



Uploaded to the VFC Website

▶▶▶ 2019 ◀◀◀

This Document has been provided to you courtesy of Veterans-For-Change!

Feel free to pass to any veteran who might be able to use this information!

For thousands more files like this and hundreds of links to useful information, and hundreds of "Frequently Asked Questions, please go to:

[Veterans-For-Change](#)

If Veterans don't help Veterans, who will?

Note:

VFC is not liable for source information in this document, it is merely provided as a courtesy to our members & subscribers.



The History, Use, Disposition and Environmental Fate of Agent Orange

Alvin L. Young

The History, Use,
Disposition
and Environmental Fate
of Agent Orange

 Springer

Alvin L. Young
Cheyenne, WY, USA
YoungRisk@aol.com

The views and opinions expressed in this book on:
The History, Use, Disposition and Environmental Fate of Agent Orange
do not necessarily represent those of Battelle Memorial Institute, the United States Department of
Defense, or any other Department or Agency of the United States Government.

ISBN 978-0-387-87485-2 e-ISBN 978-0-387-87486-9
DOI 10.1007/978-0-387-87486-9

Library of Congress Control Number: 2008939877

© Springer Science+Business Media, LLC 2009
All rights reserved. This work may not be translated or copied in whole or in part without the written permission of the publisher (Springer Science+Business Media, LLC, 233 Spring Street, New York, NY 10013, USA), except for brief excerpts in connection with reviews or scholarly analysis. Use in connection with any form of information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed is forbidden. The use in this publication of trade names, trademarks, service marks, and similar terms, even if they are not identified as such, is not to be taken as an expression of opinion as to whether or not they are subject to proprietary rights.

Printed on acid-free paper

springer.com

Preface

For almost four decades, controversy has surrounded the tactical use of herbicides in Southeast Asia by the United States military. Few environmental or occupational health issues have received the sustained international attention that has been focused on Agent Orange, the major tactical herbicide deployed in Southern Vietnam. With the opening and establishment of normal relations between the United States and the Socialist Republic of Vietnam in 1995, the time has come for a thorough re-examination of the military use of Agent Orange and other “tactical herbicides” in Southern Vietnam, and the subsequent actions that have been taking place since their use in Vietnam.

The United States Department of Defense has had the major role in all military operations involving the use of tactical herbicides, including that of Agent Orange. This included the Department’s purchase, shipment and tactical use of herbicides in Vietnam, its role in the disposition of Agent Orange after Vietnam, its role in conducting long-term epidemiological investigations of the men of Operation RANCH HAND, and its sponsorship of ecological and environmental fate studies. This book was commissioned by The Office of the Deputy Under Secretary of Defense (Installations and Environment) with the intent of providing documentation of the knowledge on the history, use, disposition and environmental fate of Agent Orange and its associated dioxin.

A large body of historical records and other data exist on the use of Agent Orange in Vietnam. Many of these primary historical records are now openly available, and they permit a comprehensive assessment of the procedures and supporting historical data related to spraying of herbicides in Vietnam. An extensive collection of environmental data has been assembled on Agent Orange and its associated dioxin. These data provide insight into the mechanisms of dissipation and degradation as they relate to the distribution and bioavailability of the herbicides and dioxin in the environment, i.e., issues related to human exposure. Procurement records from the United States Air Force and Defense Supply Agency, complemented by records from the Chemical Companies that produced the tactical herbicides, and from the National Institute for Occupational Safety and Health, permit new estimates on both the quantities of tactical herbicides sprayed in Vietnam and on the level of dioxin in those inventories. Lastly, workshops between the United States Department of

Defense and Vietnam's Ministry of National Defence have opened a dialogue on how the two governments can work together to resolve the remaining controversy over Agent Orange and "dioxin hot spots" in Southern Vietnam.

It is hoped that the history and science described in this book can correct many of the misperceptions about the use of tactical herbicides in Vietnam. In particular the science of the degradation of the herbicides and its associated dioxin and historical records, have not yet received the recognition in the debates of the issues that they should. It is my hope that this discussion and this book will make a positive contribution to society's effort to put the Vietnam War behind us and to look to the future relationships between both countries and their peoples.

1 July 2008

Alvin L. Young, Ph.D.

Acknowledgments

First, I want to thank the United States Air Force and the United States Government for giving a young man from the prairies of Wyoming the opportunity to have an exciting career for 40 years in environmental chemistry and toxicology of pesticides and related materials.

For those of us who went to college in the 1960s, the Vietnam War was a major social and political issue. I was a ROTC (Reserve Officer Training Corps) cadet at the University of Wyoming and 1964 was the year of my commissioning and graduation, and it was the year that the War became a national commitment. Because I was a graduate from the College of Agriculture, I was aware of the military's interest in herbicides. Accordingly, I contacted Air University and was given the opportunity to seek a PhD in Herbicide Physiology/Environmental Toxicology at Kansas State University. In 1968, I reported for active duty at Eglin Air Force Base, Florida where I had the opportunity to work closely with the men of Operation RANCH HAND in the evaluation of the aerial spray equipment that was continually being upgraded for use in Vietnam.

I also had the opportunity to conduct the first ecological studies on the dioxin contaminant in Agent Orange. While at Eglin, I began to collect documents on the tactical herbicides Orange, White, and Blue, on their use in Vietnam, and on subsequent studies related to their disposition, environmental fate, and toxicology. During the next 20 years the collection continued to develop as I advanced in my Air Force career. Eventually the size of the collection became large, and I was fortunate in having the interest of the Special Collections Division of the National Agricultural Library, Agricultural Research Service, Beltsville, Maryland. The Air Force School of Aerospace Medicine graciously provided funds to have the collection (>5,850 documents, reports, articles, photographs, and maps) placed into an electronic database, so that it could support the literature needs of the ongoing Air Force Health Study (the RANCH HAND Epidemiological Study). Thus, my thanks to the National Agricultural Library and to Sarah H. Fugate and Patricia Murphy for establishing "The Alvin L. Young Collection on Agent Orange." The collection is located at the following web site: <http://www.nal.usda.gov/speccoll/findaids/agentorange/intro.htm>.

The collection at the National Agricultural Library is one of two primary sources for this book. The other primary source is the Armed Forces Pest

Management Board's Literature Retrieval System. The Literature Retrieval System houses more than 150,000 electronically available documents, reports, and books on pests, pesticides, and AFPMB's worldwide studies. The AFPMB's Literature Retrieval System is located at the following web site: <http://www.afpmb.org>

The unique nature of this book is enhanced through the outstanding photographs and first-hand accounts of all phases of the various tactical herbicide operations and research. Many of the details and photographs of RANCH HAND missions were provided by men who served in Operation RANCH HAND in Vietnam. I am especially indebted to Lt. Colonel Paul F. Cecil, USAF (RET), Ph.D, Military Historian, who provided great assistance in reviewing and commenting on Chapter 3. The other men of Operation RANCH HAND that I wish to acknowledge are Major John "Jack" Spey, USAF (RET); Colonel Ralph Dresser, USAF (RET); Lt. Colonel James Pochurek; and, to the RANCH HAND Vietnam Association. I wish to acknowledge the experience and knowledge shared by men who served as Forward Air Controllers for RANCH HAND missions, especially Colonel Charles "Chuck" Hines, USAF (RET) and Lt. Colonel Leo Tibbitts, USAF (RET). Thanks also to Lt. Colonel Warren Hull, USAF (RET), BSC, for information on Project PACER IVY, and to Major James W. Tremblay, USAF (RET), BSC, who contributed photographs and details on Operation PACER HO. I am grateful for the special scientific expertise of Lt. Colonel Charles "Charlie" E. Thalken, USAF (RET), VC, and Lt Colonel Lorris G. Cockerham, Ph.D., USAF (RET), Colonel Robert Clegern, Ph.D., BSC, USAF (RET), and Colonel William Cairney, Ph.D., USAF (RET) in the conduct of ecological studies at Eglin AFB, Florida, and the Site Monitoring Programs at the Naval Construction Battalion Center, Gulfport, Mississippi, and Johnston Island, Central Pacific Ocean. I wish to give a special thanks to Mr. J. Ray Frank, Frederick, Maryland (formerly with the US Army Chemical Corps, Fort Detrick, Maryland) for many of the photographs included in the book.

I wish to acknowledge the opportunity provided me by Dr. James L. Regens to serve as a Visiting Professor and Senior Fellow with the Institute for Science and Public Policy, Sarkeys Energy Center, The University of Oklahoma, Norman, Oklahoma. Dr. Regens and his Research Associate James T. Gunter encouraged and provided a forum for me to document the history of Agent Orange. Dr. Regens is now Presidential Professor, Occupational and Environmental Health, University of Oklahoma Health Sciences Center, Oklahoma City, Oklahoma. A special appreciation is also given to Dr. Nathan Karch, Exponent, Inc., Washington DC for the many excellent suggestions that contributed to improving the book.

I wish to acknowledge the Program Manager for this project, Mr. Willam J. Van Houten, Environmental Readiness and Safety Group, Office of the Under Secretary of Defense, Washington, DC, and to the Project Manager, Mr. William B. Andrews, Battelle Memorial Institute, Richland, Washington.

It was great pleasure to travel to Hanoi, Vietnam and participate with them in Workshops on “Agent Orange and Dioxin Remediation”.

In conclusion, I wish to acknowledge my colleagues, the men and women who served with honor and distinction in the War in Vietnam. May their sacrifices never be forgotten!

Colonel, USAF (RET)
1 July 2008

Alvin L. Young, Ph.D.

Contents

1 Vietnam and the Agent Orange Controversy Revisited	1
1.1 Background	1
1.2 The Use of Tactical Herbicides in the Vietnam War	3
1.3 The Disposal of Agent Orange	6
1.4 Finding a Resolution to Vietnam Veterans' Health Concerns	7
1.5 The Return to Vietnam	11
1.6 Methodological Issues in Assessing Impacts	14
1.7 Overview of the Book	16
References	18
2 A History of the Development and Procurement of Tactical Herbicides	23
2.1 Background	23
2.2 The Initial Development of Tactical Herbicides	24
2.2.1 Previous Research Supporting the Initial Deployment of Tactical Herbicides in Vietnam	25
2.2.2 The Selection of the First Tactical Herbicides for Use in South Vietnam	26
2.3 The Defoliation Conferences	31
2.4 The Major Three Tactical Herbicides Used in Vietnam	37
2.5 Physical Properties, Handling and Safety Evaluations of the Tactical Herbicides	40
2.6 The Procurement and Management of Tactical Herbicides	41
2.6.1 Purchase Descriptions for the Tactical Herbicides	41
2.6.2 Quantities of Tactical Herbicides Procured	43
2.6.3 Ports of Embarkation	44
2.6.4 Management of the Tactical Herbicides	44
2.6.5 Summary of What Defined Tactical Herbicides	46
2.7 The Role of the Armed Forces Pest Control Board and Commercial Herbicides	46
2.7.1 Summary of the Use of Commercial Herbicides by the DOD	49

2.8 Implications of Tactical Versus Commercial Herbicides 49

References 49

3 The Military Use of Tactical Herbicides in Vietnam 57

3.1 Environmental Characteristics of South Vietnam 58

3.2 The Rationale for Herbicide Use in South Vietnam 60

3.3 Combat Tactical Zones 63

3.4 Historical Background on Early Spray Missions 65

3.5 Use Patterns of Individual Herbicides 66

3.6 Historical and Procedural Information on Operation RANCH HAND 68

3.6.1 Deployment of Aircraft 68

3.6.2 Development, Test, and Evaluation of Aerial Spray Systems for Vietnam 70

3.6.3 RANCH HAND Support Activities and Concepts 74

3.6.4 Accidental Spills 81

3.7 MACV Directive 525-1: Herbicide Procedures and Operations 82

3.8 Post Approval Procedures in Operation RANCH HAND 83

3.9 Coordinating RANCH HAND Spray Missions 86

3.10 Encountering a Hostile Environment 87

3.11 The Critical Role of the Forward Air Controller 89

3.12 Executing the Spray Mission 90

3.13 Preparation of the Daily Air Activity Report (DAAR) 92

3.14 Other Herbicide Requests 96

3.15 The Role of the Army Chemical Corps 97

3.16 Herbicide Operations in the Individual Combat Tactical Zones 100

3.17 The Preparation, Accuracy, and Use of the Military Records 105

3.18 Other Sources of Herbicide Consumption Data 107

3.19 The Accuracy of Geographic Data 110

3.20 Alternate Methods of Clearing Vegetation 111

3.21 Insecticides and Operation FLYSWATTER 112

3.22 Termination of Herbicide Use 114

References 115

4 Removal from Vietnam and Final Disposition of Agent Orange 121

4.1 Background 121

4.2 Operation PACER IVY 123

4.3 Storage and Maintenance of Agent Orange in the United States 134

4.4 Operation PACER HO 142

4.4.1 Selection of At-Sea Incineration and Discussion of Alternative Methods 142

4.4.2	Operation PACER HO	143
4.4.3	Description of Land-Based Operations.	145
4.4.4	Operations at the Naval Construction Battalion Center	145
4.4.5	Operations at Johnston Island, Central Pacific Ocean	151
4.4.6	Land-Based and Shipboard Air Monitoring Programs	155
4.4.7	Brief Description of Shipboard Operations	155
4.4.8	The Termination of Operation PACER HO.	156
	References	158
5	Agent Orange and its Dioxin Contamination	161
5.1	The Significance of the Dioxin Contaminant in Agent Orange	161
5.2	Formation of the TCDD Contaminant	162
5.3	Establishing Agent Orange and its Contaminant as a Major Public Health Issue.	165
5.4	Composition of Agent Orange and Associated Contaminants	169
5.5	Estimates of Quantities of Tactical Herbicides Procured by the Defense Supply Agency.	172
5.6	The Initial Analysis of Dioxin Contamination in the Agent Orange Inventory	174
5.6.1	Sampling the NCBC and Johnston Island Inventories of Agent Orange	174
5.6.2	Air Force Results of Johnston Island Analyses for Dioxin	177
5.6.3	Results of the Naval Construction Battalion Center Analyses.	178
5.7	A Re-analysis of TCDD in Agent Orange Stocks	179
5.7.1	A Re-evaluation of the NCBC and Johnston Island Agent Orange Inventories	179
5.7.2	Statistical Methodology for Air Force Data	180
5.7.3	Results for NCBC and Johnston Island Agent Orange Inventories	181
5.8	TCDD Data from the NIOSH Studies of 2,4,5-T Production	182
5.8.1	Statistical Analysis of Dioxin Levels in Production Samples of 2,4,5-T Formulations	182
5.8.2	Results and Discussion of NIOSH Data Sets	185
5.9	Conclusions as to the Amount of TCDD Disseminated in South Vietnam	185
	References	186

6	The Testing of Aerial Spray Equipment, and Ecological Impacts of the Programs at Eglin Air Force Base, Florida	191
6.1	Introduction	191
6.2	Background	193
6.3	Test and Evaluations Projects on Test Area C-52A	199
6.4	Hardstand 7 Herbicide Loading and Storage Site	200
6.5	Herbicides/Chemicals Sprayed in the Test and Evaluation Programs	208
6.6	TCDD in Agent Orange and Purple Disseminated on the Test Area	209
6.7	The Military's Response to the Herbicides Sprayed on Test Area C-52A	211
6.8	Chemical and Bioassay Studies of Soil Cores from Test Area C-52A	214
6.9	Studies of the Vegetation of Test Area C-52A	221
6.9.1	Synopsis of Vegetative Studies	221
6.9.2	Discussion of the Sampling Procedure, Results, and Photographic Records	223
6.9.3	Studies of the Mammals, Birds, Reptiles, and Amphibians	229
6.9.4	Aquatic Studies	233
6.9.5	Insect Studies	237
6.9.6	Summary of Ecological Surveys	238
6.10	Persistence of TCDD in the Soils of Test Area C-52A	238
6.11	Routes of TCDD Disappearance on Test Girds Receiving 2,4,5-T Herbicide	241
6.12	Animal Studies of TCDD Uptake	243
6.13	Long-term Field Studies of the Beachmouse, <i>Peromyscus polionotus</i>	246
6.14	Actions to Control the Movement of TCDD from Hardstand 7 and Test Area C-52A	253
6.15	Conclusions	254
	References	256
7	Monitoring Studies of Former Agent Orange Storage Sites in Mississippi and Johnston Island	263
7.1	Requirements for Site Reclamation of NCBC and Johnston Island	264
7.2	Historical Background on the Naval Construction Battalion Center	266
7.2.1	The Issue of Defective and Damaged Drums	267
7.2.2	Results of the USAF Academy Monitoring Program, 1974–1976	269
7.2.3	Environmental Health Laboratory Monitoring Program, 1974–1976	271

7.3	Historical Background on Johnston Island	272
7.3.1	Results of Early Monitoring Programs on Johnston Island	273
7.3.2	Potential Water Contamination of Johnston Island.	274
7.4	Design of the Protocol for Monitoring the Herbicide Storage Sites	276
7.4.1	Preliminary Evaluation of the Protocol at NCBC	277
7.4.2	Implementation of the Formal Protocol	279
7.4.3	Chemical Analyses of Samples	280
7.4.4	Microbial Analyses of Samples	281
7.5	Results and Discussion of Herbicide and Microbial Data	281
7.6	Aquatic System Monitoring for TCDD at NCBC, 1977–1979	287
7.7	Management Recommendations for the NCBC Herbicide Storage Site	290
7.8	Implementation of the AFESC Herbicide Orange Monitoring Program	292
7.9	Site Characterization Study of NCBC in Preparation for Reclamation	294
7.10	Final Reclamation Actions at the Naval Construction Battalion Center	295
7.11	The Reclamation of the Johnston Island Herbicide Storage Site	297
	References	299

**8 Agent Orange and Dioxin Remediation and the
Return to Vietnam**

	Return to Vietnam	303
8.1	The National Academy of Sciences Study, 1971–1974.	303
8.2	The Period of Limited Access to Vietnam and Studies on Agent Orange, 1976–1995	305
8.3	Normalization Between the United and the Socialist Republic of Vietnam, 1995-Present	308
8.4	The Agent Orange Dioxin Remediation Workshops, 2005–2007	309
8.4.1	Background on the Workshops	309
8.4.2	The 1st Agent Orange and Dioxin Remediation Workshop, August 2005	310
8.4.3	The 2nd Agent Orange and Dioxin Remediation Workshop, June 2007	313
8.4.4	History and Maps of the Former Tactical Herbicide Storage and Loading Sites in Vietnam	314
	References	320

Postlude: Can there be a Satisfactory End to the Agent Orange Controversy? 325

 The Resolution in Vietnam 325

 The Resolution for Vietnam Veterans 327

 References 327

Index 329

Alvin L. Young Biographical Sketch, 2008

For 40 years, Dr. Alvin L. Young has collected documents, reports, and photographs on the use, disposition, and environmental fate of Agent Orange and other tactical herbicides used in the Vietnam War. He has published or edited four books and more than 70 peer reviewed publications, commentaries, and editorials on the herbicides (and the associated dioxin contaminant) used in Vietnam. He completed his PhD in Herbicide Physiology and Environmental Toxicology at Kansas State University in 1968. He began his Air Force career as a Project Scientist with the United States Air Force in 1968, evaluating both the dissemination characteristics of the Air Force aircraft and the fate of the herbicides used in South Vietnam. In his 21 years with the Air Force (obtaining the rank of Colonel), he was involved with all phases of the Agent Orange Controversy, from test and evaluation of equipment to environmental fate and health impacts. During his years as Associate Professor at the United States Air Force Academy (1971–1977), Colorado Springs, Colorado he conducted studies on the environmental fate of TCDD including studies on the biodegradation of massive quantities of Agent Orange.

From 1977 to 1983, Dr. Young was affiliated with the Epidemiology Division, The School of Aerospace Medicine, Brooks AFB, Texas, and the Environmental Epidemiology Unit of the Department of Veterans Affairs, Washington, DC. His primary responsibilities were the documentation and establishment of exposure assessment protocols for the epidemiological studies of Vietnam veterans. From 1983 to 1987, Dr. Young was assigned to the Executive Office of the President, Washington, DC, where he provided advice to the White House on the issues of Agent Orange and Dioxins. From 1987 to 1997, he was a Science Advisor for the United States Department of Agriculture. From 1997 to 2001, he was the Director, Center for Risk Excellence, United States Department of Energy, Argonne, Illinois. From 2002 through 2007 he was a Visiting Professor and Senior Fellow with the Institute for Science and Public Policy, The University of Oklahoma, Norman, Oklahoma. He currently is President, A. L. Young Consulting, Inc., Cheyenne, Wyoming. His scientific specialty is on the use, toxicology, and human and environmental risks associated with the military herbicides used in South Vietnam, 1961–1972.

Dr. Young has traveled, lectured, attended and sponsored conferences and workshops in 32 countries speaking on issues related to Agent Orange and TCDD, ecological studies, environmental toxicology, and biotechnology. He has served as a Co-editor for four different journals and has more than 300 publications in the scientific literature. He is currently the Editor-in-Chief of the *International Journal Environmental Science and Pollution Research*. He maintains a Special Collection on Agent Orange at the USDA's National Agricultural Library, Beltsville, Maryland, at: <http://www.nal.usda.gov/speccoll/findaids/agentorange/index.htm>

Chapter 1

Vietnam and the Agent Orange Controversy Revisited

For almost four decades, controversy has surrounded the tactical use of herbicides in Southeast Asia by the United States Department of Defense. Few environmental or occupational health issues have received the sustained international attention that has been focused on Agent Orange and its associated dioxin contaminant. However, the breadth of that controversy has spanned the gamut from alleged military use of chemical weapons, to ecological damage and public health impacts, and to social and political concerns. This spectrum of controversy has represented the crossroads of science and society, i.e., where the significance of the science is “filtered” by the perceptions of the society. Only now that much of the acrimony from that military conflict has subsided can we revisit the military’s use of tactical herbicides in Vietnam and the subsequent actions that have occurred since their use. Indeed, today the legacy issues of Agent Orange remain as one of the last contentious issues with the veterans of that war, and between the United States and Socialist Republic of Vietnam.

1.1 Background

Significant confusion has existed about how herbicides were selected by the US Military to be used in the defoliation program in the Vietnam-American War (i.e., the Vietnam War). The belief that commercially available herbicides were simply purchased from US chemical companies and deployed directly to Vietnam was incorrect and contrary to historical records. “Tactical Herbicides” were herbicides and formulations developed specifically by the United States Department of Defense (DOD) to be used in combat operations. The missions to develop tactical herbicides and delivery technologies were assigned to the US Army Chemical Corps, specifically to the Plant Sciences Laboratories at Fort Detrick, Maryland. Fort Detrick evaluated numerous formulations of herbicides for potential tactical use from 1957 through 1967 (Irish et al. 1969; Young 2006). However, the component herbicides that comprised the “tactical herbicides” used in Vietnam were those herbicides

being developed or already adopted for domestic agricultural use before they were used in Vietnam. Prior to and during their use in Vietnam by the military, the two phenoxy herbicides, 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) and 2,4-D (2,4-dichlorophenoxyacetic acid), the major components of Agent Orange, were extensively used in the United States (Bovey 1980a). Prior to the controversy surrounding Agent Orange, an extremely voluminous amount of research data, demonstration, and use experience had been accumulated on all aspects of these two herbicides, from toxicity in animals, to environmental fate, and to weed and shrub control recommendations under field conditions (Young et al. 1978; Bovey 1980b; Lavy 1987).

The herbicide 2,4,5-T was first commercially produced in the United States in 1944 (Hammer and Tukey 1944). The quantity of 2,4,5-T produced and used in the United States, and in world agriculture, increased steadily until 1968–1969, after which a sharp decline in its use occurred. During the period 1961 through 1969, 70 million kg were produced in the United States. Approximately 24 million kg (34.5%) was procured by the United States military for use in Vietnam; almost 36 million kg (51%) were used in domestic herbaceous and woody plant control programs, and the remaining 10 million kg (14.5%) was exported to other countries (Bovey 1980a). The herbicide 2,4-D has long been recognized as one of the safest, non-persisting, and most widely used herbicide worldwide (Lavy 1987). The production and use of 2,4-D greatly exceeded that of 2,4,5-T, and today it is still a major herbicide used in weed control programs. Between 1966 and 1971, 2,4-D was applied annually to almost 23 million hectares of cropland, pastures, and residential lawns in the United States, while 2,4,5-T was annually applied to 607,000 hectares of pastures, rangeland and forests. A mixture of the two herbicides was found to be invaluable for the control of hard-to-kill woody brush and undesirable trees, e.g., honey mesquite (*Prosopis juliflora*) and sand shinnery oak (*Quercus harvardii*). Forestry programs traditionally used 2,4-D and 2,4,5-T in combination to kill competing broadleaf shrubs and trees, thus allowing for conifer release in new plantings of pine and fir trees (Bovey 1980a; Lavy 1987; Newton and Young 2004). The termination of all 2,4,5-T production occurred in the United States after the US Environmental Protection Agency (EPA) issued an Emergency Suspension in 1979 that cancelled all registrations of 2,4,5-T. A Professor of Forestry at Oregon State University noted:

After 30 years of use without substantial incident and thorough documentation, politics, media bias, and societal concerns eventually destroyed a product with an excellent safety record and an enviable record of benefits to costs (Newton and Young 2004).

Agent White, the second most applied tactical herbicide in South Vietnam contained the two domestic herbicides, 2,4-D and picloram (4-amino-3,5,6-trichloropicolinic acid). As with 2,4,5-T, picloram was a non-selective broadleaf herbicide having a very low toxicity value, and was readily biodegraded by soil microorganisms in soil conditions having adequate moisture,

warm temperatures, and high in organic matter (WSSA 1979). Although picloram was readily water soluble, breakdown occurred in UV light and was greatest in clear moving water and on soil and plant surfaces (WSSA 1979). Agent Blue, the third major tactical herbicide used in South Vietnam, consisted of the organic arsenical, cacodylic acid (hydroxydimethylarsine oxide) and its sodium salt (sodium cacodylate). Blue was a contact herbicide that would rapidly defoliate or desiccate a wide variety of plant species, especially grasses and grains, e.g., rice (Hood 1985). The phytotoxic properties of cacodylic acid were quickly inactivated on contact with soil. This organic form of arsenic was considered to have very low toxicity to mammals (Hood 1985). Thus, three (2,4-D, picloram, and cacodylic acid) of the four herbicides contained in the tactical herbicides used in Vietnam are still used commercially in the United States and in world agriculture (WSSA 1979; Bovey and Young 1980; Hood 1985; Lavy 1987). So why so much controversy about the use of herbicides in the Vietnam War?

1.2 The Use of Tactical Herbicides in the Vietnam War

The controversy initially involved the actual deployment of tactical herbicides as a weapon of war in the former Republic of Vietnam (RVN) by the United States Air Force (USAF) and the United States Army (USA). The Biological Laboratories, Army Chemical Corps, Fort Detrick first evaluated tactical formulations in South Vietnam in December 1961 (Brown 1962). From January 1962 to February 1971, the USAF aerially deployed tactical herbicides in combat operations to improve visibility in enemy controlled or contested jungle areas in order to expose infiltration routes, base camps, weapon placements, and storage sites. In addition, with the assistance of the US Army Chemical Corps, tactical herbicides were sprayed along enemy-entrenched lines of communication, transportation routes, around the outside of base perimeters, and for limited but selectively-approved use for crop denial (Fox 1979; Cecil 1986). As developed, tactical herbicides were to be used only in combat operations, not for weed or brush control on military bases and installations. With the full concurrence and support of the Republic of Vietnam (South Vietnam) and the Army of the Republic of Vietnam (ARVN), USAF Operation RANCH HAND was initiated 7 January 1962. Operation RANCH HAND was responsible for the fixed-wing aerial applications from UC-123 aircraft, and applied 95% of the tactical herbicides sprayed in Southern Vietnam (Cecil 1986; Stelman et al. 2003). Helicopters and ground equipment assigned to the US Army Chemical Corps and to Combat Engineers of other Allied Forces sprayed the remaining 5 percent (Young et al. 2004a; see Chapter 3). Figure 1.1 illustrates the results of the first defoliation mission in January 1962 in the South Vietnam.



Fig. 1.1 Results of the first defoliation mission, January 1962, Ca Mau Peninsula, Vietnam (Photograph courtesy of US Army Chemical Corps, Fort Detrick, Maryland)

It should be noted that although the United States government terminated all use of tactical herbicides on 31 October 1971, stocks of Agent White and Blue remained at Da Nang Air Base and Bien Hoa Air Base. These stocks were subsequently sprayed by the South Vietnamese Air Force (VNAF) using aircraft given to the VNAF by the 7th Air Force as part of the Vietnamization Program. No records could be found as to the final fate of those stocks, but procurement records indicated how much was sent to Vietnam in late 1970 (Craig 1975; Cecil 1986).

To obtain the quantities of tactical herbicides purchased and used in the Vietnam War, procurement records were obtained from the Defense Supply Agency and the Air Force Logistics Command (the San Antonio Air Materiel Area, Kelly Air Force Base, Texas), and validated with data from the chemical companies that provided the tactical herbicides under Military Specifications (Craig 1975; Product Liability Litigation 1982). Data provided in Table 1.1 represents the most recent data (as of March 2008) and the best estimates of the quantities of tactical herbicides used from 1961 to 1972. The color designation given to the tactical herbicides came from the 7.5 cm (3-in.) color-coded band around the center of the 18-gauge steel 208-l (55-gal) drum, not from the color of the liquid herbicide (Craig 1975; see Chapter 2). The quantities of tactical herbicides used in Vietnam are provided in Table 1.1.

The tactical herbicides were also color-coded to facilitate herbicide selection, transportation, and incompatibility issues. Thus the military code names Orange, Blue, White, Pink, Green, and Purple were given to each different military formulation, with Orange being the most widely procured and used (Young 2006). Tactical operations using these tactical herbicides were deployed against the Viet Cong and regular Armed Forces of the Democratic Republic of Vietnam. While Operation RANCH HAND was the USAF military operation

Table 1.1 Estimated quantities of tactical herbicides used in Vietnam, 1961–1972

Tactical herbicide	Commercial components	Number of drums ¹	Number of liters	Years of use
Green ²	2,4,5-T	365 ³	75,920	1962
Pink ²	2,4,5-T	1,315	273,520	1961–1963
Purple ²	2,4-D; 2,4,5-T	12,475	2,594,800	1962–1965
Blue	Cacodylic Acid	29,330	6,100,640	1966–1972
White	2,4-D; Picloram	104,800	21,798,400	1966–1972
Orange ²	2,4-D; 2,4,5-T	208,330	43,332,640	1965–1970
Total		356,615	74,175,920	

¹ Data based on US Defense Supply Agency and Air Force Logistics Command records (Craig 1975; Young 2006); Data as of March 2008.

² These tactical herbicides contained 2,4,5-T herbicide and its associated contaminant, 2,3,7,8-TCDD. Pink was used in the 1964 Thailand tests, but available data indicted last Pink Mission in South Vietnam was in 1963; the Daily Air Activity Reports often confused Purple and Pink.

³ All herbicide drums sent to Vietnam were of 18-gauge steel and held 208 l or 55 gal of product that were applied in concentrated form and not diluted.

responsible for the tactical fixed-wing aerial dispersal of the herbicides, the Army Chemical Corps was responsible for the use of helicopter and ground equipment to deliver tactical herbicides on base perimeters and other selected military targets. Aerial spray systems were specifically developed by the military for fixed-wing and helicopter aircraft (see Fig. 1.2) (Buckingham 1982; Cecil 1986).

Only the US Army Chemical Corps and the US Air Force Logistics Command were authorized to purchase tactical herbicides. However, many commercial pesticides, including herbicides, were used in Vietnam on US and



Fig. 1.2 Three UC-123 aircraft spraying defoliants over the Ashau Valley on 9 May 1967 (Photograph courtesy of J. Ray Frank, Frederick, Maryland)

Allied Bases. These commercial pesticides were purchased under Federal Specifications, and the Armed Forces Pest Control Board regulated their uses (Young 2006; Young et al. 2008).

The Civil Engineering Squadrons assigned to all US and Allied Bases were responsible for acquisition and use of commercial pesticides (see Chapter 2). The Civil Engineering Squadrons in Vietnam were not approved to use the tactical herbicides Orange, Blue, and White. This distinction between tactical and commercial herbicides has been a source of misunderstanding by the public, veterans of the Vietnam War, the Department of Veterans Affairs, and the Vietnamese (Young 2006; Young et al. 2008).

Generally the term “Agent Orange” has been used by the public to describe a group of “Tactical Herbicides” used in combat operations by the US Military and other Allied Forces in the Vietnam War for the suppression and control of vegetation. However throughout the war, military units referred to the herbicides as “Herbicide Orange” or “Herbicide Blue”, but the media and critics of the use of these chemicals in military operations (i.e., warfare) called them “Agents” [Cecil 1986]. Hence, in the late 1960s and early 1970s as ecological and public health issues began to receive intense media coverage, “Herbicide Orange” became “Agent Orange”. The term “agent” became even more sensational in the media with the recognition in late 1969 that 2,4,5-T was contaminated with a toxic substance known as dioxin, or TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin). In April 1970, as a consequence of concern over potential public health impacts of TCDD in 2,4,5-T herbicide, the government of the United States restricted the herbicide use both in Vietnam and in the United States (DuBridg e 1970; MacLeod 1971). In September 1971, the Department of Defense initiated a process (Operation PACER IVY) to return the unused Agent Orange to the United States (i.e., to Johnston Island, Central Pacific Ocean) for final disposition (Young et al. 2004b; see Chapter 4).

1.3 The Disposal of Agent Orange

By the mid-1970s, the focus of the controversy shifted from issues associated with herbicide use to technical concerns about its safe disposal. The major issue involved questions of how best to dispose of the surplus herbicide and the associated dioxin contaminant following the termination of active US involvement in the Vietnam War (Department of Air Force 1974; Thomas et al. 1978). Numerous options for the disposal of Agent Orange were evaluated. However, extensive media and public concern limited the feasibility of most options (Tremblay 1983). In the military operation PACER HO, conducted in the summer of 1977, the USAF disposed of 8.6 million liters of Agent Orange by high temperature incineration at-sea aboard a specially designed incinerator ship (Fig. 1.3) (see Chapter 4) (Tremblay 1983).



Fig. 1.3 The at-sea incineration of Agent Orange near Johnston Island in the Central Pacific Ocean by the *M/T Vulcanus* during Operation PACER HO in August 1977 (Photograph courtesy of USAF OEHL, Brooks AFB, Texas)

1.4 Finding a Resolution to Vietnam Veterans' Health Concerns

Five nations provided combat troops, i.e., Allied Forces, to support the Army of Vietnam, 1962–1973. Australia/New Zealand deployed 46,852 combat troops. The government of Thailand contributed 11,790 military personnel to include Naval, Army, and Air Force units. The Republic of Korea (South Korea) deployed 312,853 combat troops, and the United States deployed 3.2 million military personnel. No figures were available on either the number of troops deployed by the Republic of Vietnam (South Vietnam) as Allied Forces, or the Viet Cong Insurgency Forces or the Democratic Republic of Vietnam (North Vietnam), but the numbers were also in the millions (Young 2002).

In 1977, following the completion of Operation PACER HO, veterans of the Vietnam War began to complain of serious health problems that they believed resulted from exposure to Agent Orange while on duty in Vietnam (Reggiani 1988). The basis for these beliefs were the press reports related to dioxins following the 1976 industrial accident in Seveso, Italy, and the continued concern over the domestic use of 2,4,5-T by the US Environmental Protection Agency (Reggiani 1988). In 1978, with the help of a reporter from the Columbia Broadcasting System, Bill Kurtis, the issue of Agent Orange and its potential impact on veterans' health was presented to the nation in a television documentary entitled "Agent Orange: Vietnam's Deadly Fog" (Kurtis 1978). As Reggiani noted:

In this way the public became aware of the magnitude of the veterans concerns, and Agent Orange reached the dimensions of a public health problem (Reggiani 1988).

Any attempt by the scientific community to refute this charge simply spread the suspicions within the veteran community. In responding to the documentary, the Council on Agricultural Science and Technology stated:

...the program clearly implied that exposure of the veterans to the dioxin in Agent Orange was responsible for some of their current health problems—problems of the type suffered to some degree by persons who were never exposed. Available scientific evidence does not support 20/20's (CBS) allegation (CAST 1978).

As Holden noted in 1979:

For Vietnam veterans the herbicide has become a symbol for everything that was wrong about the war. The veterans don't want answers in 10 years. They want satisfaction now (Holden 1979).

However, the answers to such questions would require the tremendous commitment of the research establishment and significant Federal funding.

The perceptions that governments have done little to resolve whether Agent Orange, its associated dioxin, or other tactical herbicides were responsible for the many health problems reported in the Vietnam veteran population are not based on the facts. In 1982 and 1983, the Congressional Research Service, Library of Congress, prepared extensive "Issue Briefs" on the actions of the US Government to address "Veterans Complaints Concerning Exposure to Herbicides in South Vietnam" (Smith 1982; Davis 1983). The Veterans Administrations (now the Department of Veterans Affairs) and other Government Agencies in the United States and Australia initiated registries of veterans concerned about Agent Orange, and funded literature reviews, surveys, and epidemiological studies of Vietnam and Vietnam-Era veterans (Hunter 1981; Shepard 1981; Sinclair 1982; Kang et al. 1984; Hood 1985; Lavy 1987; Coombs 1988; CDC 1987, 1988, 1990).

The importance to the Federal Government in resolving veteran health issues was demonstrated in December 11, 1979, when the Executive Office of the President (President Jimmy Carter) directed the establishment of an "Inter-agency Work Group to Study the Possible Long-Term Health Effects of Phenoxy Herbicides and Contaminants" (the IWG) (Eizenstat 1980). Members of Interagency Work Group (IWG) included representatives from the Departments of Agriculture, Defense, Health and Human Services, Housing and Urban Development, and Labor, and representatives from the Environmental Protection Agency, Veterans Affairs, Office of Management and Budget, Council of Economic Advisors, and Office of Science and Technology Policy. A major issue presented to the IWG was the Congressional interest in having an epidemiological study conducted of ground troops who may have been exposed to Agent Orange during combat operations. Such a study would require the Department of Defense to identify exposed and non-exposed cohorts. In anticipation of such a study, the Department tasked the US Army and Joint Services Environmental Support Group to conduct record searches and identify at least five battalions (over 20,000 potential study subjects) of Army combat personnel

who served in III Corps in South Vietnam during the War (del Real 1981). The IWG tracked this activity carefully for two years and in a April 1981 reported to the Assistant to the President for Policy Development that:

The DOD has searched company-level records of five battalions and has been able to determine that certain units operated in close proximity to areas sprayed with Agent Orange. However, DOD has not been able to identify individuals or even units whose exposure to Agent Orange is or can be documented reliably. The Work Group believes that it is reasonable to presume that military personnel entered sprayed areas. However, a study based on no more than presumed exposure would represent such a serious flaw in scientific design as to be of questionable validity. The Work Group strongly endorses DOD's recommendation that the records search effort by DOD (ESG) be reviewed by outside records search experts to insure that no means of possibly identifying individuals whose exposure to Agent Orange is or can be documented has been overlooked (del Real 1981).

In August 1981, the IWG was expanded and elevated to become the "Agent Orange Working Group" (AOWG) at the Cabinet Council level by President Ronald Reagan. The task assigned to the AOWG was... "to guide and monitor all Federal research into the possible adverse health effects of Agent Orange and similar chemicals on humans, with a particular focus on the health of Vietnam veterans" (HHS NEWS 1981). Secretary of Health and Human Services was appointed Chair of the AOWG, and the Director from the Centers for Disease Control and Prevention (CDC) was appointed Chair of the AOWG Science Panel. The Congressional Office of Technology Assessment and the General Accounting Office were invited to become observers and advisors to the Group. The AOWG undertook a massive effort encouraging, supporting, and monitoring studies conducted by VA, DOD (the Air Force Health Study of RANCH HAND personnel), CDC, other Federal Agencies, and the international community (e.g., Australia and New Zealand) (Davis 1983). Subcommittees were formed to examine the use of TCDD as a bio-indicator of exposure to Agent Orange (Rall 1981), and the Science Panel of the AOWG undertook a comprehensive assessment of the feasibility of conducting the major study of ground troops (Beach 1984). Between 1986 and 1988, the results of many studies conducted by the US Federal Agencies and monitored by the AOWG were reported (Murray 1986; Bowen 1988). A Fact Sheet developed by the AOWG (Bowen 1988) reported on 17 major studies or projects conducted by the CDC (Vietnam Experience Study, Mortality Assessment Study, Selected Cancer Study, and Agent Orange Exposure Study); by the National Institute for Occupational Safety and Health (NIOSH Mortality Study of Production Workers Exposed to Dioxin, and NIOSH Medical Study of Production Workers Exposed to Dioxin); Veterans Administration (Vietnam Veterans Mortality Study, Soft-Tissue Sarcoma Study, Retrospective Study of Dioxins and Furans in Adipose Tissue, Review of Soft-Tissue Sarcoma Cases in VA Patient Treatment File, Specially Solicited Research Projects, Agent Orange Registry, Monograph Series, Literature Review, and Women's Vietnam Veterans Health Study); and, Department of Defense (RANCH HAND Study, i.e., the Air Force Health Study).

Major General John E. Murray, US Army Retired, submitted the most controversial report to the AOWG in May 1986. General Murray, a US Army Records Expert, had been selected and tasked to examine the military records that were collected in anticipation of conducting the large epidemiological study of ground troops (Murray 1986). General Murray conducted a three-month long study of seven battalions that had been identified by the US Army and Joint Services Environmental Support Group. In his Final Report, he noted:

...the three-month long pilot study ...did produce invaluable facts that helped to clearly display the complexity of the problem, and to display the lack of preciseness to solve the problem. Accordingly the continuance of the study (i.e., the Ground Troop Study) is NOT recommended (Murray 1986).

Subsequently, Richard Christian, Director of the Environmental Support Group, testified to the Congress (House of Representatives) in July 1986 with the following concluding statement:

Over the past three years the Military Services have been scrutinized, scrubbed, and critically examined by distinguished groups of experts, such as the National Academy of Science, the Science Panel of the White House Agent Orange Working Group, and most recently the Sub Panel on Agent Orange Assessment. The (military) records do not support continuance of the Agent Orange Epidemiological Study. We are proud of our exhaustive work (Christian 1986).

The Executive Office of the President subsequently cancelled the Congressionally-mandated Agent Orange Study (Bowen 1988). Thus, in the ten years from 1979 through 1989, the US Federal Departments/Agencies committed vast sums of research funds and scientific expertise in addressing the health issues that were allegedly caused by exposure to Agent Orange (Bowen 1988; Gough 1987). Dr. Michael Gough, the Congressional Office of Technology Assessment concluded after reviewing the studies of the AOWG:

The likely end of spending hundreds of millions of dollars on chasing after possible health effects of Agent Orange exposure in Vietnam will be results that show no adverse health effects. But for sure, the studies can't prove Agent Orange caused no health effects. It's impossible to prove a negative (Gough 1987).

Thus, the failure to clearly establish "cause and effect", i.e., never confirming that the herbicides had actually caused health problems in Vietnam veterans, resulted in the Congress of the United States and the President taking political action to address veterans concerns by passage of Public Law 102-4, the Agent Orange Act of 1991 (IOM 1994, Young 2002). For the Vietnam veteran, this political route provided a resolution to the debate of whether the government would assume responsibility for any related health impacts that might have been caused by exposure to military herbicides while on duty in Vietnam.

The Agent Orange Act of 1991 established procedures that the Department of Veterans Affairs must follow in deciding whether to create presumptions of service connection for disabilities suffered by Vietnam veterans that may be associated with exposure to Agent Orange or other herbicides in Vietnam. The

procedure required that the Department of Veterans Affairs contract with the National Academy of Sciences' Institute of Medicine (IOM) to conduct reviews of the scientific literature on the health effects of exposure to TCDD, Agent Orange, and the other military herbicides (IOM 1994, 1996, 1998, 2000, 2002, 2004, 2006). In accordance with their findings, the Department prepared a list of conditions of disabilities that were "presumed" to be associated with herbicide exposure. For those veterans who served in Vietnam between 9 January 1962 and 7 May 1975, and have one or more of 11 diseases (on the current list), the Department must presume that they were exposed to herbicides and their disease service connected (Young 2002; DVA 2007).

Since the implementation of the Agent Orange Act in 1991, research has continued on the examination of historical military documents, procurement records, and on environmental fate and human studies (Young 2006; Hofmann and Wendelborn 2007; Hatfield Consultants 2007; Cecil and Young 2008). These studies have provided additional understanding of potential human exposure, and the environmental fate and impact of the use of tactical herbicides and TCDD in Vietnam. However, neither the various governments nor the scientific community have been able to resolve the numerous controversies involving the War in Vietnam, including the use of tactical herbicides. In part this may be due to the fact that the Agent Orange Controversy is really an issue that strikes at the fundamental concept of "quality of life"; and hence, science alone cannot resolve the controversy (Palmer 2004; Young 2008). Many veterans of the War returned from Vietnam with apprehensions that were manifested by fear of the unknown about how they were going to re-adjust back into a society that was rapidly changing in its social and economic values (Young 2008). Vietnam and Agent Orange are now public policy issues as well as medical and scientific issues. There are strong public policies favoring our veterans, and rightly so. The government should have acknowledged that many Vietnam veterans do appear to be at risk for a range of diseases and health problems due to the 'Vietnam experience' as a whole. Why focus on Agent Orange instead of on providing treatment and benefit for all these veterans? In hindsight, the government could have been fairer and more generous to all Vietnam veterans with such a program (Young 2004).

1.5 The Return to Vietnam

More than 30 years after its last use by American forces in South Vietnam, the controversy has now shifted primarily to delineating the potential impacts of Agent Orange and dioxin on the environment and people of Vietnam. From 3 to 6 March 2002, a joint United States-Vietnam Scientific Conference on Human Health and Environmental Effects of Agent Orange/Dioxins was held in Hanoi. It was co-sponsored by the US National Institute for Environmental Health Sciences (NIEHS) and the Vietnamese Ministry of Science, Technology, and

the Environment (NIEHS 2002; Young 2002). The conference was organized under the auspices of the joint United States-Vietnam Cooperative Research Program on the Health and Environmental Effects of Agent Orange and Dioxin. Experts from throughout the world were invited to attend the conference. The conference had three goals:

- Exchange current scientific information on the health and environmental effects of Agent Orange/dioxin;
- Exchange current scientific information on remediation measures to reduce exposures to Agent Orange/dioxins in humans and the environment; and,
- Examine the current state-of-knowledge and identify future research needs (NIEHS 2002).

Scientists from the NIEHS, US Environmental Protection Agency (EPA), US Centers for Disease Control and Prevention (CDC), and the Vietnamese Ministry of Health held discussions in conjunction with the conference. These discussions were designed to establish a process for guiding research and obtaining funding for studies focusing on human health outcomes from exposure to dioxin, and the environmental and ecological effects of dioxin and Agent Orange. Following the scientific conference and joint discussions, the Director of the NIEHS Division of Extramural Research and Training and the General Director of the National Environmental Agency of Vietnam signed a Memorandum of Understanding outlining a framework for research to guide future joint collaborations. In his comments about the Memorandum of Understanding that was signed by both the U.S. and Vietnamese governments, the Honorable Raymond Burghardt, US Ambassador to Vietnam, stated:

This agreement and the scientific conference that preceded it mark a new step forward in our relations with Vietnam. It is too soon to predict what the eventual benefits will be, but it is certain that Americans and Vietnamese working together in the pursuit of a common interest can achieve a great deal (NIEHS 2002).

The proposed framework envisioned the preparation and implementation of a broad-based research program that would be conducted in collaboration with Vietnamese and US scientists (Young 2002). However, following government-to-government discussions, the only project to be accepted and implemented by both parties was a project to investigate whether or not the former Tactical Herbicides Storage and Loading Sites in Southern Vietnam constituted a source of dioxin contamination to adjacent communities (Young and Andrews 2005). To initiate this project, the “1st Agent Orange and Dioxin Remediation Workshop” was held in Hanoi, Vietnam in August 2005, and a “2nd Agent Orange and Dioxin Remediation Workshop” was held in Hanoi in June 2007 (See Fig. 1.4) (Young and Andrews 2005; Young et al. 2008).

At the 2nd Workshop, the US Department of Defense presented to Vietnam’s Ministry of National Defence (MOD) a special Report prepared by the United States Department of Defense on “The History and Maps of the Former Tactical Herbicide Storage and Loading Sites in Vietnam” (Young and



Fig. 1.4 A Photograph of many of the participants who attended the Agent Orange Workshop in Hanoi, Vietnam on 19 June 2007 (Photograph courtesy of Vietnam's Ministry of National Defence)

Andrews 2006). The Report provided: (1) Detailed information on the quantities of tactical herbicides used or spilled in Southern Vietnam; (2) Detailed information on the types and quantities of dioxins in Herbicide Orange; (3) Maps of the Air Bases used in Operation RANCH HAND and Operation PACER IVY detailing the sites where loading, storage and re-drumming operations had occurred; and (4) An update on remediation and environmental studies. At the request of DOD, the MOD provided: (1) Detailed results from analytical studies conducted in and around Da Nang Air Field; (2) Results of studies on the detoxification of dioxin in soil by an active landfill bioreactor; and, (3) Research data on adsorption efficiency of activated carbon for PCDDs/PCDFs from aqueous solutions. After each presentation, thorough discussions occurred.

Environmental informatics and spatial analysis methods that link various data have been crucial to the integrated assessments for this project. The information and approaches developed to evaluate residual risks from past use of tactical herbicides project are relevant to other ongoing research and remediation activities in Vietnam and other countries. Those efforts include programs for managing environmental dioxins and furans from other sources and managing other persistent organic contaminants (Young et al. 2008). Additional details of the current programs between the US and Vietnam are covered in Chapter 8.

1.6 Methodological Issues in Assessing Impacts

The most intense use of Agent Orange in South Vietnam occurred in the years 1967–1969. That time period coincided with the highest level of combat operations involving US ground forces. At that time, it was not possible for members of the scientific community to conduct thorough scientific field investigations at the sites where herbicides had been repeatedly sprayed, or even at bases where the herbicide operations originated (NRC 1974). Studies initiated under the auspices of the NAS starting in 1971, confronted these difficulties (NRC 1974). Indeed, in the 1974 letter transmitting the final NAS report to the Secretary of Defense and the US Congress, Dr. Phillip Handler, the President of the NAS at the time, noted:

As we entered upon the task, some of its inherent difficulties were self-evident: appraisal of the effects of herbicide usage, necessarily, had to be taken well after the fact. Since the war in South Vietnam was certainly not conducted as a controlled experiment, valid conclusions might well be seriously constrained by the complexity of actual circumstances, by lack of adequate records or qualified observers on the scene at the time of the spraying program . . . separation of the effects of herbicides from all other aspects of the war would be difficult at best (NRC 1974).

Public discussion and scientific research have proceeded largely on the assumption, rather than a determination, of widespread substantial exposure to tactical herbicides and the associated dioxin to US and Allied Combat Forces and Vietnamese civilians during the Vietnam War. Does sufficient knowledge about the environmental fate of tactical herbicides and dioxin support the conclusion that allied ground troops and Vietnamese civilians could have been contaminated, if not by direct exposure, perhaps by entering previously sprayed areas (Young et al. 2004b)?

To address this question, a recent critical review was published on: “Environmental Fate and Bioavailability of Agent Orange and Its Associated Dioxin During the Vietnam War” (Young et al. 2004b). The findings were summarized:

In-depth evaluations of the spray systems used to disseminate tactical herbicides in Vietnam showed that they were capable of highly precise applications both in terms of concentrations sprayed and area treated. Research on tropical forest canopies with leaf area indices (a measure of foliage density) from 2 to 5 indicated that the amount of herbicide and associated TCDD reaching the forest floor would have been between 1 and 6% of the total aerial spray. Studies of the properties of plant surface waxes of the cuticle layer suggested that Agent Orange, including the TCDD, would have dried (i.e., be absorbed into the wax layer of the plant cuticle) upon spraying within minutes and could not be physically dislodged. Studies of Herbicide Orange and the associated TCDD on both leaf and soil surfaces have demonstrated that photolysis by sunlight would have rapidly decreased the concentration of TCDD, and this process continued in shade. Studies of “dislodgeable foliar residues” (the fraction of a substance that is available for skin uptake from plant leaves) showed that only 8 percent was present 1 hour after application, and this dropped to 1 percent of the total, 24 hours after application. Studies with human volunteers confirmed that after 2 hours of saturated contact with bare skin, only 0.15–0.46 percent of 2,4,5-T entered the body and was eliminated in the urine. Moreover, serum TCDD levels in veterans claiming direct exposure to Agent Orange while conducting combat operations were no different than of veterans who never served in Vietnam (Young et al. 2004b).