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The Role of Botanists during World War II in the Pacific Theatre[1]

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1. The following material has been assembled from personal experiences, recollections and records (pers. recoll.), and through recent correspondence (pers. comm., dated) and telephone calls or interviews (pers. conv.) with botanical colleagues who were graduate students or professional botanists at the beginning of World War II and who served their country in various ways. The majority of the data pertains to United States citizens, but some information is supplied regarding Canadian, New Zealand, Australian, Dutch, and British botanists and their activities. This subject matter will be retained as an open file to be on deposit at the library of the Arnold Arboretum, Harvard University, 22 Divinity Ave., Cambridge, MA 02138 USA. Any additions or corrections will be appreciated.

I. Abstract

During World War II some professional botanists and graduate students who were drafted, enlisted, or commissioned in the armed forces were fortunate to be able to use their training directly or indirectly. This was especially true for the Pacific theatre. Others served their country as civilians. The roles of botanists in the military ranged from teaching or research to participation in combat or support operations. A few botanists in uniform, in spite of their occupational obligations, were able to collect botanical specimens and were encouraged to do so by civilian museum personnel. The best known projects for botanists as civilians involved the search for native supplies of strategic raw materials, particularly *Cinchona* and *Hevea,* while *Cryptostegia* and

Guayule, as possible sources of latex, were grown on plantations and studied in detail.

Tropical problems of fungal deterioration of fabrics and optical equipment involved primarily civilian botanists in both military and academic laboratories. Some older botanists and those deferred for marital, dependent, or physical reasons served as instructors in regular academic programs or the special college programs for military personnel.

This paper is a summary of the contributions of botanists from the United States, Canada, Australia, and New Zealand to the war effort in the Pacific theatre during World War II.

Resumen

Durante la Segunda Guerra Mundial algunos botánicos profesionales y estudiantes graduados que fueron reclutados, enlistados, o comisionados en las fuerzas armadas fueron afortunados en poder utilizar su entrenamiento directamente o indirectamente. Esto fue especialmente cierto en el teatro del Pacífico. Otros sirvieron a su país como civiles. El papel de botánicos en las fuerzas militares incluyó desde la enseñanza o la investigación hasta la participación en combates o en operaciones de apoyo. Unos pocos botánicos uniformados, a pesar de sus obligaciones militares, pudieron colectar espécimenes botánicos y fueron alentados a hacerlo por las autoridades civiles de museos. Los proyectos mejor conocidos de botánicos trabajando como civiles involucraron la búsqueda de fuentes nativas de materias primas estratégicas, particularmente *Cinchona* y *Hevea*, mientras que *Cryptostegia* y guayule, posibles fuentes de látex, fueron cultivados en plantaciones y estudiados detalladamente.

Problemas con el deterioro por hongos de telas e instrumentos ópticos en los trópicos involucraron principalmente botánicos civiles tanto en laboratorios académicos como militares. Algunos botánicos de mayor edad y aquellos diferidos por razones de estado marital, por tener dependientes, o por razones físicas sirvieron como instructores en programas académicos regulares o en programas universitarios especiales para personal militar. Este trabajo es un sumario de las contribuciones de botánicos de América, Canadá, Australia, y Nueva Zelandia a la guerra en el teatro del Pacífico durante la Segunda Guerra Mundial.

II. Introduction

CHRONOLOGY OF WORLD WAR II, PRIMARILY FOR THE PACIFIC THEATRE

1941 7–8 December. Japanese attack Pearl Harbor from aircraft carriers, attack bases in the Philippines by air from Formosa, and attack Thailand and Malaysia by land.
8 December. Congress votes a Declaration of War against Japan and Germany.
10–26 December. Japanese troops land in the Philippines.
23 December. First U.S. forces, those on Wake Island, surrender to the Japanese invasion.

1942 4 January. First Japanese air attacks on Rabaul, New Britain, followed by invasion 23 January.
6–11 January. Japanese occupy many islands of the Netherlands Indies.
15 February. Fall of Singapore.

19 February. Japanese attack Darwin in Australia.
28 February. Japanese forces land in Java.
17 March. General MacArthur escapes from the Philippines and lands in Australia.
9 April. U.S. forces on Bataan surrender.
5–8 May. Sea–air battle of Coral Sea.
6 May. U.S. forces at Corregidor surrender.
4–6 June. Naval battle at Midway.
7 June. Japanese occupy Aleutian Islands of Attu and Kiska.
4 July. U.S. air forces replace Flying Tigers Volunteers in Burma theatre.
6 July. Japanese construct air base on Guadalcanal and begin to reinforce garrison there.
21 July. Japanese forces land in Gona area, Papua/New Guinea.
7 August. U.S. First Marine Division lands on Guadalcanal. Japanese continue to reinforce their troops; battles continue until the decisive campaign on 21 February 1943.
8–9 August. Battle of Savo Island.
25–26 August. Japanese forces land at Milne Bay.
17 September. Japanese drive over Owen Stanley Mts. in New Guinea; halted by Australians near Wau.
8 November. U.S. and British forces invade French Morocco to start African campaign. German and Italian forces in North Africa surrender 13 May, 1943.
19 November. U.S. attack against Japanese begins at Buna.

1943 22 January. Organized Japanese resistance ends in Papua.
2–5 March. Battle of Bismarck Sea.
6 June. Operation Overlord, the invasion of Europe, begins.
29–30 June. United States begins landings in central Solomon Islands.
5 September. U.S. 503rd Parachute Regiment jumps into Markham Valley above Lae.
1 November. U.S. Marines are landed on Bougainville.
20 November. U.S. forces capture and occupy the Gilbert Islands.
15 December. U.S. cavalry RCT is landed on southwest coast of New Britain.

1944 31 January. U.S. forces land on Kwajalein in the Marshall Islands.
8–9 May. Surrender of German forces in Europe. VE Day.
27 May. U.S. forces land on Biak Island.
15 June. U.S. forces attack Saipan in Marianas.
21 July. Invasion of Guam is begun by U.S. forces.
24 July. Attacks on Tinian begin.
15 September. Attacks on Morotai begin.
17–20 October. U.S. Sixth Army invades Leyte in the Philippines.
15 December. Invasion of Luzon begins.

1945 12–25 January. U.S. Third Fleet attacks Indochina coast, Formosa, Hong Kong, Canton, Hainan, and the Ryukyus.
3 February. U.S. forces reach Manila.
15 February. Bataan and Corregidor secured by U.S. and Philippine forces.
10 March. First U.S. landings on southwest Mindanao.
19 February. U.S. Marines begin landings on Iwo Jima.
26 March. United States begins assault on Okinawa.

April-May. U.S. and Australian forces secure Hollandia section of New Guinea.
1 May. Australian forces begin assault on Borneo and Brunei.
July. Allied carrier- and land-based aircraft bomb Japanese islands, supported by naval bombardment.
27 July. Allies issue ultimatum to Japan for immediate and unconditional surrender. Japan refuses.
6 August. Atomic bomb is dropped on Hiroshima.
14 August. Japan surrenders. VJ Day.
17 August. Republic of Indonesia proclaimed.

With the war raging in Europe, the Burke–Wadsworth Selective Service and Training legislation was passed by the U.S. Congress in 1940. It mandated the registration of men between the ages of 21 and 35 for subsequent drafting into the armed forces.

At the beginning of the U.S. involvement in the war in Africa and the troop buildup in Great Britain, few American college students who had majors in botany or biology were involved in the Reserve Officer Training Corps (ROTC) programs that would have given them specific assignments and roles in the service. Yet all of them faced the possibility of being drafted into an unknown role in the Army or the Navy by the Selective Service System. Exemptions were made for those married with family, those working in essential industry (including agriculture), those aged forty or above, and those physically or mentally disqualified. These exemptions applied to few students, but they did occasionally apply to young and old faculty members.

College students in general could be admitted to officer training programs and temporarily avoid the draft, but they still had no assurance that their education in biological science would carry any weight in a military assignment. A college student could often transfer his registration from his home town to a local draft board in his college town. Some of these were sympathetic, permitting deferment until an academic year was completed or a degree received. This gave the potential draftee a chance to enroll in an officer training program or find deferrable employment, but such action was out of favor with a draft board needing to produce a quota of draftees (Powell, pers. comm., 1992). Other local draft boards seemed prone to draft college students with out-of-town residences before selecting the local people. Home town draft boards were often less sympathetic to deferments for students in distant colleges. If the advanced student of biology or the young staff member with a degree in biology could find employment in a defense industry, he would often obtain a draft deferment. Some were able to find deferrable employment in special projects created by wartime commissions, where their talents could be employed for the national benefit (Bonner, pers. comm., 1992). In the missions to locate sources of quinine and rubber in the wilds of South America, selection of botanists was originally limited to men over 35 years of age. When it was shown that the strenuous field work required younger individuals, that age restriction was removed (Steere, 1992a).

What, then, did prove to be the role of botanists during World War II?

The older college teachers, especially those with families, were permitted to stay at home and continue their teaching. Most colleges had special programs, such as the Navy V-5 and V-8, or special classes for all of the military services. Professors often had heavy teaching loads in day, evening, and weekend classes. Often they were required to teach subjects unfamiliar to them or to organize new and special topics

(Billings, pers. comm., 1993; Cheadle, pers. comm., 1992; Sharp, pers. comm., 1992; J.W. Thomson, pers. comm., 1993). One taught special science courses for the rehabilitation of returning soldiers who had lost their sight (Nichols, pers. comm., 1993). Laboratories were also diverted to investigate problems of military significance. Research was often "classified" and conducted behind locked doors in patterns unfamiliar to the professor (Patt, pers. comm., 1992; Swanson, pers. comm., 1992; Tindale, pers. comm., 1993). Sharing information was restricted if the investigation was classified (Patt, pers. comm., 1992). Often, publication of research results had to be approved by supervisors or censors, or was even delayed until long after the war ended (Johnston, 1949). Those biologists who stayed at home and taught or did directed research made their own unrecognized or unappreciated contribution to the war effort.

Some botanists, in school or training when drafted, ended up serving in combat units in the Army and the Army Air Force, the Navy, or the Marines (Benninghoff, pers. comm., 1992; Clark, pers. comm., 1992; Correll, pers. comm., 1992; Cowan, pers. comm., 1992; Creech, pers. comm., 1992; Ellis, pers. comm., 1993; Moran, 1945; Powell, pers. comm., 1992; Thorne, pers. comm., 1992; Wood, pers. comm., 1992). One was assigned to a destroyer as Officer of the Deck and took part in the invasion of North Africa, had North Atlantic convoy duty, and participated in the invasion of Sicily and then the Pacific campaigns at New Guinea, Okinawa, the Philippines, and Japan (Powell, pers. comm., 1992). A few were killed (Beasely, pers. comm., 1992; Davis, pers. comm., 1993; Leavenworth ex Hillemann, pers. comm., 1993), and some are still listed as missing in action (Heintzelman, pers. comm., 1992).

At the first base to which the draftee was assigned he was subjected to a barrage of tests—I.Q., aptitude, physical, etc.—before he continued on to a basic training program. Those selected for further training or schooling may have had successive assignments to various programs. In my own case, although I had a new Ph.D. degree, I was denied a commission in the Navy because of my height. Others I know were denied such appointments for reasons of weight or vision (Constance, pers. comm., 1991; Soper, pers. comm., 1992). The Army, however, accepted me as a draftee for basic training, and then I waited three weeks in the induction camp at Fort Devens, Massachusetts, until shoes of my size could be procured. When an interviewer in the admission process learned that I had some experience in laboratory work, I was assigned to medical basic training at Camp Pickett, Virginia, where I practiced carrying a litter and giving first aid under simulated combat conditions. Because I excelled in this, my assignment was further training at Lawson General Hospital, a general military hospital near Atlanta, Georgia, where I was to become a laboratory technician. However, the simple procedures and chemistry being taught were familiar to me, and I spent my time repairing or adjusting microscopes, sharpening microtome knives, and, for a while, working as a technical assistant in the hospital morgue embedding and sectioning specimens of tissues for analysis. When my class graduated from the laboratory technician program, I received a certificate as so qualified, but I was assigned to a blood fractionation laboratory at Walter Reed Hospital in Washington, D.C. So far, each instructor had assured the class that the occupation and skills we were learning would make us employable in civilian life after the war.

My career as a blood technician never began, as my orders were changed and I was assigned to take the course in aviation physiology at the School of Aviation Medicine

at Randolph Field, Texas. I was uncomfortable as the only enlisted man in the class of officers, mostly physiologists with M.D. or Ph.D. degrees. Even though some of my classmates had recently been fellow graduate students with me, there was, in the Army, a class distinction between the officers and the enlisted men. Upon completion of the course, I continued at that base as an aviation physiologist. Eventually I received a direct commission as Second Lieutenant and continued briefly as an aviation physiologist before becoming a Personal Equipment Officer and, finally, a Survival Specialist. Each of these assignments represented an area of military service where specialization, training, or talents as a biologist were used.

However, not all draftees were equally fortunate in assignments. One highly qualified senior plant taxonomist was drafted one month before he would reach the exempt age of 40 (Kobuski, pers. recoll.). After basic training, he was classified as a hospital orderly and assigned to a hospital ship in which he made 27 crossings of the Atlantic during the war years. Another, trained as a laboratory technician, became a specialist in venereal diseases and typhus, and then, with an assignment to a Naval medical hospital, a specialist in tropical diseases. Part of his service was on Guam and part in the Philippines, searching for the snail or rat or dog carcass which was a carrier of schistosomiasis (Glassman, pers. comm., 1992). A man with a Ph.D. in plant morphology was assigned to an environmental section of the Quartermaster Corps, where he was the subject individual who tested zippers, goggles, and clothing in the adverse weather of environmental chambers or in winter on the summit of Mt. Washington. Later the testing switched to desert materiel (Cross, pers. conv.).

The officer training programs also had a procedure of classification which, in theory, assigned new officers according to their education and training. The majority of biologists, as graduates of an Officer Training School, were used as navigators by the Army Air Force or as communications officers by the Navy (Thorne, pers. conv.). A few immediately or ultimately ended up as weather officers (Harkness, pers. comm., 1992; McCamey, pers. comm., 1992). Entomologists were used primarily in malaria study or control programs, but botanists were also used in this area, and one served in epidemiology in the African theater (Dethier, pers. comm., 1991; Parsons, pers. comm., 1991). A few botanists received special training in Japanese or other languages and had assignments in intelligence operations (Cody, 1985; Gillet, pers. comm., 1992; Grant, pers. comm., 1992; Kruckeberg, pers. comm., 1992). By contrast, a geneticist commissioned in the Navy served for months as an educational officer at a Naval hospital assisting the convalescents (Swanson, pers. comm., 1992).

III. Military Units That Used Botanists

A. THE ARCTIC, DESERT, TROPIC INFORMATION CENTER (ADTIC)

The Arctic, Desert, Tropic Information Center (ADTIC) may have been one of the first offices supplying general geographical and environmental information to all branches of the military. It was established in 1942 by order of the Joint Chiefs of Staff, who requested that an organization of experts on anthropology, geography, geology, and allied sciences be created in order to supply technical and intelligence information on the nontemperate regions of the world. A group of thirty scientists was selected, most of whom were commissioned as officers of the Army Air Force.

ADTIC was first set up at Eglin Field, Florida, in November 1942. It was then moved to Broad Street in New York City, where much use was made of the facilities of the

New York Public Library and the American Museum of Natural History. In 1943 ADTIC was moved again, this time to Orlando, Florida, as part of the School of Applied Tactics, with the arctic section in Minneapolis, Minnesota (Cooper et al., 1990; Eklund, pers. recoll.; Sutton, pers. recoll.; Weber, pers. comm., 1992). The organization prepared information on routes or areas of military interest in the form of flight data sheets and water or land surveys (Anon., 1944f). General information, from climate and weather data to the attitudes and foods of native inhabitants, was made available in printed form. ADTIC produced some of the early survival pamphlets and training films (Anon., 1943g, 1943h, 1944d, 1944e, undated). All articles were published without authorship and varied considerably in quality. After the war ADTIC moved to the Air University, Maxwell Air Force Base, Alabama. It was disbanded in late 1945 and reactivated in 1947 as the Environmental Information Division. Its library, administrative and historical records, and most of its publications are available in Alabama (Laseter, pers. comm., 1991; Wise, 1990). Much of the instructional activity of ADTIC is today carried on at the Survival School at Fairchild AFB in the state of Washington.

B. AVIATION PHYSIOLOGY PROGRAM

The School of Aviation Medicine (SAM) at Randolph Field, Texas, was concerned with the medical problems of flying even before the beginning of World War II. With the need for more pilots and crews and the development of flight training bases in Texas, the SAM expanded its programs to training physicians in flight medicine (flight surgeons) and offering refresher courses to medical doctors from overseas bases. The Aviation Physiology part of this curriculum was organized by Randolph Lovelace, M.D., and Detlev Bronk, Ph.D., authorized by a directive from the Air Surgeon's office in June 1942. The first class was held from 6 July through 8 August 1942. As was stated in the *Aviation Physiologists Bulletin*,

> *The procurement of personnel for its operation became an important problem. The employment of medical officers was an obvious solution, but there were two objections. It was assumed that medical officers would be more interested in the practice of their profession than in the mere physiological aspects of the program. It was furthermore recognized that the urgent need for officers qualified for the practice of medicine would ultimately preclude the use of such personnel for duty if others not qualified for medical practice were available. It was accordingly decided to recruit officers with a broad training in the physiological sciences who had completed the requirement for the degree of Doctor of Philosophy. From the outset it was realized that the success of this pioneer undertaking would depend less on formal direction and more on the selection of personnel with a broad scientific training, versatile adaptability, and suitable personalities. The choice of personnel has accordingly been made only after the most careful examination of each applicant's personal and professional qualifications, based on a careful evaluation of the opinions of outstanding scientists familiar with the applicant. . . . There was thus initiated for the first time in the history of this country—probably of the world—formal recognition and classification of physiologists as being professionally qualified for specific duties in military aviation.* (Aviation Physiologists Bulletin, *1943, 2–3)*

Subsequently, medical officers and physiologists from medical schools and from departments of biology were recruited, but occasionally people with majors other than physiology were included (Grobstein, pers. comm., 1992; R.A. Howard, pers. recoll.; Masland, pers. comm., 1992; Wigodsky, pers. conv.). One geneticist with ability in statistics arrived weeks early for a scheduled class and was co-opted into a statistics section (Greene, pers. comm., 1992). Those with Ph.D. degrees were commissioned, while those with M.A. degrees or less remained in non-commissioned or enlisted ranks (Akers, pers. conv.). Eventually a few physiologists were commissioned and assigned directly, avoiding the training program at Randolph Field (Patt, pers. comm., 1992).

By the end of 1943, there were 45 physiological training units operating 60 altitude-simulation chambers. There were 90 M.D. and 134 Ph.D. physiology instructors. The indoctrination they gave students ranged from a consideration of the proper foods for flight crews, the proper flying clothing, the proper use of oxygen masks and bail-out equipment, and factors of night vision to protection against g-forces (Sheffield & Stork, 1990). Simulation of the conditions of high altitude was created in a hypobaric chamber (then called simply a low-pressure chamber). Students were trained to operate the chambers and taught how to fit oxygen masks and then test for proper fit. Cadets from neighboring air fields were shown the equipment, outfitted, and then taken in a pressure chamber "ride" to a simulated high altitude, usually 38,000 feet, for a demonstration of anoxia and its effects on performance. Cadets were screened simultaneously for sensitivity to anoxia (hypoxia), for claustrophobia, and for altitude and motion sickness. Eventually the program expanded to become an adjunct of the Personal Equipment Officer program (q.v.). Graduates of the Aviation Physiology Program had the MOS 3327 and operated similar programs at various air bases in the United States (Hecht, pers. comm., 1992; Llano, pers. comm., 1992; Zinn, pers. conv.). A roster of the graduates of the Aviation Physiology Program was published in the *Aviation Physiology Bulletin* in 1945.

The U.S. Navy, under Naval Aviation Medicine, also operated pressure chambers for training aviation cadets and crews in flight physiology, use of oxygen equipment, flight safety, and so forth. Instruction was given at bases at Pensacola, Florida, and San Diego, California (Shelesnyak, pers. comm., 1992).

The *Aviation Physiologists Bulletin* was issued, in mimeographed format, by the Air Surgeon's Office, with ten numbers appearing in 1944 and 1945. The first number stated, "Recognizing the pioneer character of the Altitude Training Program, it has been deemed desirable to provide a suitable medium for the dissemination of information among those engaged in its operation." Aviation physiologists were encouraged to submit notes and articles "out of channels" for publication. In 1945, regular publication ceased and supplements to the *Aviation physiologists Bulletin* were issued for a short period (Sherman, pers. comm., 1993).

C. BIOLOGICAL WARFARE

Research programs in biological warfare were conducted at Camp Dietrich, Maryland, with civilian staff as well as biologists in uniform. Information on the full program is still difficult to obtain. "C" division of the base was the plant division, headed by a plant biochemist. A cytogeneticist and other plant physiologists studied the herbicidal effects of growth hormones or growth-controlling substances on various food plants. The ultimate goal was the destruction of enemy crops or agriculture by

aerial spraying with "weed killer" hormones, fungi, or other plant pathogens (Page, pers. comm., 1992; Swanson, pers. comm., 1992). These herbicides were never used, and the scientific results of the studies were published after the end of the war in the *Botanical Gazette* (Swanson, 1946; Swanson et al., 1946).

The use of growth hormones or weed killers as defoliating agents was also developed within the general program. Experimental use of aerial-delivered defoliants, the predecessors of Agent Orange, were tried on the vegetation of San José Island, Panama (Johnston, pers. recoll.; see also Civilian Defoliation Program).

Another section of "C" division dealt with wheat rusts. The plan was to assemble large quantities of spores and use them in aerial spraying of enemy wheat fields for the subsequent destruction of their crops (Swanson, pers. comm., 1992). In a comparable way, plant pathogens of rice were improved for use against Japanese agriculture (Mills, pers. comm., 1992). They were never used.

D. PERSONAL EQUIPMENT OFFICER

Early in its operations in the European theater, the Eighth Air Force recognized the need for one person at various administrative levels, from group to squadron or higher, to be responsible for the equipment for flying personnel. The position of Personal Equipment Officer was created by the directive AAF 55-7, 28 October 1943, "to supervise, maintain, and care for all personal and protective equipment and to train aircrews in the use of all such equipment and related procedures. These include parachute maneuvers, air–sea rescue search, and the fundamentals of survival operations." The Personal Equipment Officer replaced the miscellaneous designations of "Unit Oxygen Officer," "Land Rescue Officer," or "Jungle Training Officer" used by various commands. The fundamental training was conducted at the School of Applied Tactics at Orlando Air Force Base, Florida (Anon., 1944a; Dohrman, pers. recoll.; McGavic, pers. recoll.). A fairly large number of enlisted and officer personnel with botanical or biological study backgrounds served as Personal Equipment Officers and their assistants. Several, in fact, earned commendations for their suggestions on the improvement of equipment or the need for specific items (R.A. Howard, pers. recoll.).

E. SURVIVAL TRAINING PROGRAMS

The mandate to Personal Equipment Officers to "train aircrews in . . . the fundamentals of survival operations" soon became their major role. Air crews wanted the information, and the information was reasonably easy to teach. Special publications, training programs, and, eventually, recognized roles followed.

A Basic Field Manual entitled *Jungle Warfare* (FM 31-20) was issued 15 December 1941. It contained five pages of information, without illustrations, on poisonous jungle plants and trees and eleven pages on poisonous jungle snakes, venomous jungle insects, and wild jungle animals, again without illustrations. FM 31-20 was reprinted with slight revisions in three issues of 1942. It was then replaced by the War Department Field Manual FM 72-20 of 27 October 1944, also entitled *Jungle Warfare.* Native plants, both edible and poisonous, were illustrated, but information on poisonous animals was omitted. The authors and artists are unknown.

The first manual during the war years to consider the role of plants in survival was the booklet *Edible, Poisonous, and Medicinal Plants of Central America,* by Army

Captain A.B. Godshall, published in 1942 by the Panama Canal authorities. Simultaneously, Paul Allen of the Missouri Botanical Garden staff prepared a paper on the poisonous and injurious plants of Panama which was published in 1943 (Allen, 1943). It is not known if these projects were independent of each other. As E.D. Merrill of the Arnold Arboretum, Harvard University, commented, "After its [the Godshall volume's] appearance, twenty-one different individuals and agencies representing various branches of service commenced preparing something for the benefit of servicemen. There was no coordination of effort, and too frequently individuals with no knowledge of the subject and no tropical experience were assigned tasks of compiling data. Because of this confusion, a meeting of representatives of various services was called under the auspices of the National Research Council in September, 1942" (Merrill, 1945a). On 15 September 1942, E.D. Merrill began his assignment, the preparation of TM 10-420, *Edible and Poisonous Plants of Islands of the Pacific.* Copy was completed 1 January 1943 and published 15 April 1943. The illustrations were prepared by Gordon Dillon, and were subsequently copied in many other survival publications.

In a memo, Merrill reported that photographs of five of the plates were sent to General Douglas McArthur for his criticisms. There is no indication of a reply (Merrill, pers. comm., undated). There is, in the Walker papers in the Smithsonian Institution Archives, an extensive correspondence between Merrill and Walker regarding the development and content of survival manuals. At one stage, a list of the plants to be considered as edible or poisonous was a document classified as secret (Walker to Merrill, 10/26/42, 12/1/42, 12/15/42, 12/27/42; Merrill to Walker, 10/29/42, undated memo probably in early December 1942, 12/11/42, 12/21/42, 1/6/43).

P.C. Standley and B.F. Dahlgren of the Field Museum of Natural History, Chicago, were assigned the arctic, subarctic, and American tropics. *Edible Plants of the Arctic Region* was issued by the Navy Bureau of Medicine and Surgery in 1943, credited to Paul C. Standley. *Edible and Poisonous Plants of the Caribbean*, written by Dahlgren and Standley, was published by the Navy in 1944. *Survival on Land and Sea* was prepared for the U.S. Navy by the Ethnogeographic Board and the Staff of the Smithsonian Institution, with contributions by the Bureau of Aeronautics and the Bureau of Medicine and Surgery, in 1944.

Probably the first teaching of survival principles in World War II was done in Hawaii, immediately after the attack on Pearl Harbor, by Kenneth Emory of the Bishop Museum, a civilian, in informal lectures and demonstrations for transient military personnel (Emory, 1943a, 1943b, 1943c; Takeuchi, 1992). This eventually developed into a formal lecture and presentation at the museum. A Jungle Training School was started in the Kahana Valley on Oahu, and later an advanced survival training camp was established by the museum staff on Espiritu Sanctu, which was the headquarters for General MacArthur's re-invasion of the Philippines (Krauss, 1988).

The Navy survival training program began in 1943 as a part of the instruction in the preflight school in the Naval Aviation Physical Training Program, patterned after some lecture/demonstrations given at the University of Michigan. A program for instructors began with training at Chapel Hill, North Carolina, for land survival; continued at the Naval Air Station at Pensacola, Florida, with information on water survival; and was completed with a section on tropical survival in Miami at Chapman Field, the U.S.D.A. Plant Introduction Station (Craighead, pers. comm., 1991, R.A. Howard, pers. recoll.). Other instruction was given subsequently at Jacksonville,

Florida; Corpus Christi, Texas; overseas in Panama, Brazil, and the Galapagos Islands; as well as Hawaii and Guam. Survival training museums were developed at Jacksonville and Pensacola. The manual *How to Survive on Land and Sea* was published by the Aviation Training Division of the U.S. Navy through the U.S. Naval Institute, Annapolis, Maryland, in 1943. Although published without credits, the volume was written by John and Frank Craighead (Craighead, pers. comm., 1992; Craighead & Craighead, 1984.)

The Navy reorganized its survival training program in January 1945, appointing a Staff Survival Training Officer for each fleet and noting that "duplication of instruction by medical officers, physical maintenance officers, and aviation equipment officers has resulted in loss of time."

For the Air Force, instruction in the use of native foods was requested in 1943 at the School of Aviation Medicine at Randolph Field, Texas, by flight surgeons and medical flying officers returning from Pacific island bases. This led to lectures on general survival education and became a course in the Personal Equipment Officer program, which was transferred in 1944 to the Aero-Medical Department of the School of Applied Tactics in Orlando, Florida (AFSAT). It was soon established as an independent section, the Jungle Survival Training Program, under the supervision of Lt. Richard A. Howard. Indoctrination instruction was given to visiting general officers; a regular, three-week course was offered for survival officers; a detailed training program was designed for crews scheduled for special missions (especially B–29 crews); and all Personal Equipment Officers received survival training. The three-week program involved a week-long field exercise in living off the land, and this was coordinated with equipment testing (Anon., 1945b, 1945c; Field, 1944; R.A. Howard, pers. recoll.; Shallett, 1945). The AFSAT program also developed a museum, including a garden and a zoo for casual training.

An Arctic training school was opened at Buckley Field, Denver, Colorado, designed to teach men how to live under conditions of extreme cold. A later program operated at Lowry Air Force Base, Colorado, and field exercises were held at Berthod Pass, Colorado (Weaver, pers. comm., 1993). It was later operated at Echo Lake and expanded to include the rescue squadrons of the Alaska command at Chip Lake, Canada. For a brief period, Portage Lake, west of Presque Isle, Maine, was used as an arctic training school (R.A. Howard, pers. recoll.). Records indicate that arctic survival training in association with air–sea rescue programs was conducted at Seattle and Port Angelus, Washington; Somerset, Nova Scotia; Sidney, Prince Edward Island, Canada; and in Labrador (Shelesnyak, pers. comm., 1992; Weaver, pers. comm., 1993). The aviation physiologist and staff of the Eleventh Air Force, with headquarters at Elmendorf Field, Alaska, operated a pressure chamber but also undertook arctic survival training. The program, Arctic Survival and Personal Equipment, involved field exercises simulating survival episodes in the Chugach Mountains, on the delta of the Knik River, and on adjacent glaciers (Wilber, 1944, 1946, 1957, 1959, pers. comm., 1992).

The Royal Canadian Air Force conducted survival training exercises for the Arctic beginning in 1944, and issued a pamphlet on ditching procedures.

In March of 1943, Military Training Pamphlet #9, *The Jungle Book,* was issued to personnel stationed in India by the British Army Staff. Another pamphlet, *Under the Greenwood Tree*, was issued by the Royal Air Force India specifically for operations in Burma. The pamphlet, *Food Is Where You Find It,* was written in 1943 by the staff

of the Auckland Museum in New Zealand, with principal credit to Dr. Lucy Cranwell (now Mrs. Watson Smith). It was requested by Colonel W.G. Farrell of the U.S. Marine Corps, operating on Guadalcanal, to meet the needs of his command, and proved to be so acceptable to the troops that copies were distributed to both American and ANZAC forces. The 13th Army Air Force requested ten thousand copies for that command. A special printing made for the British Army was used in Burma and used widely in the Pacific theatre (L.C. Smith, pers. comm., 1991). A fifth printing was issued in 1992, forty-eight years after the original issue (L.C. Smith, 1992). The Air Department in Wellington issued for the Royal New Zealand Air Force the booklet *Survival Hints for Aircrew, Pacific Area*, in 1945.

In 1944, the Australian Army Education Service issued the book, *Living Off the Land: A Manual of Bushcraft,* which was compiled from articles contributed to *Salt,* the Army education journal. The foreword is by Major General S.G. Savige, and the acknowledgments note the contribution of Mr. P.F. Morris, Senior Botanist at the National Herbarium in Victoria.

In 1945, a contingent of men recorded as the Australian "Jungle Craft Team" offered field instruction to troops of an air–sea rescue section of the U.S. Air Force in the southwest Pacific, apparently at Gusep Air Force Base, northwest of Lae in New Guinea. Details of the composition and operation of the team have not been located, although a syllabus of the training is preserved.

No information can be located concerning a "Jungle Environment Survival Training Unit" staffed by "negrito aborigine instructors" somewhere in the Philippines (Craighead & Craighead, 1984). New Zealand armed forces conducted a survival training program at the Trentham Military Camp near Wellington, another based at the Burnham Military Camp out of Christchurch, and a special training program in the Fiji Islands. Again, no specific details of curriculum or staff have been located, but Bevan (1992; pers. comm., 1993) cited one reference to the Fiji program in the history of the 37th Infantry Division and another in a letter from a U.S. serviceman from South Carolina. He wrote, "There was a jungle warfare/survival school staffed by a New Zealand cadre. I was selected to attend the ten-day course. As I recall, they really put us through the paces. I really think that they wanted to see what we were made of and just how much we could take. The training culminated in a two-day field exercise. This consisted of dropping you off in the bush with nothing but your weapon, ammunition, and field gear with a compass. You were given two days to get back to base camp.... We were loud in our praise for our instructor's competence and professional knowledge."

The selection of personnel to staff U.S. survival training cadres and rescue operations was difficult during the years of World War II. Professional biologists or those with degrees were not necessarily adept in tropical field work and living in remote areas. Individuals who had camping experience as Boy Scouts were added to those professing abilities in camping or hunting and fishing. Today, following the many years when field work for biologists has been supported by National Science Foundation grants, the selection of instructors with knowledge of field biology and the ability to present the problems of life and travel in remote areas is less difficult. After the war, the programs were continued in various areas by an air–sea rescue unit under the Military Air Transport Command or the Strategic Air Command.

Survival training today is offered by the Department of Defense in five SERE (Survival, Evasion, Resistance, Escape) programs. Two of these are under the Air

Force, with the headquarters unit adjacent to the Fairchild Air Force Base in Washington and a unit at the U.S. Air Force Academy in Colorado. A field training program for the Fairchild Air Force Survival School is conducted under simulated evasion conditions in the Colville National Forest (Weaver, pers. comm., 1993). Two programs are run by the U.S. Navy at Brunswick, Maine, and San Diego, California, while an Army program operates at Fort Bragg, North Carolina. An arctic training program is operated out of Eielson Air Force Base east of Fairbanks, Alaska. The water survival school at Homestead Air Force Base, Florida, was put out of commission by Hurricane Andrew in August 1992. The tropical survival school in Panama is no longer operating. The British, however, do run a tropical survival program in Belize (Kummerfeldt, pers. comm., 1992).

An AFSC classification of 121 XO (formerly Military Occupation Specialty) designation now exists for a career progression as an Air Force rescue and survival specialist. This is now independent of the Personal Equipment Officer position, which has the AFSC classification of 122 XO (Erickson, pers. conv.).

F. MEDICAL DEPARTMENTS

Draftees whose records included college work in laboratory technique and medically related subjects were occasionally selected for work in medical departments or units of the Army or the Navy. Some served in combat units, others were in combat field hospitals or base hospitals overseas, while some remained in the United States. Service ranged from field medic or hospital ship orderly to laboratory or surgical assistant or technician to medical specialist such as X-ray technician or pathologist (Belcher, pers. comm., 1993; Elliott, pers. comm., 1993; R.A. Howard, pers. recoll.; Kobuski, pers. recoll.). One mycologist worked in a clinical laboratory in a military hospital studying bacteria and fungi from individuals infected with "jungle rot" following overseas duty in the tropics (Beneke, pers. comm., 1993). A few were selected to be physiotherapists (Glassman, pers. comm., 1992).

The United States of America Typhus Commission, was established by executive order of President Roosevelt as a quasi-independent agency under the aegis of the Preventive Medicine Service of the Office of the Surgeon General, United States Army (Belcher, pers. comm., 1993). An outbreak of murine typhus was investigated in Egypt, but the major concern was the occurrence of rickettsial scrub typhus (tsutsugamushi disease or Japanese river fever) among the American and Australian troops in the Solomons and in New Guinea (Blake et al., 1945; Kohls et al., 1945). South Bat Island in the Purdy Group was abandoned for military purposes in mid-April 1944 when two-thirds of the military personnel got the disease within six weeks of their arrival (Philip & Kohls, 1945). There followed severe outbreaks in "Merrill's Marauders" in Central Burma area and among British troops in the area of Imphal, India, and in Central Burma (Mackie et al., 1946). The USATC India–Burma Field Party formed a "Botany Section" in June 1944 with a mission to sample the vegetation around infested camp sites and control areas for infected mites. There were also sections on mammology and entomology. A British typhus commission with A.A. Bullock of Kew as botanist had suggested the mites were confined to stands of elephant grass (Belcher, 1953). Drying plants in the monsoon was a problem. Army blanklets were cut into rectangles to be used as blotters in presses with Coleman stoves as sources of bottom heat in improvised drying cabinets. Gervasi E. Juan, a native of

Luzon in the Philippines, had collected for E.D. Merrill and was assigned to the typhus botany team and aided the collecting of specimens. The 3,000 numbers were sent to the Smithsonian (Walker, 1946) and shared with Merrill (Merrill, 1946a), but identifications were delayed for lack of data on locale. No official published reports of this work have been located. One new species was published from the collections (Belcher, pers. comm., 1993).

There is reference to "chigger work" by a Navy Medical Research Unit. Walker referred to 300 specimens sent to the Smithsonian by Walter L. Necker for identification in connection with this work. No other references have been located (Walker, 1945).

Malarial survey units, because of the severe and debilitating effects of malaria on troops in the southwest Pacific Islands, attempted to eradicate the mosquito vectors and to develop medicinal alternatives to quinine (Potts & Potts, 1985). The survey and control work was usually done by medical personnel, with entomologists and several botanists playing a major role. Much work was done by Australian and New Zealand medical staff (Dumbleton, 1952; Laird, pers. comm., 1992).

Nearly every member of the *Cinchona* missions and the *Hevea* search teams working in South America suffered from malaria or blackwater fever (Grant, 1986; Schultes, pers. comm., 1992; Seibert, pers. comm., 1991).

In Trinidad it was determined that the malarial mosquito bred in water in the rosettes of epiphytic Bromeliaceae. The bromeliads were identified by a taxonomist in the States (Smith, pers. comm., 1992), and a program of eradication by sprays removed all bromeliads, designated by botanists, for a considerable distance around the military bases (Downs & Pittendrigh, 1946).

G. FORESTRY UNITS

It was estimated that between 350 and 400 professional foresters, members of the Society of American Foresters, served in the Armed Forces (Anon., 1942d). At the beginning of World War II, individuals trained in forestry were in short supply and were deferred from military service by most draft boards. Students in forestry schools who had completed two years of satisfactory study were also deferred (Dana, 1943). The Navy required a college degree for a commission as ensign and military service in aerial map interpretation, and some forestry students were so involved. The Army granted commissions to graduates and to students with two years of satisfactory schooling to serve in the Air Force's Photo-Interpretation Units (Operational Intelligence) (Anon., 1942e).

In the early months of the war, military personnel in the Corps of Engineers or the Navy constructions battalions (Sea Bees) conducted all forestry operations. The first unit claimed to have been formed for the purpose of forestry operations was the 799th Engineer Forestry Company activated at Fort Lewis, Washington, in July 1942. The unit first served at Kodiak, Alaska, specifically on Afognak Island, producing lumber for military operations on Kiska and Attu. The company then served in France and Germany in 1944 and moved to Manila and North Mindanao in the Philippines in 1945, where it was disbanded (Glazebrook, 1946).

The 800th Engineer Forestry Company was considered the "guinea pig" company activated at the A.P. Hill Reservation in Virginia to be close for study by the Engineer Board. In 1943, this company was moved to Camp Claiborne, Louisiana, "for actual

lumber work" and was shipped overseas to North Africa and Italy in 1943 (Anon., 1945f).

A logging and milling operation was conducted by the Marine Engineers of the 4th Base Depot on the Russell Islands in the Solomon's group in 1943. Stoddard (1946) reported on their activities and on the trees cut and processed. Herbarium specimens and wood samples were sent to the Arnold Arboretum, and one specimen proved to be a new species, *Mastixiodendron stoddardii* (Merrill & Perry, 1946).

Camp Claiborne, near Alexandria, Louisiana, was the principal training site for the forestry engineering units utilizing the Evangeline unit of the Kisatchie National Forest. Units trained there served in the construction of a 305-mile-long sector of the Alaska highway (Clepper, 1944), in Italy, and in India (Knotts, 1983). A unit reported from the "South Pacific" has not been identified nor has the operational area for the engineer forestry companies 1388th to 1392nd (Klepper, 1944). The 797th Engineer Forestry Company comprised specially recruited regular Army personnel. They left Camp Claiborne on 8 November 1943 for Deolali, India, and then overland to their station cutting timber to build the Ledo Road into Burma—507 miles of log road with 165 bridges. The unit left Karachi in December 1945 to be disbanded at Camp Kilmer, New Jersey, in January 1946. E.D. Merrill commissioned the Indian botanists Chjatterejee and Biswa to collect plants along this newly created Ledo road (Walker, 1946 to Merrill).

Following the surrender of Japan and the occupation of the country, the Allied Powers created the Natural Resources Section on 2 October 1945 to correlate the needs and the use of the country's resources. A forestry division, one of the sections created, was responsible for forest resources, fuelwood, lumber, and allied products, as well as pulp and paper. Men and women still in uniform were transferred to the appropriate units but soon were replaced with civilians. The positions were considered choice assignments (Spillers, 1946). Knotts (1983), stated, "Today the only active forestry unit in the U.S. Army is the 457th Engineer Detachment, a reserve unit from Hurley, Wisconsin."

Three publications were prepared to aid forestry engineers in the Pacific theatre. "Notes on the Forests and Trees of the Central and Southwest Pacific Area" was a mimeographed publication of the Forest Service, United States Department of Agriculture. Requests for it were so frequent, it was distributed without revision or correction of the original typescript (Sparhawk, 1944).

Native Woods for Construction Purposes in the Western Pacific Region, written by J. H. Kraemer and published by the Bureau of Yards and Docks in May 1944, was issued in an amplified edition in September 1944 (Merrill, 1945b). Ninety-nine original illustrations for this publication were deposited in the Smithsonian Institution by the Navy Department in 1945.

Native Woods for Construction Purposes in the South China Sea Region, by J. H. Kraemer, was issued as NAVDOCKS P 163, January 1945.

For the important role of Australian botanists and foresters in northern Australia, New Guinea, and other South Pacific islands, see under "Collectors."

IV. Role of Civilian Botanists in War-Related Services

Agriculture, agronomy, food processing, horticulture, and the like represented areas in which biologists, in the broadest sense, made a contribution to the war effort. No

attempt is made here to list all roles played by men and women in these disciplines.

One unusual role occurred in Canada, where members of a Forage Division of the Department of Agriculture helped establish and maintain sod for landing strips at the many Air Training Stations being developed. Grass aerodromes were also used in Australia and New Zealand, and there, too, botanists were employed in developing and maintaining the sod landing strips (Anon., 1942c, 1976; Anstey, 1986).

Food production was most important for New Zealand, for there was need to supply civilian allies as well as troops in the European and the Asian theaters. Emergency rations for air crews involved developing methods of food concentration and dehydration (Mason, undated; Thomson, pers. comm., 1992). The early work on food preservation by using radiation was in military laboratories (Hyatt, pers. recoll.). In Australia, localized food production was especially important to supply troops en route to the combat areas on islands to the north. A program of the Australian Army Service Corps (AASC) Farms was developed under the supervision of a botanist from the Sydney Botanical Garden. The first farms in northern Australia were developed to supply troops passing through Darwin. Deep wells were dug to supply water for gardens in the area of Alice Springs. Later, gardens were established in New Guinea. In the highlands near Wau, coffee plantations were confiscated not only to supply coffee, primarily for passing American forces, but also vegetables for all armed forces. Vegetable seed was also produced and distributed to local native villages at Mt. Hagen, Goroka, and Chimbu, where the produce was grown for the armed services. As the war progressed, farms were developed near Moresby, Narakapor, Lae, Madang, Aitape, and Bulolo (Mair, pers. comm., 1993). The farms were classified and numbered; for example, the 6th Australian Farm Company consisted of a Headquarters Unit and eight platoons. Each platoon consisted of at least one "soldier specialist" (botanist) plus staff for general labor. Production of AASC Farms in 1944 included 1,257,662 pounds of vegetables, 83,530 pounds of fruit, 12,965 pounds of peanuts, and 11,006 pounds of coffee. The farms also supplied honey, chickens and eggs, and pork (Fairclough, 1962).

A. ARCTIC SURVEY TEAMS

The construction of an emergency Alaska Military Highway began in March, 1942, to supply bases in Pacific Canada and Alaska by land. It offered an opportunity to study the environment of the area not previously open to explorers (Correll, pers. recoll.; Merrill, 1943–1946; Raup, pers. conv.). Cooperation among botanists of the Arnold Arboretum, staff members of the National Museum of Canada, and the military authorities supported field studies which assembled collections of plants, animals, and data on the terrain. Since 1948 the highway has been known as the ALCAN Highway and has been driven by many tourists. A project determining the life history and control measures for the black fly, or biting fly, was begun by Canadian botanists during the war but continued in the years after, with little success.

B. CAMOUFLAGE PROJECTS

One committee established under the National Defense Research Committee was titled "camouflage" and chaired by a physicist from M.I.T. (Stewart, 1980). Its task was to find methods of disguising equipment and operations in the field. One free-lance ornithologist had a project designing patterns of camouflage for military

vehicles, utilizing his knowledge of bird plumage (McCamey, pers. comm., 1992), and another ornithologist, from the Smithsonian Institution, compiled a booklet on the natural history background of camouflage, examining ways plants and animals conceal themselves in nature (Friedman, 1942). A committee of botanists at Harvard University, in cooperation with the U.S. Army Engineering Board at Fort Belvoir, supplied lists of plants suitable for camouflage purposes. Two publications were based on experimental studies of methods of prolonging the life of cut branches from native and exotic species. The studies involved both temperate and tropical plant materials, the former using materials from the Arnold Arboretum in Jamaica Plain, Massachusetts, and the latter work done at the Plant Introduction Station of the U.S.D.A. near Miami, Florida (Anon, 1943a, 1943b). A lichenologist was particularly useful, since he was color blind and interpreted camouflage efforts in a different way (Llano, pers. comm., 1992).

A distinguished plant physiologist noted that military buildings were camouflaged by painting them green. The aerial photos used infrared film, and the chlorophyll of plants reflected in the infra red, so green paint showed up dark against the lighter background of trees and grass. An attempt was made to develop paint of a stabilized chlorophyll that wouldn't bleach out. They finally succeeded in getting one to withstand 24 hours of high-intensity imitation sunlight. The material was accepted, but the formula is still classified. Only the fact that the chlorophyll came from spinach can be revealed (Thimann, pers. comm., 1991).

Australian botanists were also engaged in projects to develop a camouflage for aerodromes using living plant material (Anon., 1942c).

C. DEFOLIATION PROJECTS

Areas of undisturbed tropical vegetation on San José Island, off the west coast of Panama, were surveyed by a botanist from the Arnold Arboretum to determine the composition and distribution of the cover (Merrill, 1946). The areas were sprayed from the air with defoliating agents by the Chemical Warfare Service and then reexamined botanically to determine the nature of reaction to the spray. The vegetation studies were published as *The Botany of San José Island (Gulf of Panama)* (Johnston, 1949). The nature of the defoliant and its action has not been published, and to our knowledge the island was never revisited in subsequent years to determine lasting effects of the defoliant.

In Canada, the control of poison ivy around military bases became a problem of major concern to the military and the Department of Agriculture. Maintenance crews for aircraft were affected by the poison ivy, often becoming hospital patients. The 2,4 D compounds proved effective defoliants leading to eradication of poison ivy, but were generally less satisfactory and less economical than ammonium sulphamate, known as Ammate (Anon., 1946b, 1946c).

D. FOREIGN ECONOMIC ADMINISTRATION (FEA) PROJECTS

The Foreign Economic Administration (FEA) was the successor to the Board of Economic Warfare and its predecessor, the Office of Economic Warfare. The FEA was a government wartime agency which had the responsibility for the accumulation of strategic materiel. Many botanists and foresters were involved. The two best-known projects involved sources and supplies of quinine and of rubber.

1. The Cinchona Missions

For the last half century preceding the outbreak of war in the Pacific, the island of Java had supplied, through plantation crops, 95% of the world's need for *Cinchona* bark. *Cinchona* is the source of quinine, and the plantations were owned and operated by Dutch growers and suppliers—the Kina Bureau. The high-yielding strains grown in Java had been procured from South America, primarily Bolivia, and carefully selected for their yields. When the Japanese invasion of the South Pacific Islands captured the *cinchona* plantations, the supply of quinine to the United States was disrupted. Lack of quinine to combat the effects of malaria was soon all too evident in the troops in the South Pacific (Caufield, 1985; Potts & Potts, 1985). It was suggested that bark from existing wild sources in South America be again collected (Camp, 1949; Core, 1951; Hodge, 1944, 1945, 1946, 1947, 1948a, 1948b, pers. comm., 1992; McComb, 1946; Rogers, 1944).

In June 1942, a proposal was sent to the War Department by H.H. Bartlett of the University of Michigan to send nine young people to South America to seek out wild sources of quinine (Crum, 1977; Jones, 1975). Shortly thereafter, a cinchona mission was established under the Board of Economic Warfare, with the cooperation of the Department of Agriculture and the National Arboretum. A botanist from the University of Michigan (W.C. Steere) and one from the Department of Agriculture (F.R. Fosberg) left Washington in October 1942 with two foresters (D. Winters, W. Silcocks), on a mission to locate supplies of quinine bark, supervise the harvest, obtain seeds for seed beds, and establish plantations for future harvest (Fosberg, 1945). Agreements had to be developed with each country to permit the search, harvest, and export of bark as well as seeds (Landrum, 1986). In the arrangement, the United States agreed to exclusive purchase of all bark with certain levels of total alkaloid and to the replacement of the harvested trees. The initial agreements were with Colombia and Ecuador. Agreements with Venezuela and Peru followed, but Bolivia refused to permit a U.S. quinine mission and continued its cooperation with the Dutch Kina Bureau.

The four significant alkaloids in cinchona bark—quinine, quinidine, cinchonine, and cinchonidine—occur in species of the genus *Cinchona* and in certain species of the related genera *Remijia* and *Ladenbergia.* All were to be tested.

The genus *Cinchona* has a natural distribution from southern Costa Rica and northern Panama through the Andes of Colombia, Venezuela, Ecuador, and Peru into Bolivia. The range is from sea level to the upper limits of tree growth at 11,000 feet. The species were not clearly recognized at that time. It was soon determined that there were variations in individual plants as to the location of the alkaloids as well as the type and amount. There was valuable "good bark" and valueless "bad bark." Color and taste tests often proved to be unreliable. The *Colombia Cinchona Manual* was prepared for the use of the 21 botanists who eventually joined the projects (Fosberg, 1944, 1945, 1947, pers. comm., 1991; Grant, 1986; Little, 1945; St. John, 1976). Although there was some regional harvest of bark in Colombia and Ecuador, the local people did not always recognize the plants and were no longer skilled at stripping the bark and processing it for shipment. Rivalry with local collectors, with land owners, and with other governmental agencies became disruptive and competitive (Drew, pers. comm., 1992; Grant, 1986; Steere, 1992a, pers. recoll., 1992b). The federal governments in South America had declared that all trees, wherever located, were federal property and so available for collection by the Cinchona Mission. The trees found near the trails or roads were soon collected, and much of the exploration extended into

remote areas. The work was arduous and in isolated, uninhabited areas. The botanists suffered from the altitude, wetness, malnutrition, malaria, and amoebic dysentery (Core, 1951; Drew, pers. comm., 1992; Seibert, pers. comm., 1991; Steere, 1992a). The search teams consisted of one botanist who was supposed to identify the plant, one forester who supervised the felling of trees and stripping of bark, and a few natives. Some species occur in clusters or groupings of trees, but *Cinchona* species are never dominant components of forests. The individual plants varied from small shrubs to very tall trees. Recognition of the desired plants was not an easy task. The botanists did make a simple analytical test in the field, which only indicated the presence or absence of alkaloids. Ideally, samples of the bark of several trees were taken and sent for laboratory analysis. With a favorable report, cutters then felled the trees and stripped the bark from the trunk and the larger branches (Fassett in Peattie, 1954). High-yielding trees might be marked and saved for a later visit to collect seeds for propagation. The bark had to be dried quickly in the sun or heat-dried with wood fires. The dried bark was then cut into manageable size and divided into loads for transport by man or mules to collecting centers. Samples of each lot were sent to central laboratories at Quito, Lima, Bogotá, or La Paz for analysis before the lot was accepted, paid for, and shipped to the United States for processing.

In the spring of 1943, one botanist began an independent search for quinine in Ecuador under the auspices of the American Quinine Company (Crum, 1977; Steere, 1945a; Steyermark, pers. recoll.). Subsequently this operation was moved to Venezuela, where the quantity and quality of quinine bark proved uneconomical. Colombia and Ecuador supplied sufficient quantities of cinchona alkaloids so that Peru was inadequately explored, and Bolivia was unavailable.

Seed beds were established in Colombia and Ecuador to permit the development of plantations in accordance with the agreement to replace cut trees. High-yielding seeds and seedlings were also sent to Costa Rica and Guatemala, where plantations were to be established. Much work was accomplished in the study and control, when necessary, of plant diseases, in handling of seeds and seedlings, in methods of grafting or vegetative propagation, and in fertilization (Imle, pers. comm., 1991; Pinkus, pers. comm., 1991; Rosengarten, 1944, 1991).

Since the alkaloid-yielding plants were not easily recognized at the beginning of these projects, the botanists were generally encouraged to collect botanical specimens from the trees that were harvested as vouchers of known alkaloid yields and to make general collections. The team leader noted that in Ecuador he made 345 collections of only members of the Rubiaceae, which were sent to Paul Standley at the Field Museum, Chicago, for identification. Standley identified these as representing 145 species, of which 56 were given tentative names as new species (Killip, pers. recoll.; Standley, pers. recoll.; Steere, 1945b). The collections made by the Cinchona Missions were to be the basis of taxonomic studies permitting a monograph of *Cinchona* or at least a better understanding of the genus. The specimens are deposited in the U.S. National Herbarium at the Smithsonian Institution, still awaiting study (Camp, 1952; Fosberg, pers. comm., 1991).

The development of atabrine as a synthetic product reduced or eliminated the need for more cinchona bark, and the South American exploration work was canceled in late 1944 and the missions closed in 1945. However, between 1 December 1941 and 1 August 1945, the United States imported 34,418,548 pounds of cinchona bark and approximately 700,000 ounces of cinchona alkaloids from hemisphere sources. Co-

lombia was the leading supplier of cinchona bark, Ecuador was second, Bolivia next, and Peru fourth (Anon., 1946d).

2. The Rubber Missions—Hevea

The United States lost 90% of its source of natural rubber as a result of the Japanese invasion and control of lands and plantations in the southwestern Pacific. In an attempt to expand a western hemisphere source of rubber, several agencies were created to search for stands of *Hevea* to tap and to exploit other sources. The Rubber Reserve Company, later called the Rubber Development Corporation, was established under the Reconstruction Finance Corporation. Within the U.S. Department of Agriculture, the Rubber Plant Investigations Office was organized under the head of the Office of Sugar Plant Investigations. Several stations of the Department of Agriculture were offices of investigations. In Florida, the Plant Introduction Station near Miami functioned as a transfer station for clones of *Hevea* to make certain that the leaf blight and other diseases were not introduced to seed plantations (Loomis, pers. recoll.). In California, a U.S. Acclimatization Garden at Bard reexamined some of the lesser-known sources of rubber and reported that their stocks of *Alstonia scholaris*, *Carissa macrocarpa*, *Gonocrypta sp.*, *Marsdenia verrucosa*, *Strophanthes spp.*, and *Thevetia neriifolia* were promising.

A U.S.D.A. botanist, hired in 1940 as an "agent-botanist," with a rubber planter from the Far East and a plant pathologist from Liberia, examined plantings of *Hevea* and possible sites for breeding programs and plantations in Cuba, Haiti, the Dominican Republic, Panama, Costa Rica, Venezuela, Colombia, and Brazil (Seibert, 1947, 1950, pers. comm., 1991). With this knowledge, field teams were then sent to the Amazon of Brazil, to Colombia, and to Peru to seek superior, blight-resistant, high-yielding, high-quality rubber trees and to encourage additional tapping of existing trees (Allen, 1944, 1945; Butler, pers. comm., 1992; Schultes, pers. conv.). In many of the areas there were no native people. The field team located rubber-producing plants, established a camp site, and then hired and transported native people to the camp. In many cases the native people had to be taught how to tap. Tapping was usually done very early in the morning. Trees were reexamined mid-morning, and those still flowing received special attention. Their branches were examined for leaf blight. Those clear of the fungus were termed "elite" trees, from which seeds were collected for germination in test plantations. A breeding program involving the high-yielding and blight-resistant clones was established in Haiti and in Costa Rica. Other U.S.D.A. botanists explored South America, particularly the Amazon basin, for additional sources of *Hevea* and related genera (Baldwin, 1947a, 1947b; Bangham, 1947; Fuller, 1951; Hodge, 1964; Rands & Polhamus, 1955; Schultes, 1945a, 1945b, 1947, 1948, 1949a, 1950, 1952a, 1952b, 1952d, 1953; Williams, T., pers. comm., 1991).

So serious was the wartime rubber shortage that almost every rubber-producing species in temperate as well as tropical America was tested for rubber possibilities. While crop specialists from the Department of Agriculture dominated the employment in field operations, a broad range of expertise was represented in projects of crop improvement, crop biology, and crop utilization. The principal genera of rubber-producing plants which were exploited during the war in tropical America, either on a large scale or to a minor extent, were *Hevea*, *Castilla*, *Manihot glaziovii*, *Parthenium* or guayule, *Hancornia*, *Sapium*, *Micrandra*, and *Cryptostegia* (Baldwin & Schultes, 1947).

3. Carica papaya

The latex of *Carica* was first investigated as a potential source of rubber and immediately rejected, and then plants were grown and studied as a source of digestive enzymes (McVaugh, 1943a).

4. Castilla elastica

Plantations of *Castilla* had been established in tropical America during World War I and were abandoned because production costs were high and the quality of rubber was low in comparison with *Hevea*. Yet many of these trees had survived, and in Venezuela and Trinidad, had been underplanted with cacao. So, during World War II they were again tapped. The yields of individual trees were low, and they could be tapped only three or four times before they went dry. Larger quantities of latex, averaging 75 pounds per tree, were obtained if the trees were felled. The principal effort in obtaining *Castilla* rubber was carried on in Costa Rica (Polhamus, 1948; Whaley, 1946, 1948).

5. Cnidoscolus

Botanists conducted extensive field studies in Mexico to locate native stands of *Cnidoscolus*, the source of chilté, and eventually named an additional dozen species of the genus. Plantations were established in Durango, Sinaloa, and Nayarit, Mexico, but the latex production was never significant (Gentry, pers. comm., 1991; Lundell, 1944, 1945a, pers. comm., 1992; McVaugh, 1943b).

6. Cryptostegia

During World War II, two species of the Madagascar genus *Cryptostegia* and a hybrid between them were grown and studied extensively as a promising source of rubber (Polhamus et al., 1934). Much of the propagation research and the distribution of production clones was carried on at the U.S.D.A. Plant Introduction Station south of Miami, Florida. The largest plantations, totalling 45,000 acres, were established by the Société Haitiano-Américaine de Développement Agricole (SHADA) in several areas of Haiti, unfortunately by requisition of the most productive sugar and vegetable crop fields (Archives, 1992; Camp, pers. recoll.; Fennell, pers. conv.; Gentry, pers. comm., 1991; Knight, pers. conv.). In some ways, the current troubles in Haiti can be attributed to the emergency rubber program of World War II, when the best agricultural land was confiscated to grow rubber and oil palms, at the same time disrupting the sugar industry. Additional plantations of *Cryptostegia* were established near Culiacán, Sinaloa, Mexico. Major studies and trials also were carried on in Australia and in India (Anon., 1942c). Many methods of harvest and extraction were tried, but, even when the project was terminated, no satisfactory way of handling *Cryptostegia* had been agreed upon. The *Cryptostegia* project was second only to guayule production in utilizing botanical scientists in the studies of the plant.

In his autobiography, W.E. Klippert (1972), Vice President of the Goodyear Rubber Plantations Company, was critical of the Haitian operation. He wrote, "Late in 1944 I was asked by the Export-Import Bank of Washington to join a survey party to investigate large wartime rubber plantings which the bank had financed in Haiti through a joint Haitian–American agricultural development corporation known as

SHADA. Under the wartime urgency to develop quick sources of natural rubber, SHADA, with the encouragement from certain inexperienced offices in Washington, had rushed into a large development program and had spent millions on the planting of thousands of acres of *Cryptostegia*, a latex-bearing ornamental vine native to Africa. Unfortunately, no rubber experts had been consulted prior to undertaking this massive program, nor had any serious research been undertaken to develop an economically feasible method of extracting the rubber from this pretty little vine. Shortly thereafter the entire *Cryptostegia* project was abandoned as a total loss.

"Concurrently SHADA, without consulting any of the major plantation companies, had planted some 54,000 acres of *Hevea brasiliensis* in two widely separated and poorly chosen areas.

" . . . Of course we had no alternative but to recommend the abandonment of most of the planted area."

A contrasting report of the SHADA culture of *Hevea* in Haiti is found in an anonymous article in the *Journal of Forestry* (Anon., 1944h).

In Australia, *Cryptostegia* was also field grown in plantations as a potential source of rubber. No satisfactory method of harvesting and extracting the latex was developed, and the project was abandoned (Mair, pers. comm., 1992–1993).

7. Hancornia

Hancornia speciosa was tapped in native stands in Brazil during World War II. The yield was low, and yet an estimated 2,000–2,500 short tons of mangabeira rubber were produced (Cutler, 1946; Monachino, 1945; Schery, 1944).

8. Micrandra

Although related to *Hevea*, species of *Micrandra* were tapped in the field but yielded mostly "scrap" latex due to poor flow (Schultes, 1952c).

9. Manihot

Local sources of *Manihot glaziovii* were sought in dry regions of eastern and northern Brazil. Small-scale plantings were not promising in yields of latex, and interest in this plant was dropped (Cutler, 1946; Schery, 1944).

10. Parthenium—Guayule

Parthenium argentatum, the source of guayule rubber, is a well-known native shrub of desert areas of Mexico (Brandes, 1942; Gentry, pers. comm., 1991; Hammond & Polhamus, 1965; Lopez & McGinnies, 1978; Whaley, 1948). Long before World War II, the plant had been cultivated in both Mexico and South America, and was the subject of investigations of its potential as a source of rubber (Voss, 1961). On 5 March 1942, the U.S. Congress passed Public Law 473 forming the Emergency Rubber Project, whose purpose was to create a U.S.-based supply of a rubber-producing plant, specifically, guayule. The law permitted acquisition from the private Intercontinental Rubber Company of 1,483 acres of land, of which 674 acres were in guayule; a mill for processing the plants; 22,867 pounds of seed; and more than 14 million seedlings in one nursery. The law authorized the planting of 75,000 acres, which was later increased to 500,000 acres. Botanists were assigned projects to better understand the

plant. Studies on its morphology and anatomy located the areas of rubber formation and storage within the plant (Artschwager, 1943; Bonner, 1943a, 1943b; Bonner & Galston, 1947; Cooney & Emerson, 1964; Emerson, 1949; Esau, 1944, 1946). Studies on the physiology determined the time and season of rubber formation (Bonner & Galston, 1945, 1946; Bonner, pers. comm., 1992). Studies of the genetics of the plant revealed the existence of apomixis, of polyploids, and the possibility of hybrids for greater yields of latex (Rollins, 1950, 1975, pers. conv.; Stebbins & Kodani, 1944).

It has been said that no nearer complete or better coordinated organizational plan had ever been prepared in government. No one will ever know whether it was as good as it looked, because when the organization was ready to begin work, the expansion was halted to minimize interference with food production and the project put on stand-by. On 30 November 1945, the project was ordered liquidated, and on 14 December the last pound of rubber was produced. A total 1,473 tons of rubber had been produced, but another 10,500 tons were destroyed in the eradication of the plantations. More than a billion seedlings were in nurseries ready for planting.

11. Sapium

At least one botanist had the task of locating *Sapium* trees in the field for tapping. Six or seven species of *Sapium* were tapped in Venezuela, Colombia, Peru, and Bolivia. The scattered trees and the difficulty of tapping due to the hard bark made the project uneconomical, and no *Sapium* rubber was produced (Williams, 1944).

12. Solidago

Edison had reported many years previously that *Solidago* was a potential plant for rubber production. A program at the U.S.D.A. Plant Introduction Station near Savannah, Georgia, to produce rubber from *Solidago* was not successful during World War II. The selections Edison studied and cultivated in Florida have been lost (Anon., 1945a; Minshall, 1957; Polhamus, 1933).

13. Taraxacum

Taraxacum kok-saghyz, the Russian dandelion, was reported to be a potential source of rubber, with plants yielding as much as 25 pounds of rubber per acre. In 1942 five tons of seed were received from the Soviet Union, unselected for quality. The yield from these plants was so low and costs of culture and harvest so high that the plant was considered an uneconomical source of rubber, even in wartime. Nevertheless, plants were grown experimentally in 42 states (Anon., 1942a; Whaley, 1946, 1948; Whaley & Bonner, 1947), including Alaska, and in Canada (Minshall, pers. comm., 1992) as well as Australia (Anon., 1942c). Its culture was most successful in Vermont, Michigan, Wisconsin, Minnesota, and Oregon. State agriculture experiment stations were enthusiastic in creating experimental plantings. The U.S. Forest Service attempted to improve the quality of the seed production. Selected plants in Canada were known to contain 12% rubber content, and a few were found to contain 15% (Anon., 1946c). No known quantity of rubber, if any, was derived from any of these plantations.

14. Synthetic Rubber

No botanists appear to have been involved in the production of synthetic rubber by

a powerfully organized chemical industry, which eventually succeeded in having the projects involving natural rubber terminated, closed down, and the resources destroyed (Loomis, pers. recoll.).

C.M. Wilson (1945) stated, "The manufacture of synthetic rubber opened frantically but in some measure brilliantly, though the facts are still sorely obscured by partisan politics, the quest of United States Treasury subsidy, the naive incompetency of numerous pseudo-scientific reporters, and the staging by pretentious political appointees, and certain other individuals, of one of the most audacious publicity field meets in history."

Certainly the feeling in 1993 of the survivors of work on *Cryptostegia* and guayule is one of extreme bitterness at the unfair treatment their projects received at the hands of representatives of the chemical industry and their subsidized patrons in the federal bureaucracy and in Congress (Fennell, pers. conv.; Rollins, pers. conv.).

The need for a local supply of rubber was also felt in Australia and Canada. In Queensland, Australia, the local latex-producing plants were assembled by botanists from the state herbarium and botanical garden, to enable the chemists to screen for the best possible source (Johnson, pers. comm., 1992). The search extended into southern Papua and New Guinea as war conditions permitted (Mair, pers. comm., 1992–1993).

In Canada, nearly all members of the Economic Botany Section of the Division of Botany and Plant Pathology of the Canada Department of Agriculture were involved in seeking substitutes for rubber, kapok, or other strategic materials restricted by the war in the Pacific. Samples of latex-producing plants were obtained from many parts of Canada (Anstey, 1986; Berman, 1949; Groh & Dore, 1945; Minshall, 1957, pers. comm., 1992). A total of 300 species of native and introduced plants were analyzed by the extraction method for resin and rubber content. Genera containing benzene-extracted latex in excess of one percent dry weight were *Apocynum*, *Asclepias*, *Eucommia*, *Euonymus*, *Euphorbia*, *Lonicera*, *Parthenium*, and *Solidago*. Several species of *Asclepias*, *Apocynum*, and *Solidago* were deemed worthy of further study and were grown in extensive plots for studies of soil preference, time and place of latex production within the plant, and methods of increasing total yield. *Asclepias syriaca* was the most promising, yielding, in addition to latex, quantities of floss from the seeds to be used as a substitute for kapok (Anon., 1945a; Anstey, 1986). *Asclepias incarnata* was grown most easily under normal methods of cultivation. Plantings of the Russian dandelion, *Taraxacum kok-saghyz,* were made of Russian seed obtained through the U.S. Department of Agriculture and studied throughout the southern portions of Canada. It was found to be a cool-weather, high-soil-moisture, sun-loving plant. The Russian dandelion was also tried extensively but with little success in Australia (Anon., 1946c).

Several Canadian botanists were involved in the search for latex-producing plants in British Guiana (Dathan, pers. comm., 1992).

All projects with latex substitutes for *Hevea* were stopped when the development of synthetic rubber seemed more promising.

E. MISCELLANEOUS PLANT PRODUCTS

1. Generalities

For the F.E.A., botanists and foresters were often assigned, as a principal mission or a secondary one, the location and often exploitation of specific strategic crops.

The Defense Supplies Corporation operated in a fashion comparable to the Cinchona Mission but with few trained botanists (Gilly, pers. comm., 1991; Hermann, 1947; Little, pers. comm., 1991). At various times their interests were in balsa; barbasco, a source of rotonone; cacao; curare, a medicinal; figue, the fiber of *Furcraea*; and wild ipecac roots, a source of emetine.

The U.S. Commercial Company sought sources of insecticidal material. One report concluded that from the standpoint of economic culture the ideal insecticide had not been discovered. *Derris* and *Lonchocarpus,* as sources of rotonone, and *Chrysanthemum,* for pyrethrum, were grown in Guatemala and Peru. Red squill—*Urginea maritima*—an effective raticide, was imported from Algeria in 1943 and 1944 and grown by U.S. organizations in Enseñada, Mexico (Gilly, pers. comm., 1991). Edible and commercially useful oils were sought from various plants. *Elaeis*, the oil palm, was grown extensively in Haiti as one of SHADA's projects (Camp, pers. recoll.). *Garcia* proved a promising genus (Lundell, 1945b). In Australia, extensive trials were conducted on the culture of "insecticidal plants," including commercial sources of *Chrysanthemum cinerariaefolium* and the native species of *Derris* and *Lonchocarpus.*

Antimalarial compounds other than quinine were sought, as were gums and resins, by several private companies (Landrum, 1986; Spencer et al., 1947).

Australia and New Zealand suffered severely through their isolation. Previously dependent on supplies of vegetable seeds from overseas sources, they were forced to attempt to grow their own seeds and then crops from them. The Council for Scientific and Industrial Research in a classified "War" report indicated the drugs in critical supply were opium, morphine, codeine, hyoscine, hyoscyamine (atropine), ephedrine, emetine, strychnine, quinine, strophanthin, cuabain, santonin, glucosides of *Digitalis*, Filix-mas, and ergot (Anon., 1942c). In New Zealand, efforts were made by botanists to collect material from wild sources of medically useful plants for local needs and for export to Europe. Cultivated plots were also established for foxglove (*Digitalis spp.*), deadly nightshade (*Atropa belladonna*), thorn apple (*Datura stramonium*), and henbane (*Hyoscyamus niger*) (Anon., 1942b, 1946a; Collins et al., 1990; Thomson, 1976). Several species of the native genus *Duboisea* proved to be sources of several of the drugs, and extensive programs were begun to learn how to propagate, culture, and harvest the plants. In New Zealand, school children were encouraged to collect ergot-infested grasses for medical use (Thomson, pers. comm., 1992). In Australia, the important drug plant survey to identify pharmacologically active plants commenced during the war years and extended well beyond the war (Anon., 1942c; Collins et al., 1990; Webb, pers. comm., 1992).

2. Agar-agar

Agar was declared a "critical war material" by the War Production Board when the supply from Asia was cut off by the Japanese. A botanist from North Carolina undertook a survey of possible algal sources along the North Carolina coast. During the war years, the number of factories producing agar was increased to five but decreased after the war to three. Also involved in this project was research on marine agar-digesting bacteria involved in the fouling of mines (Humm, 1942, 1947, pers. comm., 1992; Humm et al., 1946).

A Canadian biochemist devoted his research to finding an alternate source of agar-agar from marine algae to replace the supply from Japan cut off by the war (Gibbs,

pers. recoll.). The replacement of agar sources was one of the interests of the Department of Scientific and Industrial Research (DSIR) of New Zealand (L.C. Smith, 1992; Thomson, 1987, pers. comm., 1992). Through the efforts of Dr. Lucy Moore, a botanist of the DSIR, local seaweeds were identified as sources. Maori people and school children were involved in the harvesting. Over 100 tons of agar were extracted for export during the last two years of the war.

In Australia, Valerie May Jones, a phycologist, worked with the CSIRO on a wartime project to seek alternative sources to replace imports of agar (Briggs, pers. comm., 1992).

3. Balsa

Supplies of balsa were located and harvested in Ecuador for construction of the mosquito bomber, for submarine mine floats, and for aircraft pontoons. Plantations were established in Costa Rica. The demand never exceeded the supply during World War II (Fletcher, 1951; Grant, 1986; Little, pers. comm., 1991).

4. Cavanillesia

This soft-wood tree, native to Central America, was sought and harvested as a substitute for balsa (Anon., 1944c; Grant, 1986).

5. Fibers

A special division of the Commodity Credit Corporation of the U.S. Department of Agriculture, financed by money from the Defense Projects Corporation, aided the culture of *Cannabis sativa* as a source of linen fiber to replace the supply of abaca from the Philippines, cut off by the Japanese. Arrangements were made to plant 46,000 acres of hemp in Kentucky, Wisconsin, and Minnesota. Forty mills were established to process the fiber, and two harvests in 1943 and 1944 produced sufficient fiber to meet the current needs. In 1945 the project was terminated (Fishler, 1949).

In Australia the Council for Scientific and Industrial Research (CSIR) and in New Zealand the DSIR were also involved in developing supplies of "linen flax" under emergency measures. European supplies of flax were cut off by the German invasion of the continent. Flax was needed for airplane wing fabric, parachute harnesses, fire hoses, and camouflage netting, among other items. In 1941, 13,123 acres were sown, and this was increased to 20,202 and 21,858 during the next two years. With no tradition of growing, harvesting, and retting the plant, many agricultural and botanical scientists were involved to develop procedures. Seventeen mills were built, as well as a by-products factory. *Phormium*, *Cannabis,* and *Linum* were grown and processed. This project was continued in peacetime as the Linen Flax Corporation of New Zealand (Anon., 1942c; Atkinson, 1976; Ferrier, 1971; Raeside & Mason, 1946; Thomson, 1992).

In Australia, flax (*Linum*) was grown widely in Victoria. Research on flax fiber selection was conducted at the Botany school, University of Sydney, for the Australian Army by botanists in uniform (Mair, pers. comm., 1993, Thomson, pers. comm., 1992).

A shortage of kapok, fruit fiber from *Ceiba pentandra*, was strongly felt in Canada, where the material was used in life jackets and emergency flotation gear. The use of *Asclepias* changed during the war from the production of latex to the utilization of the seed hairs to meet this need (Anstey, 1986).

6. Medicinals

Mycologists and bacteriologists were listed on the staff of the Commercial Solvents Corporation, which produced penicillin during the war years (Raper, 1978; Raper & Thom, 1949).

A group of botanists at Stanford University directed their efforts to a study of the antibiotics produced by the unicellular alga *Chlorella* and other green plants. Later, a project was focused on growing *Chlorella* as a source of foodstuff. This project determined how protein and fat content could be controlled by altering environmental factors, and proved to be a valuable contribution (Beadle, 1954).

F. THE MANHATTAN PROJECT

The Manhattan Project, which produced the atom bomb, had a Biology Section at the Metallurgical Laboratory at the University of Chicago whose task was to determine safe levels of fission products. This involved a large animal facility with workers in radiation biology, physiology, biochemistry, histology, hematology, pathology, and oncology (Grossenbacher, pers. comm., 1992; Prosser, pers. comm., 1992).

A New Zealand malaria specialist visited Hiroshima in June 1946, ten months after the bomb was dropped, and reported on the regeneration of trees in the blast area (Laird, 1946, pers. comm., 1992).

G. SURVIVAL MANUALS

Many manuals, for a great variety of informational or instructional use, were prepared by military and civilian organizations during World War II. Those of interest to botanists were survival manuals and the manuals for collectors.

1. The Arctic

In 1935 Vilhjalmur Stefansson agreed to write a report on problems of living and operating in the Arctic. This was published by Macmillan in 1940 as the *Arctic Manual* and reissued in 1945 by the Government Printing Office. A condensed version was issued as the *Arctic Manual* TM 1-240, compiled by the staff of ADTIC and sent to Stefansson for comment. By one report, his opposition was violent (Eklund, pers. recoll.), but in the introduction to the *Arctic Manual* issued in 1944 he stated, "I was surprised; but when I read it I was not so disappointed, for, though familiar with the material, since it is largely derived from my own experience, I am not a bit sure that I could have condensed it so well" (Stefansson, 1944).

ADTIC issued an Informational Bulletin, Series A No. 6, on 1 July 1943, titled *Living Off the Arctic*. Although published anonymously, the material was largely compiled by John Marr (Marr, pers. comm., 1992).

The Training Division, Bureau of Aeronautics, U.S. Navy, issued a series of publications illustrated by cartoons. *Aleutians Sense* and *Arctic Sense,* described in 1943 as "forthcoming," never have been located.

2. At Sea

The Raft Book: Lore of the Sea and Sky was privately published in 1943 by Harold Gatty. This book proved popular, was easy to understand, and had a wide distribution.

The publication *Dunking Sense* was issued in 1943 by the Training Division, Bureau of Aeronautics, of the U.S. Navy. A survey of actual survival experiences at sea was prepared by George Llano and published in 1955 as *Airmen Against the Sea* (Llano, 1955).

3. General Manuals

Army Air Forces Survival, AAF Manual 64-0-1 (Government Printing Office, 1943–1945), was issued in a shape (9.5 × 20 cm) to fit into the leg pockets of the standard flying suit. Some copies were printed on edible paper. Both instructors and the airmen, potential users of the manual, found this publication most satisfactory. In an attempt to improve the manual in 1945, the Department of the Air Force issued A.F. Manual 64-5, entitled *Survival,* and reprinted it in 1952. This volume, 15 × 22 cm, was less convenient to carry in flight.

How to Survive on Land and Sea was published anonymously by the Aviation Training Division, Office of the Chief of Naval Operations, U.S. Naval Institute, in 1943. It was twice revised, in 1951 and 1956, but neither of these editions has been seen. In 1984 it was revised by Ray E. Smith and D. Shiras Jarvis (Craighead & Craighead, 1984).

Castaway's Baedeker to the South Seas was written at the Bishop Museum, Honolulu, at the request of the Navy, although the title page of the second edition, September 1943, states, "Prepared jointly by Commander Air Force, Pacific Fleet and Joint Intelligence Center, Pacific Ocean Areas."

South Sea Lore, by Kenneth P. Emory, January 1943, is a revised version of the Baedeker issued as Special Publication #36 by the Bernice P. Bishop Museum. At least one reprinting is recorded, in September 1943.

4. Regional and Specific Manuals

Edible, Poisonous, and Medicinal Fruits of Central America, Capt. A.B. Godshall, 1942, was written for troops stationed in the Canal Zone.

TM 10-420. *Edible and Poisonous Plants of Islands of the Pacific,* E.D. Merrill, was issued 15 April 1943.

Living Off the Southwest Pacific Tropics, Informational Bulletin, Series A—No. 5, 1 July 1943, ADTIC.

Friendly Fruits and Vegetables, 1943. Anonymous, Australia. Prepared by the General Staff, L.H.Q. Australia, and distributed under the authority of the Commander, Allied Land Forces, S.W.P.A.

Food Is Where You Find It, Dr. Lucy Cranwell & Capt. Green, August 1943. Auckland Museum, New Zealand, 5th printing 1992.

Edible Plants of the Arctic Region, Paul C. Standley, 1943. NAVMED 119. Bureau of Medicine and Surgery.

Edible and Poisonous Plants of the Caribbean, B.F. Dahlgren and P.C. Standley, 1944. Bureau of Medicine and Surgery.

The Pacific World, New York Zoological Society, 1944.

Native Woods for Construction Purposes in the Western Pacific Region, J.H. Kraemer, Bureau of Yards and Docks, May 1944. Amplified edition September 1944 (Merrill, 1945b). Ninety-nine original illustrations for this publication were deposited in the Smithsonian Institution by the Navy Department in 1945.

Native Woods for Construction Purposes in the South China Sea Region, J.H. Kraemer. NAVDOCKS P 163, January 1945.

Plants of the Southwest Pacific, Smithsonian Institution, U.S. National Museum. Revised edition 1945. Original edition not known.

Emergency Food in Arctic Canada, National Museum of Canada. Special Contribution—45-1, 20 pp., 1945. Prepared by A.E. Porsild (Porsild, 1945b).

Flora and Fauna of the Netherlands East Indies, Weekly Survey No. 28. Netherlands Information Bureau Library. Undated.

Edible Wild Plants of Eastern North America, 1943. Originally written as a student project by A.C. Kinsey, the manuscript was revised and enlarged by M.L. Fernald as a contribution to the war effort.

Tropical Flora of Medical Importance (Unit 9A) and *Edible Plants of the Tropics* (Unit 9B). NAVMEDSCOL Global Medicine Synopsis Series. Each unit consisted of 54 cards, 6.3 × 8.9 cm, or playing-card size. Plants were illustrated in color on one side and described on the reverse side. Poisonous or toxic qualities were indicated in red ink. As flash cards these may have had educational value, but in practice they were marked with playing card symbols and so used in emergencies, when regular cards were not available.

Four summary publications reporting actual survival experiences were issued shortly after the end of the war:

999 Survived, An Analysis of Survival Experiences in the Southwest Pacific was issued as Information Bulletin T-100 by ADTIC in 1950 and reprinted eight times (Howard, 1950).

Down in the North—An Analysis of Survival Experiences in Arctic Areas was EID Publication No. A-103, issued in 1953 and twice reprinted (Howard, 1953b).

Sun, Sand and Survival—An Analysis of Survival Experiences in Desert Areas was issued in 1953 and reprinted four times as EID publication No. D-102 (Howard, 1953a). A training film was produced based on this publication. *Sun, Sand and Survival* was reprinted again and distributed during Operation Desert Storm in Iraq in 1992, later to the emergency food lifts in Somalia and Kenya, and during operation Restore Hope. (Erickson, pers. comm., 1992).

Airmen Against the Sea: Analysis of Sea Survival Experiences was issued by the Air University in 1955 (Llano, 1955).

5. Current Survival Manuals

Aircrew Survival, AF Pamphlet 64-5, issued in 1985 and reprinted 1990. Spiral bound at end, 11.5 × 17.5 cm, on heavy glossy paper, considerably changed from any predecessor in content and emphasis. This is intended to be an outline for review of the subject matter by those Air Force personnel who have had survival training.

An Instructor's Survival Manual, issued during the late period of World War II and in the postwar period, was AF Manual 64-3. An instructor's manual numbered AFR 64-4 to accompany 64-5 was issued 15 July 1985, had restricted distribution, and was under revision in 1992.

The *SAS (Special Air Services, Great Britain) Survival Handbook,* John Wiseman, Collins Harvill, London, published in 1986, supposedly utilizes the information taught in the SAS during the war years. Its printing history of thirteen issues indicates it is a popular civilian item.

The Canadian armed forces have prepared a survival manual, *Down but Not Out,*

in English and French editions. The original version prepared by the RCAF Survival Training School Staff was issued in 1970 and reprinted five times until 1980 (ISBN 0-660-01800-4). A larger and more comprehensive treatment with the same title was published first in 1984 and reprinted in 1990 (Minister of Supply & Services, Canada, ISBN 0-660-11549-2). The manual concerns primarily survival in arctic areas, with five pages devoted to desert survival and three pages to survival in tropical areas.

The Army of Sweden published *Handbok Överlevnad* in 1988 in the Swedish language, a survival manual primarily for arctic or cold areas (ISBN 91-38-12172-7). The book is printed on glossy paper, is handsomely illustrated, and has many color photographs. It is supplemented with a *Fickminne Överlevnad* (pocket manual) of six folded pages 9 × 12 cm on waterproof heavy stock paper, illustrated on both sides with colored survival instructions. The theme is stated, "The one who is prepared survives." The book is based on many years of research and practical studies at the Defense Institute of Research. Two diaries are included, reporting survival trips of nine and seven days in arctic and coastal Sweden, with minimal equipment and supplies, to test the proposals of the survival manual. Data are given on the nutritional value of lichens as emergency survival foods.

H. COLLECTORS' MANUALS

Museums and herbaria were interested in receiving specimens of plants or animals from servicemen during the war, for troops were to invade or be stationed on islands whose flora and fauna were not well represented in any museum collection. The School of Aviation Medicine made clear they would try to identify organisms that caused military problems; specimens of plants, possibly edible or possibly poisonous; and animals that bit or stung or were destructive, if they were sent for identification. Rarely were these specimens worthy of preservation, although some were retained and used as a museum or educational display (Howard, pers. recoll.). A few botanists collected specimens while in training in various parts of the United States (Kruckeberg, pers. comm., 1992; Schallert, 1985).

E.D. Merrill of Harvard University and Kenneth Emory of the Bishop Museum lectured regularly to audiences of military personnel on emergency living procedures in the tropics. They encouraged the troops to supply specimens they could collect in their spare time (Merrill, 1944). H.H. Bartlett of the University of Michigan and E.G. Walker of the Smithsonian Institution (Bartlett & Walker, 1943) collaborated on a project to encourage servicemen to collect specimens. They worked through an "Army Specialized Training Program—Company D" of the University of Michigan. A newsletter was sent to graduates of Company D, and scientists compiled *Instructions to Naturalists in the Armed Forces for Botanical Field Work.* There are titles and title pages known for eleven of these, issued as supplements to the *Company D Newsletter.* Only six have been located (Bartlett, 1944). Walker wrote to Bartlett regretting the news that no funds were available at Michigan to publish additional pamphlets. Walker offered to try to have the Smithsonian publish the remainder and asked for a "conger" manuscript to be returned (Walker, 1946a). Bartlett also indicated that the mailing list for the pamphlets was 110,000 (Bartlett, 1945a). Bartlett wrote, "The Army Education Branch decisively and conclusively turned down my request to cooperate with our project, so it isn't worth while to bother with the top boys of that. In order not to do

them an injustice, I may say that the office I contacted has headquarters at Madison (University of Wisconsin). They are too stupid or ignorant or sluggish to realize what it is all about. The 'Entertainment and Recreation Branch' may prove to be more intelligent, or the underlings of the Education Branch itself (Smyth, pers. comm., 1992)." Bartlett reported to Walker that the War Department had transmitted to him a list of all the botanists in the armed forces, 93 in number. Walker is known to have corresponded with 166 service men and women in posts all over the world (Smyth, pers. comm., 1992; Walker, 1944). One letter stated, "Your name has been given to me by Mr. Henry Clepper of the Society of American Foresters, as one who may be willing to collect plants for the United States National Herbarium. I am writing to ask if you will do this so that we may have a better representation of the flora of the region where you are now stationed." The letter included a leaflet on how to press and dry plants (Smyth, pers. comm., 1992). Johnston's booklet, *The Preparation of Botanical Specimens for the Herbarium*, was also distributed by the Smithsonian Institution as well as the Arnold Arboretum (Johnston, 1939; Merrill, 1944a). Some 41 of these servicemen sent in plant collections, over 70% of the specimens coming from the Pacific. Almost a third of the collectors were trained botanists or zoologists, about 15% were foresters, and the majority were unknown to the scientific community. Walker records specimens received at the Smithsonian from collectors in Alaska, the Aleutians (primarily Adak, Attu, and Kiska), Admirality Islands, Assam-Burma, Caroline Islands, China, Galapagos, Guadalcanal, Guam, Iwo Jima, Japan, New Britain, New Caledonia, New Guinea, Okinawa, Panama, Philippines, Rota, Saipan, and Sumatra. The greatest number of specimens was received from the Aleutians while the largest number of collectors sent specimens from Guam. Mosses and lichens were the easiest materials to collect. Walker indicated that, in addition to the Smithsonian Institution and the University of Michigan, the following institutions also received collections of plant materials from U.S. servicemen: Arnold Arboretum and Gray Herbarium of Harvard University, Chicago Natural History Museum, William Jewell College, Carnegie Museum (Pittsburgh), University of Miami, University of Texas, Cornell University, Northwestern University, and the University of Washington. Servicemen also sent collections for identification to the British Museum and the Royal Botanic Garden in Calcutta, India (Walker, 1946b).

Both Walker and Bartlett (Bartlett, 1945) wrote articles about their project, and Merrill thought he had his own program under way. Walker wrote, "Under present military restrictions, specimens often cannot be sent accompanied by the needed data on localities and dates of collection. This difficulty may be overcome, however, by numbering each specimen shipped and retaining the restricted data correspondingly numbered in notebooks. These can be turned over to the receiving institution after the war or when restrictions are relaxed. In any case, if at all possible, deposit the original or at least a copy of the data with your intelligence officer for transmittal to the Smithsonian Institution under proper safeguards when permissible" (Smyth, pers. comm., 1992). On one occasion Merrill expressed anger that good specimens had been received with no data as to location (Merrill, 1944a). It was necessary to point out to him that the collectors were subject to censors who controlled what they wrote or what they sent (Howard, 1992a; Merrill, 1946). In general, a name and APO number were acceptable, but not the name of the unit or its specific location. Bartlett sent a request to the Officer in Charge of Army Post Offices that notification go to "all A.P.O.'s officially that there are absolutely no quarantine regulations restricting the entry of

dried plant specimens" and suggesting that censorship restrictions be modified to permit "entry of scientific specimens with full collection data, lacking which the specimens are only so much junk" (Bartlett, 1945b). Walker located an Army Act for 1885 (U.S. Code, Title 10, Paragraph 73) which stated that "the Quartermaster-General . . . wherever stationed, shall receive, transport, and be responsible for all property turned over to them, by the officers or agents of any Government survey, for the National Museum." Neither request seemed to have had an effect.

I. COLLECTORS

The American Museum of Natural History did much to stimulate the servicemen's activities in zoological collecting. Several former students of the Museum of Vertebrate Zoology at the University of California, Berkeley, were able to collect extensively both plants and animals in the Pacific area during the war. The Chicago Natural History Museum received specimens from staff serving in the military forces and from others. In a report for 1945, twenty-five gifts were noted of specimens varying from one to 894, primarily from fields other than botany (Anon, 1946e). The Smithsonian Institution also recorded many types of plants, animals, and other artifacts sent in by men in uniform (Wetmore, 1944, 1945, 1946). One Navy lieutenant collected 802 specimens during an assignment of 19 months in the Southwest Pacific and the Philippines. At one period his assignment permitted him to spend two or three hours a day watching, recording, or collecting birds and mammals (Sibley, pers. comm., 1992).

A staff member of the Missouri Botanical Garden sent more than a thousand specimens, 8% of which were bryophytes from the Aleutian Islands, to the Missouri Botanical Garden (Collins et al., 1945). He also wrote and published locally a pamphlet entitled *Flowers of Island X* (van Schaack, 1945). Librarians guessed this was in the Aleutians, and it proved to be the island of Attu. A.M. Harvill Jr. was sent to Alaska by the Army in 1942 on the passenger ship *Denali.* He collected mosses at the various stops en route—Ketchikan, Sitka, Juneau, Yakatak, Cordova, and Valdez—and, for longer periods of time, around assigned bases at Anchorage and Whittier (Harvill, pers. comm., 1993). After the war he reported on van Schaack's collections of mosses (Harvill, 1947). Many other collections of mosses, lichens, and liverworts also came from Alaska and the Aleutians; one of the largest collections was made by Mrs. Margaret Bell Howard, a Red Cross worker assigned to duty on Attu by the Army for the greater part of 1945 (Clark & Frye, 1948, 1949; Harvill, 1947; Howard, 1958; Howard, 1946). Bryophytes were also collected on Attu by Robert M. Hardy (Frye & Clarke, 1946). Walker exulted, "A lupine hastily stuck in a private's pack while hunting Japs during the Aleutian campaign proved to be a new species." This has not been verified (Welsh, pers. comm., 1992). Records of other wartime collectors are maintained in a database at the University of Alaska Museum (Murray, pers. comm., 1993).

Sgt. Leslie W. Lee reported in *The Bryologist* on his own collections made in Greenland (Lee, 1944).

From the Pacific area, museums received collections from Australia and New Zealand and from New Guinea to Okinawa and the Philippines (Crum, pers. comm., 1992; Russell, 1950, pers. comm., 1992; Uhl, pers. comm., 1992). Two Navy fliers on stopovers in Guam and the Admiralty Islands collected ferns and butterflies and

published on each (Wagner, 1946, 1948a, 1948b; Wagner & Grethier, 1948). Another man with a Naval medical unit made general collections on Guam, returned after the war to continue collecting, and eventually published a checklist of the flora (Glassman, 1949; Merrill & Perry, 1946). A botanist serving as a cook in the Navy had time to collect algae and flowering plants, first on Hawaii and later on Tinian (Cowan, pers. comm., 1992; St. John, 1976). One Navy officer, formerly a cytologist, served on an LCI gunboat in the Seventh Amphibious Force in the Pacific and managed to collect vascular plants on New Guinea, Biak, and several islands of the Philippines (Uhl, pers. comm., 1992). The duty officer on a destroyer made modest collections of mosses during his ship's layovers at Samar Island in the Philippines and Bora Bora in the Society Islands, plus some mosses collected on Honshu Island, Japan, after the surrender (Powell, 1947a, 1947b, 1947c, pers. comm., 1992). Three new species of mosses collected on Okinawa were described by Bartram from the collections of W. Stanley Newcomer, made between September 1945 and April 1946 (Bartram, 1947). These collections were supplemented by those of Alfred Clebsch Jr. and Joe Herbst, whose names have not been in *American Men of Science*. A new species of *Torenia* was described from collections made by the Typhus Commission Botany Section in Assam (Belcher, 1969). A full report of the botanical collections of this commission has never been published. Two specimens cited in the description of *Torenia patens* were numbered U.S.A. Typhus Commission 455 and 541, while other collections are cited U.S.A.T.C. (Belcher, 1955).

Collections by men in uniform were made for Canadian museums from Newfoundland (which was not part of Canada at that time) and from England (Gillett, pers. comm., 1992), while others collected in the Aleutian Islands (Porsild, 1944).

The Canadian botanist Erlund Porsild is credited with the identification of rice and soil found in the ballast of one of the fire-starting balloons as Japanese in origin, and specifically from the Tokyo area. Although these incendiary balloons were intended to start forest fires on the Pacific seaboard, they never inflicted great damage (Aitkens, 1971; Bonham, 1946; Mikesh, 1973; Soper & Cody, 1978). Later Porsild was appointed Canadian consul to Greenland, in part a political/military move, to indicate Canadian interest and to deter or protect the island from German invasion. Porsild made large collections of plants along the west coast of Greenland during his stay (Porsild, 1945a). He is also credited with saving the supply of cryolite so badly needed by the American aluminum industry (Campbell, 1985).

New Zealand biologists were stationed on subantarctic islands, Auckland and Campbell, as members of coast-watching units of the New Zealand Army (Anon., 1955; Fraser, 1986; Hornibrook, 1988; Mathews, 1988). This work was done under the code name of "CAPE Expedition." The designation CAPE was chosen for security reasons and had no geographic connotation. The biologists carried out field work in botany, zoology, geology, and ecology as spare-time activities, and established complete meteorological and ionosphere observation stations. The resulting data and collections were later written up in the *CAPE Expedition Bulletin* series. The CAPE Expeditioners had been chosen for their ability to cope with isolation and their interest in an outdoor life, and all contributed to observations of the mammals, birds, insects, and flora of these islands. All were given the military rank of "private" for legitimacy, in case they were captured.

Australian botanists and foresters on assignment while in uniform collected voucher specimens for timber trees extensively in New Guinea, New Britain, and Karkar

Island. Wood specimens without herbarium vouchers were collected during timber salvage projects on Borneo (Mair, pers. comm., 1992–1993). The forests of New Guinea were to supply construction timbers for military operations to the north approaching the Japanese islands. Foresters and botanists were landed with engineers in initial invasions, and when fighting ceased they set up sawmills and established a supply of logs for piers or building frames or to be milled into boards for construction. In July 1944, a Forestry Botany School was conducted at Yalu to which about thirty American and Australian foresters and botanists were invited (Ingram, 1993). C.T. White, Lindsay Smith, and W.W. Jacobs were the principal instructors. Field teams surveyed forests and selected trees for possible use, which were identified by means of key cards developed by the Division of Forest Products, Melbourne. New Guinea natives were the axemen. Botanical specimens were collected and returned to the Company headquarters for validation and preservation. Scientific names and common names in English were sought for all specimens, in addition to the native names from the Lae and Wewak areas. C.T. White was the primary assessor of the commercial value of New Guinea timbers (Ingram, pers. comm., 1992). During the war years Lindsay Smith initially was with a mobile chemical-warfare laboratory. One special project was to find adequate substitutes for the Australian turpentine pine (*Syncarpia glomulifera*), which had marine use as a borer-resistant timber. A pier built at Lae by U.S. forces collapsed within three months from borer activity. Eventually a record of a satisfactory substitute was found in German literature as a plant within the Dipterocarpaceae. From 1944 to 1945, Smith was classified as a botanist with freedom to travel extensively in New Guinea. His many collections from the northeast New Guinea–mandated territories, with N.G.F. (New Guinea Forces) numbers, formed the nucleus for the modern herbarium of the Forestry Service that was established at Lae (Mair, pers. comm., 1992–1993; Steenis-Kruseman, 1950).

H.F. Consett Davis, an Australian entomologist, served with a Guerrilla Warfare Group of the Australian Army and was sent to the Kimberly area of Western Australia. Their mission was to live off the land and search for Japanese troops reportedly landing in the area occasionally. He collected plant specimens which were sent to the Western Australia herbarium (Davis, pers. comm., 1993; Ingram, 1993).

The quinine and rubber hunters, as part of their missions, collected specimens of the respective families Rubiaceae and Euphorbiaceae, but some also made general collections in Brazil (Baldwin, 1945; Schultes, 1945b); Colombia (Allen, 1944, 1945; Anon., 1944b; Camp, 1946; Ewan, 1951; Grant, 1986; Hodge, 1947; Little, 1970; McVaugh, 1949; Schultes, 1949b; Seibert, pers. comm., 1991; Steere, 1945a, 1947; Wiggins, 1946); Ecuador (Camp, 1949, 1952); and Venezuela (Steyermark, 1951). Several botanists had plans to write local or regional floras. Many collected extensively in groups which were their specialties (Anon., 1960; Prescott, 1946).

The Harvard Travellers Club had prepared a *Handbook of Travel* which was published by the Harvard University Press. Chapter 20 of the second edition issued in 1935 was reprinted early in the war years and distributed as *Instructions for Collectors* by the Museum of Comparative Zoology. The section on botanical collecting was written by mycologist David Linder. It was suggested on the back cover that algae, mosses, fungi, and lichens be sent to the Farlow Herbarium of Cryptogamic Botany and all animal or fossil specimens to the Museum of Comparative Zoology.

The *Field Collector's Manual in Natural History,* issued by the Smithsonian Institution in 1944, was and is an excellent handbook for all field biologists.

J. INTERNED BOTANISTS

Some botanists employed at botanical gardens in Singapore and Java were imprisoned or interned as a consequence of the Japanese attack, the surrender of the defending forces, and the subsequent occupation. In both areas, some of the scientific staff were permitted to continue their work, and the collections were not affected by the occupation. I have been unable to obtain much information on the status, activity, or fate of botanists in the Philippines or at Hong Kong. Price (1976) indicated Eduardo Quisumbing was appointed chief botanist by Dr. Hatai, head of the Bureau of Science, during the Japanese occupation of the Philippines. Quisumbing published one paper during that period (Quisumbing, 1944). The manuscript for a new illustrated flora of Manila, prepared by E.D. Merrill and Quisumbing, had been completed but subsequently was lost (Merrill, 1954). During the battle for Manila in February 1945, the Bureau of Science herbarium and library were destroyed, but the activities there during the years of Japanese occupation are not recorded. The Philippine School of Forestry at Los Baños was occupied by the Japanese. The Americans on the staff and their families were held at the Los Baños internment camp about forty miles south of Manila. The school itself continued in operation for a short time after the fall of Bataan. No American textbooks were allowed, and instruction had to be in the Japanese language. When it was apparent that Allied forces were landing in the Philippines, the Japanese forces destroyed school buildings, homes of faculty and students, textbooks, experimental equipment, test plots, and nurseries. Only one building remained when the American troops returned (Kuehlke, 1945; Phillips, 1945; Spaugh, 1944). The forest botanist and collector A.D.E. Elmer died during July 1942, while interned by the Japanese in Santo Tomas prison camp (Herre, 1945).

No one on the current staff of the Parks Department in Hong Kong could offer historical information of the period of occupation. An information sheet without date or author reviews the history of the Hong Kong Botanical Garden (Cheung, pers. comm., 1993a). It is reported that the herbarium and library were sent first to Penang and then to Singapore for safekeeping before the Japanese invasion. After the defeat of the Japanese the herbarium was returned, but the library was lost in ways not explained (Griffiths & Lau in Cheung, pers. comm., 1993b.

At the Singapore Botanic Garden, those in uniform or serving as part of the defending reserve armed forces were imprisoned if they failed to escape the island. It is known that 22 employees of the Singapore botanical gardens, mostly Indians and Malays, had died while being forced to work on the notorious Burma–Siam railway. G.H. Addison, a curator at Singapore, and A.J. Nauen, the curator of the Waterfall Garden at Penang and a sergeant in the Penang Volunteer Force, were taken as prisoners and made to labor on the railroad. Nauen died of blood poisoning in October 1943, during that imprisonment. H.M. Burkill was another prisoner of war in Thailand. His involvement was with wood-parties sent to the forests to obtain firewood in meter-length logs which were carried to a riverbank and then loaded into barges for transport to the Kanburi and other camps. The experience of being in the forest or swimming in the river produced pleasant moments. As a botanist he also had the opportunity of gathering local plants for use as medicinals (Burkill, 1982). Captain Max Lear Webber, senior curator of forests in Malaya, was imprisoned early in 1942 while in the Malaya Regiment and sent to camps in Thailand. In succeeding months he constructed and operated wireless sets in Tayso, Chingkai, and Kanburi camps.

With these sets they were able to issue regular underground news bulletins, which were the only reliable and true sources of news available in the camps. There was great personal danger in this operation, as the camps were searched frequently. Webber was honored as a Member of the Military Division of the Most Excellent Order of the British Empire after the war (Anon., 1947b). Murray Ross Henderson, who had been in charge of the Penang Gardens and a member of the Volunteer Rifles defense force, managed to escape Singapore by boat for Sumatra. After crossing that island by land he reached Colombo, Ceylon, and then Durban, South Africa, by boat. He spent part of the war years doing botanical work at Kirstenbosch Botanic Gardens until he could return to Britain and then Singapore (Burkill, 1983).

Botanists in Singapore who were not in uniform were permitted to continue their research or were instructed to maintain the horticultural work of the Garden (for details of administration see Burkill, 1977). R.E. Holttum was the director of the Botanic Garden, Singapore, at the time. During his administration he had built up the living and herbarium collections of ferns, gingers, marantas, bamboos, and orchids. While interned he was permitted to work on these groups, and much of his study was published after the war (Allen, 1977; Burkill, 1971). Holttum referred to his internment as "three scientifically profitable years," and Stearn (1991) noted that they "provided the foundation of his numerous outstanding post-war publications." Prof. Hidezo Tanakadate from Tohoku University was initially in charge of the occupation forces at the Botanic Garden. In December 1942 he was replaced by Prof. Koriba, who was assisted by K. Watanabe. In his book, *Orchids of Malaya,* Holttum stated, "My most grateful thanks to Dr. Koriba for the courtesy with which he allowed me the complete freedom to continue my studies, and for much personal kindness during that period."

E.J.H. Corner was the assistant director at Singapore during the same period. In 1981 he related his experiences under the Japanese administration in the volume *The Marquis, A Tale of Syonan-to,* in which he explains that his collaboration was to preserve the Botanic Garden as well as several libraries and museum collections from vandalism (Corner, 1981). He, too, continued his scientific studies of the form and growth of trees, fungi, and fruits and seeds. He worked closely with Prof. Koriba. In a booklet on edible plants and animals published in Japanese by the Raffles Museum, Corner wrote the material on plants. He related that while trying to identify the fallen fruit of *Sloanea javanica* there came to him the ideas he expounded in his Durian theory. Much material was assembled on the structure of fruits and seeds, which formed the basis for Corner's publication *The Seeds of Dicotyledons* issued in 1976 (Anon., 1947a).

Also interned at Singapore was Lt. H.E. Desch, a wood anatomist who, as a member of the Federated Malay States Volunteer Force, was imprisoned during 1942 at Changi camp, Singapore. The late Professor Tanakadate made it possible for Desch to return to the Forest Research Institute at Kepong and obtain his scattered, and mostly lost, manuscript on Malayan timbers. Volume one had been published in 1941. At various prison camps between January 1943 and September 1945, Desch was able to rewrite volume two, which was finally published in 1954. Desch also had the unique experience of being taken from his prison camp by the Japanese in order to correct the proofs of Malayan Forest Record No. 16, *Foresters' Manual of Dipterocarps* by C.F. Symington, which was unfinished at the time of the surrender. Desch saw this work through the press and then was sent back to the Changi P.O.W. camp. He retired from the Forest Service on medical grounds in 1946 (Anon., 1947a; Shrubshall, 1954).

While serving with the Royal Air Force in Malaya, Professor J.L. Audus devoted some of his spare time to collecting Malayan grasses and sedges and made detailed drawings of their habit and structure. When the Japanese invaded, he succeeded in escaping to Java with his drawings, only to be captured and imprisoned there in early 1942. Initially the Japanese were relatively tolerant, and Audus extended his studies and drawings to grasses of Java. Later, as the tide turned, the prisoners were put on defense work, mostly digging caves as bomb shelters. The drawings, however, survived the many searches and his assignments to working parties, and were finally brought back to England in September 1945. A selection of these drawings is incorporated in Gilliland's *Revised Flora of Malaya,* published in 1971 (Burkill, 1971).

Dr. Furtado, a Goanese employed at the garden, was not interned during the war but was in charge of labor on the grounds of the Singapore Botanic Garden.

Prof. Kwan Koriba from the University, Kyoto, at the age of 60 was assigned to be director of the Singapore Botanic Garden with the rank of Brigadier General. He wrote, "During my stay at Singapore, from 1942–1945, it was quite unexpected to find that there were such various growth-forms of trees compared with the temperate region." These he described in a paper, "On the Periodicity of Tree-Growth in the Tropics, with Reference to the Mode of Branching, the Leaf-Fall, and the Formation of the Resting Bud" (Koriba, 1958). This work compares favorably with the Hallé and Oldeman work on tree architecture published after 1970.

During the occupation, Watanabe made drawings of economic plants at the gardens in Singapore and Penang which were published as *Illustrated Guide to Tropical Plants* in 1969, prepared jointly by Corner and Watanabe (Burkill, 1977).

The Malayan Branch of the Royal Asiatic Society, with headquarters in Singapore, ceased to function as an active organization at the fall of Singapore on 15 February 1942, and remained dormant until after the liberation on 5 September 1945. "The Journals (of the Society) were kept in the Raffles Museum during the occupation, and the thanks of the Society for their preservation are due to those members of the staff who continued work during that period. . . . Credit is also due to the Japanese officers who were in charge of the Museum and Library for their success in preventing looting and pilfering" (Tweedie, 1947). Nevertheless, some looting occurred. It was noted that the Japanese removed the entire stock of vol. 5, part 3 (the text, in Jawi, of *The Tale of Trong Pipit*) (Gibson-Hill, 1947a; Tweedie, 1947). Gibson-Hill also noted that the data he had collected on the Cocos-Keeling Islands and the manuscript of a book on these islands disappeared from the Raffles Museum during the Japanese occupation of Malaya (Gibson-Hill, 1947b).

At Buitenzorg (Bogor) Botanical Garden and other Gardens in Java, the treatment of botanists was often severe. C.G.G.J. van Steenis, the best-known taxonomist at the Garden, as a 2nd Lieutenant in the Coastal Artillery was classified as a prisoner of war and interned in a P.O.W. camp at Tjimahi, near Bandung, following the invasion of Japanese troops and the surrender of Dutch forces. He was moved several times, eventually spending his internment at Buitenzorg. It was reported that ships with Japanese scientists were on their way to Java to head the various institutes, but the ships were torpedoed and sunk by Allied forces. This story may well be only a rumor. No supporting information has been located, and the event is not recorded in any obituaries of Japanese biologists who died during that period (Steenis-Kruseman, pers. comm., 1993b).

Under the military command and that of the Japanese Secret Police, the Dutch scientists received uneven treatment. They were free to study or do research work one day and arrested, imprisoned, and maltreated the next. With the eventual arrival of Japanese botanists in uniform to supervise the activities at Buitenzorg, conditions improved. Between March 1943 and 1945, Takenoshin Nakai, professor of botany at the University of Tokyo, served as director of the Buitenzorg Botanical Garden (Kitamura, pers. comm., 1993; Stafleu & Cowan, 1981). Nakai (1948) published a collection of notes under the title "Essential Results Obtained from My Observations on Tropical Plants in Java, Galang Island of Rio Archipelago, and on Japanese Plants in the Surroundings of Beppu Hot Springs, Province of Bungo, Kiusiu" in the *Bulletin of the Tokyo Science Museum.* The first article describes *Amorphophallus selebicus* and illustrates *A. selebicus, A. titanum,* and *A. Decus-silvae.* Two of the pictures were taken by Nakai in February and August 1944; two other photographs, taken in December 1944 and on 17 March 1945, have Nakai in the picture. In a footnote, Nakai reported, "A native employee of Buitenzorg Botanical Gardens found this photograph with some twenty other photographs from devastated house of Mrs. Rijckmans, and brought them to our camp in Kotabatu. By the generous examination of British officers at Tanjongpriok, Galang Island, and at Otake Harbour, I could keep them for myself and for science. Plant taxonomy is really harmless science, and I am glad that I pursued this course." In a "Souvenir photograph of principal members of Buitenzorg Botanical Gardens" (photo 3), the following people are listed: Mr. Tomooka, gardener-in-chief at Tjibodas garden and a native foreman; Dr. M. Sato, lichenologist; Ms. Dr. J.C. Ruinen, plant physiologist and secretary of director; Prof. T. Nakai, the director; Prof. O. Posthums (*sic*), head of the Treub Laboratory; Viscount Toda, head of floriculture; M. Bruggeman, curator; Mr. Toyoshima, chief secretary and business head (died 20 January 1945, of pneumonia).

Among the Japanese who were assigned to Buitenzorg were Prof. Tanakadate and Ir. Narusawa, both of whom tried to secure the release of Dutch scientists held as P.O.W.'s. About twenty were released, including van Steenis, M. van Raalte, H.J. Toxopeus, and A. Neervort, who returned to their posts at Buitenzorg but remained as P.O.W.'s, interned in special buildings or even in their own homes. Taxonomists Jisaburo Ohwi (1943–1945) and Sumihiko Hatusima (1943–1945) and physiologist Toyushima all worked at the Garden (Iwatsuki, 1978; Stafleu & Cowan, 1981). In his paper "New or Noteworthy Grasses from Asia," Ohwi stated: "During the past two years the writer has worked on the systematic study of the plants at the Herbarium in the Botanic Garden, Buitenzorg, Java. . . . His deep gratitudes are due to Prof. emer. R. Kanehira of Kiushiu Imperial University for his kindness in giving him all facilities for the investigation, and to Dr. S. Hatusima, for his encouragement during this study, and to Dr. van Steenis and Dr. de Wit for their cordial assistance" (Ohwi, 1947). Mrs. van Steenis-Kruseman reported that the relationships between the Japanese botanists and the Buitenzorg staff were commonly polite and cooperative (Steenis-Kruseman, pers. comm., 1993a).

The second article by Nakai, "The Kind of Banana Being Wild or Cultivated in West-Java, and Their Belongings," has a long preface pertinent to this report (Nakai, 1948).

Since I served for Buitenzorg Botanical Gardens of Java in March 1943 as the director, I began to have interest with Banana-trees and all other Musaceous

plants. Until the end of war I could nearly finish their historical, morphological, and taxonomic studies. However, to my great regret, all photographs and laborious manuscripts went to pieces at the house of old Mrs. Rijckmans by ignorant native robbers, while we were interned into the camp at Kotabatu, five kilometers distant south-east from Buitenzorg. The old widow was the wife of the late Rijckmans, the former governor of the state of Bandjermasin in South-Borneo. Her second daughter served faithfully as the best house-keeper and the most reliable friend for me through my sojourn at Buitenzorg. Her entire family put full credit upon me after they found me quite aloof from war and political business, and is only eager to keep the world-famous institutions and gardens of the botanical gardens in the best condition. Old lady was so nice for me to make promise to keep my botanical manuscripts and the botanical books and papers which I bought or were conferred on me through the courtesies of Dutch botanists, zoologists, and agronomists. Japanese defeat gave a chance to the native robbers far and near. They gradually came into quiet Buitenzorg from the latter half of September 1945. Their real antagonistic activity against Dutches, Britons and Japanese began after we entered into the camp by the British order in mid-October, and Dutch soldiers and sailors marched to Buitenzorg helped by British army as the leaders of Indonesia continued their shouting against Dutches to have been tyrants and enemies of Indonesians. Barbaric Indonesians must have considered that the robbing from Dutches is the privilege of their own and later devastated all what Japanese built up during three years. Buildings and houses were robbed and burned, protected forests were cut, the farms and rice-fields turned out soon to the bushes of tropical weeds. Pieces after pieces, blocks after blocks, disappearing from centuries efforts of Dutches are eloquently telling how terrible the war is against human felicity. Looking back the garden which we improved and the equipments of its laboratories and museums angurated much, I can not refrain my tears. I can not forget faithful cooperation of Dutch scientists with Japanese for the protection of the garden amidst the hardiest time, and the cordial gratitude expressed by Prof. O. Posthums [sic] *and Mr. Groeneveldt, the representatives of botanists and zoologists, and by Dr. de Wit, the representative of the herbarium staffs, which I hardly deserved, when the war ended. It was really too much to fight against obstinous young military polices throughout my directorship, however, sweet memory of our friendly relations with Dutch scientists lingers on my lids still now. May the garden be kept nicely forever, and stand as a perpetual center of tropical sciences and agriculture. (Nakai, 1948)*

Dr. O. Posthumus, a pteridologist, was the Director of the General Agricultural Experiment Station at Buitenzorg. "During the Japanese occupation he was allowed to continue his scientific work but for half of that period he was interned. Shortly after the war he was murdered by the rabble in November 1945" (Donk, 1949).

Dr. H.C.D. de Wit joined the Buitenzorg staff in 1941 to be in charge of the activities associated with the Garden Herbarium. He reported the Japanese troops arrived at Buitenzorg at night. A few houses, including his, were entered but few things stolen, and the majority of persons were not molested. "The reason was that the Japanese had strict orders to take and keep Buitenzorg undamaged and whole: institutes and civilians, including scientists. They were well aware of the importance of Buitenzorg

as the main center of research and education in natural sciences in the Indonesian part of tropical Asia, and they wanted this asset when constructing the future East Asian Sphere of Common Prosperity. The Gardens were closed to the public. The scientists at Buitenzorg had been ordered by The Netherlands government to continue work as usual. The Japanese military command confirmed that order."

Van Slooten continued as head of the herbarium but soon replaced the director of the Gardens, van den Honert (who was taken away as a prisoner of war), and after several months was dismissed and held in a civilian prison camp when Nakai became the director. Other taxonomists who remained active were S. Bloembergen (eventually interned in Siam), K.B. Boedijn, Donk, Eyma, and Dr. and Mrs. van Steenis. There were occasional visits from Kostermans. When Nakai and Kanehira arrived they had equal military rank as generals, so the Garden and the Herbarium–Library were considered automonous. The herbarium and library, located outside the boundaries of the Garden, were to be directed by Kanehira. The Garden itself was under Nakai. De Wit was commissioned to organize the books taken from individual houses in the central library, and was also instructed, by Kanehira, to cease work on the Garden herbarium and instead prepare a history of taxonomic research in the East Indies. De Wit was able to take the manuscript with him on repatriation to the Netherlands, and it was published in *Flora Malesiana* Dec. 1949 (series 1, 4(2): 70–161) (de Wit, pers. comm., 1993, Steenis-Kruseman, pers. comm., 1993a).

Four articles are based on observations made by Nakai (1948) while he was interned in Java after the Japanese surrender.

In sectionV, "*Ploiarium*, and Division of Bonnetiaceae," Nakai (1948) wrote,

> *In Galang Island of Rio Archipelago there is a tree which botanists recently put under Theaceae. Most up-to-date nomenclature of it is Ploiarium alternifolium (Vahl) Melchior. . . . We, interned Japanese in Galang Island used its wood often, however used more its young soft leaves for food. Several hundred Japanese including soldiers and civilians who were sent there for the first time in December 1945, were obliged to open jungles and make farms without receiving any food from commanding army until the end of February 1946, because of the cracked hard nut of lieutenant-general Kinoshita, new commander of Japanese Army in Malay, Sumatra, and Java. He declared upon us that we must work hardest without supply of food, and show to the Britons and Dutches how we Japanese can conquer utmost hardship. Exiled Japanese were obliged to feed themselves upon whatever seems to be good to eat, such as young leaves of trees and shrubs, crabfishes, weeds, seaweeds, mushrooms, both in raw and boiled with sea-water. Of course, number of sacrifices was there from the poison crabfishes, venomous plants and mushrooms. Among the edible leaves, the young leaves of Ploiarium were the best, and Japanese ate them greedily. The leaves are good to eat by cooking but are better to make pickle. They are a little sour and supposed to contain vitamin C. Notwithstanding their efforts to survive, the physical condition became so serious, as all of them fell into hungry disease. It was the end of February when British Major Karr came to see them. He was really frightened to find that Japanese there were standing on the margin of death from hunger, and gave them, our heartiest thanks to him, a big quantity of provisions and vitamin. . . . New Japanese name Kaiseidju or tree of reviving would be better to substitute with Yati-mokkok, as Japanese could keep their lives*

feeding themselves principally upon the leaves of this tree until Major Karr's relief came over them.

In section X, "Tropical *Abelmoschus Manihot*, and Its Use," Nakai (1948) stated,

When I and late Toyoshima became the director and the secretary general of Buitenzorg botanical gardens respectively in March of 1943, we looked after the plants available for manufacturing mosquito-incense for the first. I have chosen at first Titonia [sic] *diversifolia, a Mexican daisy, much planted in Java to cover quickly grooves and ditches, because I was told from an intelligent native at Garoet that Titonia was planted to check the propagation of Malaria-mosquito. Rubbing the leaves I found Titonia has peculiar smell which mosquito will surely dislike, and looking the leaves under loope I witnessed their undersurface is full of oil-glands. I collected the leaves and flowers, and dried them under direct sunlight separately. I burned them separately in the evening, and found that flowers are more effective than leaves to drive away mosquito. So, I asked to Dr. Meijer of the chemical institution to investigate what kind of oil the flowers of Titonia is containing. To our big rejoice he found easily that the flowers of Titonia contains about 0.6% pyrethrin—pyrethrin has hitherto been believed to be restricted in Pyrethrum cinearіaefolia. I asked to Dr. Ruinen of the Treub Laboratory to make the rods and coils of mosquito incense with Titonia. . . . By her good conduct a native employee made success to make best coils of mosquito incense with the mixture of powdered flowers of Titonia and powdered wood of Agathis alba pasted by the mucilage of Abelmoschus. How well we could keep ourselves away from mosquito is eloquently told by the fact that no Japanese served in the botanical gardens was infected by malaria disease during our three years sojourn. Japanese army learned this method from us, and much escaped from malarias.*

In April 1943, Prof. R. Kanehira had taken over the directorship of the herbarium at Buitenzorg and succeded in obtaining freedom for some Dutch P.O.W.'s to work in the laboratories or herbarium. The scientists were housed in various locations and came daily to the botanical institute under a Japanese military guard. Scientists included Ms. Dr. B. Polak, Dr. P.J.S. Cramer, and Dr. Ph. de Jongh, A. Hoogerwerf (Steenis-Kruseman, pers. comm., 1993a).

M.J. van Steenis-Kruseman (1972) reported, "Work at the herbarium was generally peaceful. No responsibility, no letters to write or answer, nothing but botany." Steenis-Kruseman was able to continue work on the *Cyclopaedia of Collectors* with the help of C.G.G.J. van Steenis. Dr. van Steenis was able to develop further the Flora Malesiana scheme proposed before the war began. During her imprisonment, Mrs. van Steenis was able to complete the manuscript for her article, "Select Indonesian Medicinal Plants," published in *Organization for Scientific Research in Indonesia Bulletin* (Steenis-Kruseman, pers. comm., 1993b). Mrs. van Steenis wrote, "I want to stress the very extraordinary position Kees and I were in. Both prisoners, working during war time in the same institute. I cannot think of others having had the same opportunity. The Japanese army was not too happy with the situation, and at several occasions house-raids took place in Kees' and my house. I got the impression that this

was more for intimidation's sake than for anything else. These raids were hardly professionally done" (Steenis-Kruseman, pers. comm., 1993a).

Dr. Pieter Buwalda, also a lieutenant in the Buitenzorg reserve, was in the group fighting the Japanese invasion. They were ordered to surrender, and suffered severe hardships in prison camps. Buwalda never fully recovered after the war, and died of diseases related to his imprisonment on 28 April 1947 (Steenis, 1948).

Pierre Joseph Eyma, a taxonomist of promise. Although short-sighted, he was admitted to the service when he demonstrated talent in marksmanship. He became a prisoner of war, but the release of scientists was opposed by the Japanese military. While imprisoned he suffered from dry beri-beri and malaria. "In the spring of 1945 all prisoners able to walk were transported to the Changi Camp, Singapore, where the 'hospital' had degenerated into a first class hunger camp, unworthy of man, from which very few survived. Under these conditions he died July 25, 1945" (Steenis, 1950).

Reinier Cornelis Bakhuisen van den Brink Sr., an herbarium botanist, was interned. His "life ended like that of many other aged Dutch civilians under the dismal conditions of a Japanese 'protection' camp in Java at Tjimahi, April 4, 1945" (Steenis, 1949).

The journal *Annales du Jardin Botanique de Buitenzorg*, printed in Leiden, Holland, was suspended in 1941 following the German occupation of the Netherlands but continued that year from Buitenzorg, Netherlands Indies, as the *Annals of the Botanic Garden, Buitenzorg*. Part 1 of volume 51 of the *Annals* was printed in Buitenzorg in August 1941, and the second part was not issued until December 1949, due to the Japanese occupation of Java and the Botanic Gardens. The editors reported in 1949 that "some pre-war work has been published in 1944 in a form that [was] probably meant to be the first number of a Japanese scientific journal. The inscription in Japanese on the fourth cover page indicates this was to be called "Shokubutsugaku ihö" (*Botanical Journal of the Bogor Botanical Garden*) and was authorized by the Military Superintendent of the Department of Industry on Java in 1944. The price was stated to be 5.5 florins, with no charge for postage and an admonition the journal was not to be copied. This publication has been inserted in the series of the *Annals of the Botanic Gardens*, Buitenzorg, as 'Volume Hors Série,' 1944. That number was edited by Dr. L.G.M. Baas Becking, Director of the Botanic Gardens, Buitenzorg; Dr. M.H. van Raalte, Acting Head of the Treub Laboratory; and Dr. H.J. Toxopeus, Head of the Botanical Institute of the General Agricultural Experiment Station, Buitenzorg. The issue contains two papers by van Raalte and two by Posthumus. It was printed by de Unie—Batavia with a postscript in Japanese. The paper used has browned with age and is inferior to that used previously in the *Annals* (Becking et al., 1944).

Mrs. M.J. van Steenis-Kruseman has kindly supplied me with xerox copies of title and introductory pages of the 1944 *Volume Hors Série of the Annal of the Botanic Gardens, Buitenzorg*. The Japanese version titled *Hortus Botanicus Bogoriensis, Java,* has the additional material in Japanese. The preface, written by J. Ruinen, is in English and is dated "June 2603":

> *Almost two years have elapsed since the publication of the first part of Volume 51 of the* Annals of the Botanic Gardens, Buitenzorg, *and 15 months since the occupation of Java by the Nippon Army.*
>
> *The world is still in the grip of war.*
>
> *Nevertheless research at the Botanic Gardens has proceeded without interruption.*

This has been rendered possible by the authorities who at once recognized the importance of this historical centre of investigation into natural sciences in the tropics. Not only they protected the institution during the first turbulent days of occupation, but also encouraged the continuation of the work afterwards.

A part of the last two years' research is laid down in this issue of the Annals, which at present and in future will bear evidence of the broad view taken.

I gladly use this opportunity to express the gratitude and homage of the entire European Staff to the Nippon Government for guarding and consolidating this institution of pure Science.

The table of contents page lists the four articles, two by van Raalte and two by Posthumus, first in Japanese and then in English.

Ms. Dr. B. Polak, a botanist working on peat formation in the Soil Science Institute, completed in 1942 a manuscript in Dutch on Rawa Lakbok.

The Japanese wanted a translation into English, which she made in 1943, and this was published in *Chuo Noozi Sikeenzyoo* no. 8, when she was interned. After the war it was published as "De Rawa Lakbok, een eutroof laagveen in Java" in *Meded. Alg. Proefstat. Landb.* no. 85, 1949, 60 pp., with map (Steenis-Kruseman, pers. comm., 1993a).

Dr. M.A. Donk was also a prisoner of war who survived and returned to a productive career. He spent the years 1942–1945 in Japanese prison camps, where he contracted malaria. R. Singer (1973) wrote, "After the war he told me how he saved the lives of many of his fellow internees, and perhaps his own life, by culturing a yeast which grew on palm inflorescences inside the camps and thus fermented rice which provided a minimum of vitamins necessary for survival."

Dutch prisoners of war also included Capt. Gerardus Johannes de Joncheere, a director of a shipping company stationed in Indonesia. He had an interest in ferns and developed a local collection. While imprisoned by the Japanese in Java he met Prof. van Steenis and thus began a lifelong friendship. After his retirement from commerce, he helped curate the fern herbarium at Utrecht and had an appointment as Honorary Research Scientist. His own fern herbarium was lost during his period of internment by the Japanese (Baas, pers. comm., 1993).

A.J.G.H. Kostermans once said that he worked on the manuscript for his *Bibliographia Lauracearum*, published in 1964, while imprisoned during the war years. However, in the introduction to that work he commented, "I was forced to leave the files uncared for in my house in Bogor and I feared they would be lost. Miraculously, upon my return I found the files had been transferred to a nearby hospital and were intact" (Kostermans, 1964). Kostermans belonged to the Burgerwacht in Java and was imprisoned by the Japanese successively at Bandung and Tjilatjap in Java; Changi camp in Singapore; and at Banpong and Kanchanaburi in Thailand, where he was forced to work on the Kwae Noi River railroad. Eventually he was permitted to collect plant materials from the local vegetation for food supplement (e.g., a grass soup to counter vitamin deficiency) and for medicine. Tobacco substitutes were found; alcohol for the medical work was distilled from fermented rice, while distilled ocimum oil or clove oil mixed with paint was used by a dentist for tooth fillings. During the last year of the war he functioned as a medical practitioner at Nakorn Patom camp for P.O.W.'s. When the Japanese surrendered, Kostermans obtained funds from E.D. Merrill of the Arnold Arboretum to collect plants along the Kwae Noi railroad, where

he had labored as a prisoner. Ironically, the British troops supplied Japanese soldiers—prisoners—as assistants, and Kostermans was able to collect 2,000 field numbers (Baas, pers. comm., 1993; Kostermans, pers. comm., undated).

Near the end of the Japanese occupation, some books and documents from the library at the Garden were packed for shipment to Japan. These were recovered from staging areas in Djarkarta and returned to Buitenzorg. "When the Japanese had surrendered, the Botanic Gardens proper were also in pre-war condition. The losses and damages to the Botanic Garden, Herbarium and Library were incurred during the aftermath of the occupation and caused by Indonesians and Allied Forces" (de Wit, pers. comm., 1993).

K. THE OFFICE OF SCIENTIFIC RESEARCH AND DEVELOPMENT (OSRD)

Before the United States was actually involved in the war, which began in Europe in 1939, the National Defense Research Committee was formed to implement needed research in armaments and to coordinate research programs. This was expanded by an order, in June 1941, which established the Office of Scientific Research and Development (OSRD) to encourage and direct research efforts but also was concerned with the development aspect of weapon procurement. The units of the OSRD included the National Defense Research Committee (NDRC), the Office of Field Service (OFS), and a Committee on Medical Research (CMR).

1. Quartermaster Fungal Deterioration Projects

One committe of the NDRC was the Tropical Deterioration Research Committee (TDRC), which operated with civilian technicians who were mycologists, pathologists, or anatomists (Anon., 1945d, 1945e). One botanist had the assignment of establishing a project in the South Pacific to study deterioration in situ (Heimsch, 1946, pers. comm., 1992). This was never approved by military commanders in the Pacific theatre, so field work and laboratory studies were conducted instead in Panama (Anon., 1943c; Barghoorn, 1945, 1946; Hutchinson et al., 1945) and in Florida (Wiley, 1981). An information center on the subject was established at George Washington University under the directorship of a mycologist from the U.S. Department of Agriculture (Greathouse, pers. comm., 1944, 1992). A technician was trained at the Biological Laboratories at Harvard (Miller, pers. comm., 1992). One of the first published reports dealt with the control of mold on optical instruments. Other reports were issued through 1945. Research grants were also made to various colleges. The Farlow Herbarium of Harvard University held a grant from the NRDC to study the "identity, nature and abundance of agents, mainly fungi" causing deterioration of fabrics (Raper et al., 1949; Rusden, 1947). Collections were assembled, and more than 4,500 cultures were grown, purified, and identified (Reese et al., 1950; Weston, 1945, 1947, 1949; Wilson, 1979). These committees operated independently of individual service projects on tropical deterioriation, the best known of which was conducted by the Quartermaster Corps of the Army in Natick, Massachusetts (q.v.) through the Pioneering Research Laboratory (Mandels, pers. comm., 1992). A Tropical Deterioration Research Laboratory with emphasis on basic research was established in 1944 at the Pennsylvania Quartermaster Depot in Philadelphia (Siu & Reese, 1953; White, 1946; Wiley, 1981), and the Biological Laboratory at the Indiana Quartermaster Depot at Jeffersonville dealt primarily with practical applications handling deteriorated

material sent back from the South Pacific (Gray, 1943; Gray & Martin, 1945; Wiley, 1981). Scientists at the Cotton Laboratory, Department of Agriculture, Beltsville, Maryland, were engaged in deterioration studies of cotton and woolen textiles (Shanor, 1945a, 1945b).

The mycologists of the Division of Botany of Agriculture, Canada, were also involved in studies of agents causing deterioration of materials in the tropics. "Tropic proofing war equipment," especially methods of preventing etching of the optics of binoculars and riflescopes, became a major concern of the Department (Saville, pers. comm., 1992).

In Australia several organizations paid attention to problems of deterioration of material, especially optical equipment (Anon., 1943d, 1943e, 1943f). Dr. B.J. Grieve was involved in research relating to fungal contamination of fieldglasses and the like under field conditions in New Guinea (Lonergan, pers. comm., 1993). Dr. Mary Tindale worked briefly in a parachute factory in Australia, concerned especially with the treatment of the fabrics to prevent fungal decay (Briggs, pers. comm., 1992; Tindale, pers. comm., 1993).

Additional references may be found in *ADTIC Special Report* (Project T-25), 1945 (Anon., 1945d).

L. OPERATIONS RESEARCH GROUP (ORG)

This group consisted of civilians in unmarked uniforms on special assignments associated with mining and undersea warfare, antiaircraft fire, U-boat attacks, aircraft carrier protection, and so forth. A few biologists are reported to have served amidst the dominance of physicists and mathematicians. These biologists have not been identified.

M. OFFICE OF STRATEGIC SERVICES (OSS)

This was an interservice agency operating with both military and civilian personnel. The only botanist who has been identified in the OSS had the title of "geobotanist" and did research on botanical problems of significance to the intelligence services (Constance, pers. comm., 1991).

The OSS made use of the map collections and photographs in the files of the Arnold Arboretum and probably those of other botanical institutions (Merrill, 1943). The collections from the South Pacific were of special interest. Collectors' notebooks and descriptions of coastlines were carefully studied. Of particular interest were the notes and collections of L.J. Brass for the Archbold expeditions to Guadalcanal held by the Arnold Arboretum (Howard, 1992a, pers. comm., 1992b; Merrill, pers. recoll.; Myers, pers. comm., 1992). In a similar fashion, the Jungle Survival Course instructors from the Air Force School of Applied Tactics, Orlando, Florida, met with Dr. David Fairchild to gain information on the poisonous and edible plants and fruits he encountered in his expedition to Indonesia and the islands to the north of it in 1939 (Fairchild, 1945; Howard, pers. comm., 1992b).

H.H. Bartlett was called to Washington and the Pentagon as the war in the Pacific approached the possible invasion of the Philippines. Bartlett was asked to suggest a beach where MacArthur could come ashore from a landing craft to fulfill his promise, "I shall return." Bartlett, who had taught at the University of Manila for several years, recalled several beaches that might fill the need for shallow slope and smooth water.

Camera crews were set up for this "photographic opportunity," and the pictures of MacArthur wading ashore were circulated around the world (Shacklette, pers. comm., 1992).

N. WOOD ANATOMY

The wood section of the Industrial Test Laboratory at the Philadelphia Naval Shipyard had three subdivisions employing botanists and zoologists. One section, concerned with marine borers and torpedo damage control, used zoologists, especially malacologists. A second section studied fire retardants and was staffed with chemists. The third section dealt with wood decay, primarily the action of fungi. A wood anatomist was in charge of the project which conducted studies on wood preservatives; finding substitutes for teak wood for decking; and studying structural characteristics associated with twisting, curling, and splitting of timbers (Tippo, 1945, pers. comm., 1992; Tippo & Spackman, 1946; Tippo et al., 1947).

O. SUMMARY

It is very clear that whom you knew was as important as what you knew in assignments in and out of uniform for botanists during World War II (Evans, pers. comm., 1992; Howard, 1992a; Powell, pers. comm., 1992; Swanson, pers. comm., 1992). Within the services a senior officer could request the service of an individual, and a transfer could be effected. Likewise, some senior botanists in civilian roles were able to capture students from the grasp of the draft board to serve in a civilian capacity and an exempt industry. However, some draftees and officers in uniform were able to find niches in which to use their talents or training for the benefit of the military. It is possible that "personnel" officers did the best they could in placing draftees in the right position. However, the numbers to be classified were overwhelming and the need for decision immediate.

The subject of a blanket deferment of scientists was raised during and after the war. Stewart, in his book *Organizing Scientific Research for War*, stated, "The subject is certainly one which should receive careful study over the next few years in order that the whole problem of scientific manpower may be better handled in the future, if the occasion arises, for it was badly handled in World War II" (Stewart, 1980).

In the modern military establishment, an attempt is made to place the candidate in a position of his choice or one where his talents are most effective. Computers certainly aid in this search. Any student of biology today should be familiar with the Army Military Occupation Specialty (MOS), Air Forces Specialty Classification (AFSC), or the Navy Rating most appropriate to his or her interests or training, should he or she be called to or choose military service.

In retrospect, a respectable number of botanists found a role in the military or in civilian life where they could contribute to the war effort in their professional field. A very few who entered with advanced degrees chose to remain in the service until retirement (Clark, pers. comm., 1992). A few returned to civilian life but continued service in the reserve (Howard, pers. comm., 1992b; Phillips, pers. comm., 1992). Most colleges and universities attempted to reemploy their staff members who had served in uniform. Returning servicemen found, all too often, that their colleagues who had stayed at home had advanced in rank and seniority. In general, the discharged serviceman found his military occupation had little value in civilian services, but there

were a few exceptions (Patt, pers. comm., 1992). If the returning servicemen of World War II had retained their health, mental and physical, many found benefits from their excellent physical condition, and they played a role intellectually as leaders, teachers, or administrators.

V. Acknowledgments

Dr. Rudolph Schmid reviewed a new printing of *Plant Life in the Pacific World* in an issue of *Taxon* (Schmid, 1991a). A few of his comments on the history of the publication and the role of E.D. Merrill did not agree with my recollections, and I wrote him to correct the record. He suggested the corrections could be published in a future issue of *Taxon* or, better still, that I compile data on the role of botanists during World War II (Schmid, pers. comm., 1991b). I decided to accept that challenge and wrote for data to the late Dr. Raymond Fosberg, who I knew had an important role in the search for *Cinchona* in South America. Subsequently, Fosberg commented to Dr. Roy McCleod of the Australian National University that I had this information and perhaps a contribution from me might fit into a planned publication of a symposium on science in the Pacific theatre during World War II. I did receive an invitation to submit an "essay," but the style and content requested would require more time and effort than I felt I could devote to it. The format I was using was compatible with the style of *Botanical Review,* and the late Dr. Arthur Cronquist, then editor of *Botanical Review,* had been encouraging. My goal in the compilation of data was to determine the role of botanists, in the broad sense, to the war effort in the Pacific theatre, in uniform or out. The impetus for this paper, then, came from the several people mentioned above, and I am grateful for their suggestions and comments. I felt this survey should not be exclusively of U.S. botanists, and sought data about botanists from Canada, New Zealand, and Australia. My contacts with the War Museum in Ottawa and with Dr. James Soper have been particularly helpful regarding Canadians. Mrs. Watson Smith, known before her marriage and professionally as Dr. Lucy Cranwell, gave me suggestions of people in New Zealand, and Dr. A.D. Thomson of the Centre for Studies on New Zealand Science History has proven to be a wonderful source of information. In Australia, I must acknowledge the help of Drs. Barbara Briggs and Knowles Mair and Mr. C.K. Ingram. Data on the role of interned botanists from Singapore and Buitenzorg has been supplied by Peter Green and H.M. Burkill of Kew and Peter Baas, Mrs. M.J. van Steenis-Kruseman of Leiden, and Prof. dr. H.C.D. de Wit of Wageningen. I consulted the Smithsonian Institution Archives for information of servicemen collectors and the Forest History Society, Inc., for data on foresters. The curators of each were most helpful. At the Smithsonian Institution Archives, the material of Record Unit 7270, the Egbert Hamilton Walker Papers in Box 1, were particularly useful.

These and a great many others are cited in the bibliography for their correspondence and conversations.

A few zoologists, physiologists, and medical specialists, who admittedly are not botanists even in my broad interpretation, were contacted in person or by letter, and a small part of their war effort contribution has been included. The full role of zoologists would be a comparable study and is left to others, with my apologies to those who responded to my general questions and then were not included in this paper.

A few individuals who responded supplied extensive information or stories from

their unpublished memoirs or "grandfather stories" written for family. I do encourage these people to consider possible publication of their full documents. When names of individuals were suggested to me, I checked in the ninth edition of *American Men of Science,* volume 2, *The Biological Sciences* (1955). The entries in this edition commonly gave some information on the war record or service during World War II as well as the date of birth. I then checked the same name in the 1992–1993 edition of *American Men and Women in Science.* Records of service for any war are rarely given, but a current address is supplied. Individuals born in 1910 would now be 83 years old, and I'm grateful to all born that year and in the subsequent decade who replied to my inquiry. World War II was fifty years ago. Memories may have faded and handwritten replies may be difficult chores. Nevertheless, old acquaintances were renewed and some pleasant memories revived. I'm indebted to all who helped.

I plan to leave this file of correspondence, along with my personal archives of World War II publications, in the library of the Arnold Arboretum of Harvard University. If I am lucky to last for a few more years, any comments, corrections, or additions would be welcomed and would be added to the files.

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