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Editorial: Authors' Perspective**Assessment of Potential Exposure to Agent Orange and Its Associated TCDD**Alvin L. Young^{1*}, John P. Giesy², Paul Jones², Michael Newton³, John F. Guilmartin, Jr.⁴ and Paul F. Cecil, Sr.⁵¹Institute for Science and Public Policy, The University of Oklahoma, Norman, Oklahoma, USA²Department of Zoology, National Food Safety and Toxicology Center and Center for Integrative Toxicology, Michigan State University, East Lansing, Michigan, USA³Department of Forest Science, Oregon State University, Corvallis, Oregon, USA⁴Department of History, The Ohio State University, Columbus, Ohio, USA⁵Historian and Archivist, The RANCH HAND Vietnam Association, Fort Walton Beach, Florida, USA* Corresponding author (youngrisk@aol.com)DOI: <http://dx.doi.org/10.1065/espr2004.10.221.2>**Introduction**

Few environmental or occupational health issues have received the sustained international attention that has been focused on the herbicide formulation called 'Agent Orange' and its associated dioxin contaminant, 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD). Governmental reports and scientific articles frequently discuss Agent Orange, draw conclusions, and offer recommendations based on an assumption that US and allied troops in Vietnam were significantly exposed to TCDD from Agent Orange. The data presented in this issue of ESPR indicate that such an assumption is inconsistent with the historical record and the environmental characteristics of TCDD.

Assessing The Use of Military Records

A search of the worldwide web for information on Agent Orange provides hundreds of examples of anecdotal information by individuals who claimed they were exposed to Agent Orange and TCDD. But the historical record does not support the position that Vietnam veterans were widely exposed to Agent Orange. Our paper, *Assessing Possible Exposures of Ground Troops to Agent Orange During the Vietnam War: The Use of Contemporary Military Records*, [1] reviews a variety of historical documents, many of which have not previously been considered in evaluating the potential exposure of personnel to Agent Orange in Vietnam. For example, there has been little appreciation of the fact that herbicide spray missions were flown at tree top level and consequently were exposed to frequent hostile fire. Therefore, fighter escorts accompanied nearly all herbicide spray missions, often bombing and strafing the spray target to suppress hostile fire and protect the RANCH HAND aircraft. To prevent 'friendly fire' casualties during these missions, military procedures mandated that a Forward Air Controller (FAC) arrive at the spray target in advance of the spray planes and direct the mission. The FAC was required to abort the mission unless he could confirm that there were no friendly forces in the area. From this and other procedural mission requirements, we concluded that: "Through detailed policies and procedures, the circumstances in which spraying occurred were carefully controlled, and as a result, spraying of troops with Agent Orange in Vietnam was highly unlikely." The anecdotal reports of direct spraying of troops in Vietnam were more likely to have been insecticide spray missions for mosquito control.

Understanding the Environmental Fate of TCDD

Public discussion and scientific research has proceeded largely on an assumption, rather than a determination, of widespread substantial exposure to Agent Orange. Thus, in our second paper, *Environmental Fate and Bioavailability of Agent Orange and Its Associated Dioxin During the Vietnam War*, [2] we address the question, "Does our knowledge about the environmental fate of Agent Orange and TCDD support the conclusions that ground troops could have been contaminated, if not by direct exposure, perhaps by entering previously sprayed areas?" Our assessment of factors such as photodegradation, bioavailability, and other relevant factors affecting the environmental fate and uptake of the herbicides and TCDD suggests that: "The prospect of exposure to TCDD from Agent Orange in ground troops in Vietnam seems unlikely in light of the environmental dissipation, little bioavailability, and the properties of the herbicides and circumstances of application that occurred." Appreciable accumulation of TCDD has been found only in veterans of Operation RANCH HAND and the Army Chemical Corps, who were subjected to repeated, long-term direct skin contact with the liquid herbicide during the course of their duties applying Agent Orange in Vietnam. Serum TCDD analyses beginning in the late 1980s and 1990s failed to find evidence of exposure to other veterans who served in areas of Vietnam where Agent Orange had been sprayed [3,4]. The historical and environmental data that we present here are consistent with the results of serum TCDD analyses and further call into question assumptions of exposure to Agent Orange.

Addressing the Challenges in Vietnam

The material presented here has greatest relevance to the issue of extent to which friendly ground troops were exposed during the Vietnam conflict to Agent Orange and TCDD. However, much of this material is also relevant to the issue of whether Vietnamese civilians were exposed and, if so, to what extent. That is, our review of fate and transport shows that much of the Agent Orange sprayed was intercepted by the upper forest canopies, and that under most conditions, the TCDD in the material sprayed had a half-life of a few hours. Moreover, application of herbicides was spatially precise and involved optimal amounts of herbicide necessary to achieve the desired result. Thus, the opportunity for widespread chronic exposure of civilian populations to TCDD was limited. Target planners also were cautioned to

avoid heavily populated areas, another factor in avoiding exposure of civilian populations to Agent Orange and TCDD. Thus, we believe it is unlikely that herbicide application resulted in exposures of civilians equivalent to those veterans who handled liquid herbicide on a repeated basis.

Nonetheless, potential effects of herbicides on the Vietnamese civilian population and environment are topics of intense current concern. In March 2002, a joint meeting was co-sponsored by the US National Institute of Environmental Health Sciences (NIEHS) and the Vietnamese Ministry of Science, Technology and the Environment in Hanoi [5]. The conference was organized under the auspices of a Joint US-Vietnam Cooperative Research Program on the Health and Environmental Effects of Agent Orange/Dioxin. At the conference, it was acknowledged that the challenge in separating the impact of the use of herbicides in Vietnam from the destruction due to decades of war would be monumental. Nevertheless, the United States and Vietnam have agreed to joint research, and one of us (John Giesy) is participating in the negotiations regarding this joint research. We are hopeful that this joint research will proceed and lead to incorporation of the best and most accurate information on the impact and environmental fate of TCDD in Vietnam.

Some important questions remain relatively unexplored, such as present day levels of TCDD in Vietnam. We are aware of the reports of TCDD in sediments and soil samples in Vietnam [6,7]. Examination of where these samples were collected suggested that the source of TCDD was not from aerial applications of Agent Orange, but rather from highly localized soil on or adjacent to former Agent Orange storage and aircraft loading sites at Bien Hoa Air Base north of Ho Chi Minh City, and Da Nang Air Base adjacent to the city of Da Nang. These locations should be evaluated for possible remediation. Based on the data we have presented, we would not expect to find substantial levels of TCDD wherever Agent Orange was sprayed in Vietnam, but only in a few such 'hot spots.' A study of representative soil samples from various regions of Vietnam would test our expectation. However, no such study has yet been conducted.

Absent evidence of widespread exposure to TCDD either from Agent Orange or from soil or other sources in Vietnam, published reports suggesting that Agent Orange has caused widespread disease in veterans and their families and the Vietnamese people should be viewed with caution. Indeed, some effects attributed to Agent Orange exposure are readily explained by alternative factors. For example, neural tube defects (e.g., *spina bifida* and anencephaly) in Vietnamese children are sometimes attributed to Agent Orange. However, other risk factors, primarily related to nutritional deficiencies of folic acid, are much more likely to be the underlying causative factors of such defects. In the United States, for example, the prevalence of *spina bifida* and anencephaly decreased by 31% and 16%, respectively, after mandatory folic acid fortification was implemented in 1998 [8]. A wider view of potential causative factors and recognition that TCDD exposure may be much less than generally assumed can release medical resources and scientists from the grip of the 'Agent Orange problem' and re-focus resources toward the real causation of health problems. An understanding of the historical records on the use of Agent Orange, and the available science on the environmental fate of TCDD, will enhance our ability to design the most appropriate epidemiological studies and health delivery programs for the people of Vietnam as well as US Vietnam veterans and their children.

The Need for a Thorough Re-examination

For the reasons outlined above, the time has come for a thorough re-examination of the extent of exposure to Agent Orange and TCDD. As scientists and historians, we invite critical review of our data and conclusions and a productive dialogue analyzing all the available evidence. The historical documents and scientific data cited in our articles are publicly available for review. We encourage the readers of ESPR and others investigating these important issues to consider our data, make publicly available any other relevant data, and respond to our evidence and conclusions in the spirit of full and open scientific inquiry, discussion, and discovery. In this way, we can make the most accurate, critical assessment of historical and current issues.

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