was on older, more extreme site. I have the impression that it right now is experimenting with different types of units to see what kind of experience they are going to have, because whatever happens here in Washington, they feel under a great deal of pressure from all sides.

Dr. Andres referred to the G.O.A.T.S. study. It is very dangerous to generalize either herbicides or any other sort of alternative treatments. The comparisons always come down to being very site-specific, and I think what we need to do is to investigate and find a real comparison, because if there is no question of safety there would be no need to be aggressive in examining alternatives. Since there is some question and since a farsighted enterprise plans for contingencies, I think it would be wise to conduct such an investigation.

As far as costs other than $450 per acre, we have done some manual release. I have done it myself. I did it before this whole issue came up. Recently we did a combined release on a stand on conifers and site preparation for inner planting where there wasn't stocking. The sites were from 2 to 10 years old. The price was $32 to $56 an acre, and the reason that BLM was interested is because they are having problems with flashback. We did one conifer contracting which was a 14-year-old site rehabilitation unit for $174 per acre.

Now, the Carter paper this morning quoted $500 per acre average in the Douglas-fir region. A recent unsigned industry paper quotes $113 as an average. I think these are good averages based on experience costs, because, why a forester chooses manual release is because he is dealing with older and more difficult rehabilitation types units. I think the the average may come down when we get more experience on the younger sites.

By the way, I wanted to correct the misimpression that I, myself, would offer manual release as a panacea because that is simply not our position. One would have to consider, as everyone has said today, consider the whole range of options, the cultural options, in which I will include the planting of hemlock and spruce which are shade tolerant species.

Prompt reforestation, adjustment of harvesting technique, for example, on dry south slopes in southwest Oregon, on a site that maybe needed release but maybe doesn't need release, but that one would want to be sure if there is a possibility of postponing release until a precommercial thinning treatment, or where they did conifer release and conducted a prethinning.

One Forest District experimented with sheep grazing, seeing if they could run sheep and also get the side benefit of brush control, which obviously has fundamental disadvantages, but they were apparently satisfied with the experiment last summer.

Another alternative is stricter definition of the level of last resource use of chemical treatment that is to attempt to become more and more discriminate over the years.

And these alternatives outlined ignore some of the imponderables that we can't quite measure and see right now; for example, the nitrogen correction in the present weed species in an age of dwindling petroleum supply, the benefits of having a developed labor force, and other social amenities.

MR. FLAMM: Thank you. Fred.

MR. ARNOLD: Within the Office of Pesticide Programs, we have a two-fold responsibility. The primary one, the one that we have been probably spending most of our efforts on, certainly in recent years, is attempting to make responsible registration and reregistration decisions under the FIFRA. A second and perhaps broader responsibility is to attempt to foster a climate which encourages effective pest management techniques with a minimum or absence of undesirable effects.

Most of the tools and techniques that Dr. Andres discussed don't fall within the registration requirements since they essentially entail the substitution of biological or labor practices for pesticides. Nevertheless, they do play a role in reaching pesticide decisions, and I would like to discuss in sort of a capsule what that role is so that perhaps you would understand the types of information and data requirements that are important in making that registration decision.

In resolving the registration questions on chemicals which have been presumed by the agency to pose an adverse effect, we consider an entire range of options that are joined by one, the decision to reregister all of the uses of the pesticide in question, and second, the other extreme, to cancel all of the uses of the pesticide in question.

These two bounds are evaluated by EPA scientists and other scientists to determine the health, environmental, and non-target effects of the current pattern of the chemical in question and also to evaluate what the world would look at from the point of view of the control in question and the cost of control if the pesticide were not available.

The options in between include selective reregistration or cancellation, changes in the label, changes in the method of application that might reduce non-target effects, changes in the timing of application. FIFRA is a fairly responsive law when it comes to trying to define use patterns that could reduce adverse effects.

The kinds of techniques that have been studied by Dr. Andres affect the registration decision on chemicals that are currently used by playing a rather significant role in defining first of all the economic impacts associated with the absence of the chemical. If it can be demonstrated that, one, the chemical poses an unreasonable effect and, two, that alternatives are available which result in little or no economic dislocations or impacts or forestry impacts, the decision certainly leans towards cancelling some or all the uses of the chemical which pose an adverse effect.

On the other hand, if the cancellation of the chemical or the restriction of the chemical would result in either practices or the use of a second chemical which poses an even greater burden, there is certainly no gain from an environmental or a health point of view of that decision, regardless of what the consequences are. So we have to evaluate the feasibility of using alternatives as well as at the same time to define what would happen in actual practice given that we adopted one regulatory stance or another.

The kinds of information that Dr. Andres has certainly been able to pull together as well as research which undoubtedly has been performed by many of you in the audience have a significant impact upon our evaluation of the economic consequences and the ability to modify adverse effects, and certainly that information is being sought right now on a number of chemicals, primarily agricultural rather than chemicals that are used in forest management, but the logic which we use and the avenues which we hope we have provided to get this information are the same in either case.

So, in summing up, the way that these techniques which don't normally fall within the confines of FIFRA, certainly from the point of playing a registration role, are significant, and they are discussed with either Mr. Johnson or whoever the decisionmaker happens to be in the case of a registration decision prior to the recommendations of the Administrator.

MR. FLAMM: Thank you, Fred. We have just reached the outside limit of the extension of time that Dave Ketcham gave me, so I guess we have to also terminate this panel without getting more questions. I greatly appreciate your patience and cooperation today.

POST-SYMPOSIUM RESPONSES TO QUESTIONS SUBMITTED TO MARY I. BURKS

QUESTION: Natural Resources Defense Council and other environmental groups have come out in support of greatly increasing intensive forest management in the South, because they believe this will "free up" public land in the West for more wilderness areas. How compatible is this position with the goals of your organization?

ANSWER: This question reveals several erroneous presumptions and a deliberate attempt to stir up controversy among environmental groups. For these reasons I would like to answer at some length, amplifying the remarks I made at the Symposium on the Use of Herbicides in Forestry. Time had run out before I spoke, and I was unable to present several points I wished to make.

First, the question is ambiguous and does not stipulate whether the questioner means increased intensive management of public or private lands. I wish to comment on each separately.

PUBLIC LAND

In 1969 the Southern Region of the U.S. Forest Service covered 12 states containing 33 National Forests with 11.9 million acres of land. This is only 6 percent of the 198 million acres of Southern forest lands. Wilderness can be established only on public lands. To manage more intensively, which in the South is synonymous with species conversion, pine monoculture and even-aged stands, the small percentage of public forestlands in the South would not release very much Western land for any purpose.

The Alabama Conservancy favors decreasing intensive forest management on public lands in the South.

PRIVATE LAND

About 73 percent of the South's forests are in private holdings. The owners, of course, have the option of selecting their preferred silvicultral management system. Professional opinion is certainly not unanimous in recommending what is commonly called "intensive management." L. Keville Larsen, head of a highly successful private timber management consulting firm in Mobile, Alabama, has stated:

> For the majority of forest land in private nonindustrial ownership (73 percent of all the forest land in the South), management of natural stands is not an alternative, it is the *only* choice (emphasis added) and will con-

tinue to produce the most volume and the best quality wood. In my opinion, in the future it will increasingly become the choice on government and industry ownership, because it provides exceptional flexibility in working toward maximum economic return or any other single or multiple-use objective.

The Conservancy believes that if the U.S. would recycle 60 percent of its paper, rather than the 20 percent currently reused, demands on all forests could be reduced by 50 percent making it unnecessary to increase intensive forest management or engage in tradeoffs for Western lands. Wilderness in the West cannot compensate for lack of wilderness in the South. There are more people in the South and more need for wilderness with less public land for recreation and preservation of gene pools.

I contacted the environmental organizations below and asked for their positions on this issue. Here are their statements:

NATURAL RESOURCES DEFENSE COUNCIL

Tom Barlow, spokesman for the NRDC, said they are calling on increased reliance on timber from private landholders in the South. NRDC unequivocally repudiated the idea of trading off Southern National Forests to obtain Western wilderness. NRDC advocates decreasing intensive management of Southern National Forests.

SIERRA CLUB

Brock Evans, head of the Sierra Club's Washington Office, said Sierra would never support intensive forestry in one region at the expense of any other region. He stated that Sierra supports intensive forestry on certain suitable sites of high productivity. However, in the East, where the population pressure is great and the acreage in public lands relatively small, the social costs of intensive forestry may be too great even on private lands.

WILDERNESS SOCIETY

Dr. Roger Scholl, Assistant Executive Director of the Wilderness Society, said that his organization approves more cutting of timber, now, from productive private lands rather than intensive utilization of public lands followed by the inevitable eventual dependence on private sources. The Wilderness Society advocates channeling U.S. Forest Service funds into intensive management of highly productive sites and urges that sites of low productivity go unmanaged.

The Wilderness Society does not approve of increased timbering of Eastern National Forests but urges, instead, increased efficiencies on private land, more recycling of paper, and better use of all wood wastes to alleviate pressures on the public forests. The Society does not advocate species conversion nor the tradeoff of one region for another.

QUESTION: Dr. Boyce's paper also states that over 1 million acres per year in the South are reverting from pine stands to hardwood. Is this greater than proposed hardwood conversion to pine lands?

ANSWER: I believe this question entirely misses the point of species conversion. If, as the questioner states, over 1 million acres per year is reverting from pine to hardwood, then why should any new land be converted from hardwood to pine? The tradeoff of cutover pine stands for productive hardwood forests cannot be equated. Why not *manage* the land *already* converted to pine stands, as Dr. Boyce suggested?

Lands which are returning through various successional stages to hardwood cannot possibly be as ecologically healthy as lands which have sustained a hardwood ecosystem for many years. Restoration of the original herbaceous plants, native shrubs, and small understory trees may take centuries or never occur. The Eastern deciduous forest has been called the most beautiful, bountiful, and diverse forest the world has ever known. There can be no substitute for it.

The quotation from Dr. Stephen G. Boyce, Chief Forest Ecologist, Southeastern Forest Experiment Station, Asheville, North Carolina, needs to be enlarged. He recommended that the main effort in the future should be devoted to reforesting those lands now growing pine. Dr. Boyce said:

> The challenge is to maintain the diversity of forest ecosystems for the production of multiple combinations of human benefits, including coniferous and hardwood forest products, hiking, fishing, recreation, solitude, clean water, and opportunities for all endemic plants and animals. . . . Diversity of ecosystems is enhanced by maintaining the interspersion of the upland hardwood, wetland hardwood, and coniferous ecosystems. . . . With adequate reforestation of harvested pine stands, the rate of harvest of pine timber *can be doubled in the next 30 years without converting large acres of hardwood ecosystems to pine* (emphasis added). Pine monoculture would be maintained on approximately one-third to one-

fourth of the commercial forest land in the South. The proposed action will not result in a major change in the proportion of hardwood and pine ecosystems that have existed in the South for at least 200 years. The action is proposed as a way to maintain the current diversity of ecosystems.

POST-SYMPOSIUM RESPONSES TO QUESTIONS SUBMITTED TO GERALD MACKIE

QUESTION: What is the turnover rate in membership (of HOEDADS)?

ANSWER: Qualitative estimate based on 4 years of personal observation and analysis: 50 percent. This actually is quite good in comparison to conventional contractors in treeplanting—through observation and discussions with these contractors, I estimate a turnover of 90 to 300 percent of them.

QUESTION: What is annual net increase/decrease membership?

ANSWER:

Season	Active Full-time Members	Assistant to other tree-plant coops; job slots created
1912	3	0
1923	25	0
1934	150	45
1945	250	85
1956*	300	115
1967	325	260
1978	325	260
1989... projection	325	460

* In 1956 season we began to approach the limit of our small business limitation (Federal tree planting is 100 percent small business set aside; the Federal sector accounts for about half the total tree planting market). Growth deceleration and stabilization is due to Small Business limitation.

MR. KETCHAM: At this point I would like to turn the session over to our Chief of the Forest Service who has spent a lot of time at the meeting. We are pleased you could do this.

The Chief of the Forest Service, John McGuire.

SUMMATION OF SYMPOSIUM

MR. McGUIRE: Thank you, Dave.

As Assistant Secretary Cutler said in his opening remarks, the primary purpose of this symposium was to share information so that better decisions can be made about the use of herbicides in forestry. I believe you have accomplished that objective very well.

This symposium has been timely for two reasons. First, we are now revising our policy on the uses of herbicides in forestry, and the information you have given us these past 2 days will have an important bearing on what happens in this regard. Second, EPA has not yet issued an RPAR on any herbicides used in forestry as Ed Johnson told you yesterday, but a decision on 2,4,5-T will be made by EPA next month or in early April. The information you presented will be very helpful to EPA in making this decision as well as future decisions involving other herbicides.

I want to recognize and thank all participants—those of you from the citizen groups who joined us, the scientific community, particularly from the universities, all of you who came from the various industries with an interest in herbicides, the State people, and those from the other Federal agencies—who helped make this symposium the success that I think it was.

I suppose it is impossible to generalize on what we have heard at this symposium, but I believe there are a number of findings that should be highlighted.

First, with one or two exceptions, I think all the speakers seemed to say, or at least imply, that some kind of vegetation management is needed. I did not hear you say that there should be no manipulation of vegetation.

Second, I think you seemed to agree that all of the methods of treating forest vegetation have their advantages and their disadvantages. They may be environmental, economic, or health and safety factors. It was repeatedly pointed out that these advantages and disadvantages do exist. I think your differences are matters of degree and judgment as to what weight to give to each one of these factors in the choice of a method.

It became apparent as we listened to the various statistics that most vegetative manipulation in forestry is done without the use of herbicides. I do not know exactly what herbicide usage amounts to for forestry as a whole, but Tom Nelson presented an estimate for the National Forests. I am quite sure the usage figures for private forests and rangelands and for other public forest and rangelands would reflect much the same picture. Forestry in this case is defined in a very broad way. It includes range management, recreation, fire protection, and rights-of-way maintenance, as well as timber management.

It also is apparent that the amount of herbicides used in forestry is relatively small compared to the total amount manufactured and sold annually in the United States. Again, there might be a dispute as to what the proportion might be, but certainly the forestry use of herbicides is far less than the use in agriculture. Because of this relatively small forestry market, there is unlikely to be any great incentive for the industry to develop new chemicals for use in forestry. The market simply isn't there to support the investment in the necessary research and development. And for that reason I think we agree that forestry is going to have to adapt agricultural herbicides to forestry uses to the extent possible.

I think we could also say that there is general agreement on the need for better information, particularly the need for better data on exposure and risk. We need to know more about what low levels of TCDD, for example, really mean in terms of human health. And, of course, the problem for us in Government, in USDA and in EPA, is to know what to do with the conflicting information that is available from the various scientific studies that have been made. We really do not know how to evaluate the divergent information that is coming in.

This symposium, I think you will agree, has shown that there is a substantial amount of public concern about the use of herbicides, regardless of what the professionals say about low hazard. Perhaps the public is making a different evaluation than the professionals are making. This is not new. It happens in other controversies. But I believe I could detect this theme throughout the symposium.

I thought I heard substantial support among you for EPA's Dioxin Monitoring Program. At least, I heard no objections to the conduct of that program during this symposium. Many questions were identified that need to be answered, and hopefully, with your support, this program can provide the answers soon.

Finally, I think there was agreement that the current processes for dealing with the herbicide issues are adequate. No one complained or criticized these processes. I am talking about EPA's registration process, including the generic approach to registration, the RPAR process, the restricted use instead of complete bans. I am talking also about the National Environmental Policy Act's environmental impact statements, with opportunities for public review of the facts and the alternatives.

To generalize, almost everyone at this symposium seems satisfied with the processes themselves, but there is dissatisfaction with the means by which the citizen can gain access to them. I could be wrong but, listening to the presentations, I detected at least dissatisfaction with the way in which the average citizen can enter into the process and thus actually influence the outcome.

Both the Department of Agriculture, including the Forest Service, and EPA want to be just as responsive as we possibly can be to your views. That is why we sponsored this symposium. Again, I think what you have had to say will influence our decisions in the immediate future, as well as in the long run. Obviously, we are going to need your support for additional research in the herbicide area. I mentioned the problem with new pesticide development prospects. But, we also need to learn more about the application and consequences of alternatives to the use of chemicals.

I am quite intrigued by some of the points made by those who have studied the use of manual methods. I think there is a lot we can do in this area, not only through contracting for jobs on public land but perhaps by greater use of some of the public unemployment relief programs that are now underway and that are likely to be expanded if economic conditions warrant. I am thinking of such programs as the Young Adult Conservation Corps.

We urged Congress, when that program was authorized, to permit the use of that YACC labor, not only on public lands but also on private lands, and we found quite a bit of interest in Congress in giving us that authority. However, there weren't enough votes or enough money at the time. But the time may come when we can find ways of using the Young Adult Conservation Corps on private as well as public lands. There are many aspects of the use of manual methods that need looking into.

I want to assure you that USDA and EPA will continue to work closely together. I think it became clear during the symposium that the two agencies have different responsibilities, one regulatory, and the other in land management. These responsibilities are defined by various laws. EPA and USDA cannot, and do not intend to, cross over into the other's area of responsibility, but we do intend to work closely together. I hope you keep an eye on us and make sure that we do.

This meeting has been far too short. I am glad to see that a little more time has been allowed for a special session tomorrow. Some of you I know cannot stay, but

I urge all of you who have additional comments to make, questions to ask, or additional papers that were prepared, but for some reason couldn't be delivered here, to give them to us soon. We would like to have all such contributions in the mail by a week from next Friday, the third of March, so that we have them on hand by about the tenth of March. We would like to get the proceedings to the printer's as soon as possible.

Again, I thank everyone for coming. Your participation has been very helpful.

POST-SYMPOSIUM RESPONSES TO QUESTIONS SUBMITTED TO JOHN McGUIRE

QUESTION: EPA registers pesticides to be used according to label directions. The Forest Service claims it uses herbicides according to label directions. Yet, aerial applicators insist that if label directions such as those on 2,4,5-T, e.g., "do not spray near streams, ponds, or bodies of water, where runoff is likely to occur," are strictly followed, there would be no spray. Therefore, applicators do the job and disregard the label directions. Does this mean that these pesticides are being used illegally and unsafely?

ANSWER: No. Recent label revisions, approved by EPA, reflect a deletion of the statement, "Do not apply where runoff is likely to occur." In truth, it would be difficult to use and enforce the proper use of pesticides with these restrictions; however, in all field applications of herbicides by the Forest Service, strict controls are enforced to minimize chemical drift, avoid runoff, assure proper application, and prevent contamination. Many techniques are used to prevent damage to other ownerships and ecologically sensitive areas. To minimize drift aerial spraying is stopped when wind speeds exceed 6 miles per hour (5 miles in the case of certain labels) or other weather conditions are not suitable. Drift is also controlled by use of nozzles which produce the largest droplets compatible with adequate coverage. In addition, spray adjuvants are used to minimize drift and volatilization. Buffer strips are also used adjacent to waterways and sensitive areas to protect them from possible adverse effects. In all instances, whenever it is necessary to use registered pesticides to achieve our resource management objectives, we comply fully with the Federal Insecticide, Fungicide, and Rodenticide Act, as amended, the National Environmental Policy Act, and all other appropriate laws and regulations.

QUESTION: The very limited use of herbicides on National Forest lands has been described. Hasn't this been the result of administrative mandate prohibiting use of certain chemicals (2,4,5-T), rather than professional judgment that these chemicals are neither needed nor effective for the job?

ANSWER: There have been no administrative mandates against the use of 2,4,5-T by the Forest Service. In 1970 the Federal Government did take action against the registration of 2,4,5-T products which could pose immediate danger to human health. These actions included the suspension and cancellation of registration of products for use on food crops intended for human consumption and for use around the home, recreation sites, aquatic areas, and ditch banks. However, these actions did not affect registered uses for brush control on highway and utility rights-of-way, rangelands, pastures, and forest lands, and for control of broadleaf weeds in rice fields.

The limited use of pesticides (less than 0.2 percent of 188 million acres of forest land treated annually) is, we feel, directly due to the professionalism of our forest management personnel. Decisions to use pesticides are made only after careful analyses of the benefits and risks involved, and the decisionmaking process is open to the public. Furthermore, whenever feasible, alternative methods of vegetation management are employed, further decreasing the total acreage treated with chemicals.

QUESTION: Only very small areas of National Forest lands are being treated with herbicides. What are actual needs? Are National Forest managers using herbicides as much as they should, or are they being influenced too much by the anti-pesticide lobby?

QUESTION: Are forest managers using herbicides as effective management tools as much as they could without the anti-pesticide lobby? In effect, are management decisions inhibited?

ANSWER: It is estimated that approximately 39 percent of the commercial forest land in this country is dominated by weeds, brush, or other competing vegetation, resulting in nonstocked or poorly stocked timber producing land. Seventy to 100 percent increases in merchantable wood production could be achieved in these stands if they were placed under proper vegetation management. Although a variety of management alternatives have evolved, chemical methods are generally preferred due to their lower cost and greater efficiency. Even with the use of herbicides, more acreage in need of treatment is being added annually than can be accomplished. For example, in 1977 alone nearly 470,000 acres of timberland were identified as being in need of release or thinning, while only 339,304 acres were actually treated for these purposes.

Adverse public opinion about the use of herbicides in forestry seems to have arisen from: (1) instances of sensational journalism and the habit of some news reporters treating all pesticides as a more-or-less uniform group of compounds, all equally poisonous and persistent; (2) growing public awareness about the effects of human activities on nontarget organisms; (3) increasing public opposition to the use of petroleum derivative herbicides; (4) unsubstantiated claims of chronic health effects resulting from herbicide usage; and (5) continuing high unemployment and an unsubstantiated claim that manual labor could efficiently and cost-effectively be substituted for chemicals. These public concerns, expressed as an anti-pesticide lobby, have created delays in vegetation management practices (e.g., court injunctions against the use of herbicides in Oregon, Arkansas, Minnesota, etc.); however, future decisions about pesticide use should be based on scientific fact rather than emotion, political considerations, or special interests. Hopefully, this symposium has presented the available factual information in a manner leading toward a better understanding of the benefits and risks involved in the use of herbicides in forestry.

QUESTION: Does the Chief of the Forest Service have the power to place a moratorium on the use of 2,4,5-T or silvex in Region 6 until EPA's RPAR process is completed?

ANSWER: Yes, and if any substantive information becomes available to indicate that significant adverse nontarget effects will result from herbicide treatments, we will discontinue them immediately. However, based on currently available information, EPA has indicated that these registered pesticides, when used according to the label, present no unreasonable risks to human health or the environment. EPA currently has 2,4,5-T and related compounds on a list of candidate pesticides for early RPAR review. The RPAR process will permit everyone with substantive information to have it carefully considered in a complete scientific review. Because of the very complex issues involved, we believe this is the most productive method of finding reasonable solutions to the phenoxy herbicide questions.

QUESTION: Why doesn't the Forest Service's pest management program have any weed scientists on staff or fund any weed research for controlling major pests in forests?

ANSWER: Weed control on National Forest lands is part of our intensive management program. We recognize that weeds have a serious impact on forests. A 10-year minimum program for control of noxious weeds is underway. This program was funded at $880,000 in FY 1977 and $1,549,000 in FY 1978 to control and maintain control of noxious weeds on National Forest lands.

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SYMPOSIUM CLOSING REMARKS

David E. Ketcham

MR. KETCHAM: Thank you, John. You did an excellent job with a very difficult task, to try to summarize what has been done today and also to take a look at where we are going to go from here.

I think where we are going to go from here is still the big issue and I think one thing that Dr. Cutler said right at the beginning which I am sure probably most everybody here has forgotten, is that this symposium— and he emphasized this point— that this symposium was a beginning, not an end. I think we should make sure that this is so.

I think that we know each other better now than we did before. I am hopeful that one of these days we can get away from this "we–they" kind of context, that I think we are dealing in, to where we can start working with a "we." I think this can be a real challenge to all of us.

John mentioned the specific times for the information to go into the proceedings, but you don't have to end your comments with that. That will be the cut-off time for getting into the proceedings; but you can talk to us any time, and we will be happy to talk to you any time.

One other point that we don't have time for here, but I am hopeful you will do it later: that is critique. What did we do right or wrong in the conduct of the symposium itself? I have had a lot of comments. I bruise easily, but I heal quickly, so don't worry about that. But let us have your comments.

One of the comments I heard already was that the panels were stacked. I heard that from both sides. So, in a way, I feel pretty good about that. It may have been pretty close to right.

The biggest problem was they didn't have time to really discuss the issues in the depth that we would like to have had. We know a lot of these things, but we want your ideas. We don't want to know all that was wrong; we want to know how can we do it better next time. We know you have good ideas. We have better ideas now that we have been through it once.

Looking toward the future, Jan and I were talking a moment ago. We may be having another symposium of one type or another on parts of these issues or other issues in the future.

I would like to do some thanking, also, not only to the speakers and panelists, but also the moderators, Barry and Jan, who worked hard to keep us on time. As Barry said earlier, this was the quickest week-long symposium he has been to in a long time. This was the time we had to do it, and we have done it. I feel good about it. Part of my feeling good may be that it is over. I think we got a lot out of it, but a lot of people worked hard, and I would like for you to join me in thanking the people out front who helped with the registration, the National Forest Products Association for hosting the coffee breaks, and all the others who worked so hard.

(Whereupon, at 4:40 p.m., the Symposium on the Use of Herbicides in Forestry adjourned.)