

Chapter 4
Island Renewable Resource
History and Trends

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Island Renewable Resource History and Trends

HISTORY OF THE ISLANDERS

Introduction

Although histories of the peoples and settlement of the U.S.-affiliated island areas are diverse, certain common factors exist: 1) at one time all but American Samoa were colonized or administered by foreign nations, and 2) at one time they have been of some strategic importance to the United States. Nearly all of the indigenous island populations suffered population depletion as a result of colonization. Direct causes ranged from the introduction of disease to the active removal or relocation of inhabitants (e.g., decimation of the Caribbean Arawak population, Chamorro wars in the Marianas).

The majority of the U.S.-affiliated islands were subject to one or more colonial powers.¹ American Samoa is the only island group which remained independent until the United States gained authority over the eastern Samoa Islands in 1899. Guam and Puerto Rico essentially experienced only one colonial authority—Spain. Both island areas were ceded to the United States at the close of the Spanish-American War in 1898. Spain's authority lasted close to 400 years in Puerto Rico and some 300 years in Guam. Although several colonial interests developed in the U.S. Virgin Islands, the Danes had the most extensive interests and authority lasting nearly 245 years. The United States purchased the Danish West Indies in 1917 after nearly 50 years of intermittent "negotiations."

Traditional island cultures depended on a variety of island resources for their sustenance and they developed many resource management and conservation techniques (18). Traditional resource management required supernatural

sanctions, a harsh discipline, inequality of people, resource apportionment, and curtailment of individual freedom (25). An ethic of minimal exploitation of necessary resources allowed for recovery of those renewable resources exploited in the traditional system. Original inhabitants of the islands were essentially self-sufficient; living off the surrounding terrestrial and marine resources or acquiring necessary resources through intra- and interisland exchange systems (1,25,46,88).

Although the social organization of individual island groups was unique, some display common characteristics. Social structure on most islands was a well-defined hierarchy that clearly outlined individual rights and duties. Most of these social hierarchies included a head or paramount chief, lesser chiefs, clans, lineages, and upper and lower classes (46,61). Although, many variations in social organization existed, they all contained some mechanism for critical resource control through social hierarchy (46).

Generally, native island resource-use techniques were not adopted by the colonial powers; although some colonial agriculturalists did adopt indigenous cropping regimes (97), the primary impetus for colonization was to secure high-value goods and minerals to supply the homeland economy. As such, the colonial attitude was not one of conservation, but rather exploitation. New production methods and values were introduced as well as new crops and livestock. Islands which were heavily exploited suffered land degradation and resource depletion.

Subsistence agriculture and fishing continued to be an important part of the indigenous society of the Pacific islands during the colonial period although, in some areas, cash crops en-

¹Colonial authority in this report refers to the various powers who claimed the islands prior to their entering various political associations with the United States.

croached on lands available for subsistence agriculture (e.g., sugarcane and copra plantations). Traditional production methods slowly became more restricted to those rural and outlying areas in least contact with the trade centers. Islanders became more accustomed to a lifestyle involving imported goods, the status of traditional subsistence methods decreased and, correspondingly, dependence on outside sources increased.

The colonial authorities in the U.S.-affiliated Caribbean islands focused on commercial agricultural production for export purposes. Nevertheless, a subsistence sector developed and persisted in Puerto Rico (97). Although the Danish West Indies were inhabited by Amerindian agriculturalists at the time of Columbus, by the time these islands were colonized in the 17th century the Indian population had disappeared.

U.S.-Affiliated Western Pacific Islands

Introduction

Ancestors of Pacific island peoples originated in Southeast Asia. Western Micronesia—the Marianas, Yap, and Palau—was first settled by migrants from the southeast. Ancestors of the peoples of eastern Micronesia and Polynesia moved through northern Melanesia and up through Vanuatu (5). These settlers brought with them nearly all the food crops that became their staples (1) and may have introduced animal species as well (46).

Social Organization

The fundamental difference between the ecologies and resource bases of the high islands and coral atoll islands was reflected in traditional cultural systems. High islands generally have larger land mass, better soils, and more abundant freshwater resources than do atoll islands (46). Despite the number of exigencies of atoll life, population densities were generally greater than on high islands.

The stratified social organization which developed in the Pacific islands was designed to provide for the subsistence needs of the members, settle disputes, and manage essential resources. For most of Micronesia, the systems of social organization and land tenure were based on matrilineal descent. Individuals were members of lineages and several lineages could comprise a clan; these units were further ranked within the society. Authority generally flowed from paramount chief, to lesser chiefs, to commoners. In most areas, certain lineages or clans were in charge, with the lineage chief being paramount and the junior ranking males serving as lesser chiefs (46). Better quality land went to higher ranking members of society in some instances; however, individuals had access to necessary raw materials (46).

One variation of this structure existed in the Carolinian atoll islands between Yap and Truk. In the Carolinian group little stratification existed and each atoll or section of a larger island was a politically autonomous community. Lineages were ranked according to their arrival and settlement on the island with the lineage of greatest antiquity being most senior and its head being the community's chief (46).

The matriclans in Yapese society functioned as in the other Micronesia islands; however, there was no lower order of landholding matrilineages. Rather each village was comprised of a number of patrilineages each with its own head and these were the landholding units of the society. Village lands were ranked as higher low-caste land and then further subdivided. High caste villages often occupied the best land and additionally "owned" the land of the low caste villages (46).

An exchange system, sawei, once linked the high island of Yap to all the atoll islands from Ulithi in the west to Namonuito in the east. This system provided a mechanism for peoples of small, vulnerable atoll islands to move freely between islands, in turn establishing a network allowing members to request aid from other is-



Photo credit: Office of Technology Assessment

Traditional Micronesian villages still exist, such as this one on a Trukese atoll island.

lands in times of need (e.g., typhoons or food shortages) (1,2).

Traditional Subsistence Economies

Traditional subsistence economies have been characterized as “nature-intensive” (25), which implies the optimum use of naturally functioning ecosystem processes to provide for the subsistence needs of the population. Islanders developed production techniques that took advantage of the natural workings of the island (e.g., stream diversion for irrigation) and the limited land resources. Atoll dwellers, with little arable land, focused on improving and increasing marine harvest methods. Trade between atoll dwellers and high islanders was common (e.g., the Yapese sawei system). Evidence exists that a form of aquiculture was practiced on several of the western Pacific islands (Pohn-

pei, Kosrae) (115) and remains of old fish ponds still exist on Yap.

Most agriculture involved food-bearing trees and root crops, many of which were imported with the first influx of settlers. Coconut palms were of major importance, as well as breadfruit, papaya, bananas, and pandanus. Root crops included wet- and dry-land taro, yams, sweet potatoes, and arrowroot. Agricultural terraces similar to those found in Southeast Asia existed in the Marianas and Palau (5). Several tree species were used for construction of dwellings and canoes; pandanus leaves were used for canoe sails, and thatch for houses. Coconut fronds, especially Nipa palm, also were used for thatch.

Marine resources were important, especially for the atoll dwellers where terrestrial resources were extremely limited. Coral reefs associated



Photo credit: Office of Technology Assessment

These Kosraean craftsmen combine traditional skills with modern tools to carve a canoe from a breadfruit tree.

with islands and lagoons of atolls supported a variety of reef fish, turtles, and shellfish. Pelagic species often were critically important to meet the subsistence needs of the society. Canoes were used for trolling in the open ocean as well as still fishing in protected lagoons. Nets, traps, weirs, and spears also were used. The tools and fishhooks were fashioned from locally available materials such as wood, shell, stone, and coral. The behavior, movement patterns, and mating habits of marine species were known in detail by the islanders. Islanders knew much about the lifecycle of many organisms and their patterns of seasonal abundance (42). Mollusks and crustaceans were gathered within the intertidal area.

Throughout the region, fishing knowledge was property of great personal value and thus not lightly shared with others in the community (42). Harvest methods, distribution patterns, and customs differed, but these patterns resulted in an apparently effective resource management system. Rights to harvest certain species or to fish in certain grounds were often held exclusively by particular families or other specific groups within the community (93). Recent research in Palau has revealed that the traditional body of knowledge of marine species and behavior was quite sophisticated and

comprehensive, rivaling that of today's marine biologist (42).

These traditional economies comprise three distinct sectors: a production sector, controlled and organized to serve individual family needs; an exchange sector, governed by kinship and traditional political organization to serve community needs; and an investment sector, through which the resources were managed (89).

The production sector centered almost entirely around the family unit with individual members performing specific tasks in providing for family needs. Each family had privileges to the land and sea apportioned to the clan (89).

The exchange sector was important in the daily working of the subsistence economy and served to ensure the flow of goods from the more productive to less productive members. This sector became particularly important when normal family production was insufficient (e.g., sick, injured member), or when there was a wider community need (e.g., natural disasters). At these times, the paramount chief could designate other members of the clan, or of other clans to assist in production, or summon labor for community benefit (89).

The investment sector characterizes the traditional economy's sustainable management of the resource base. It couples minimal exploitation of resources with fallow periods allowing recovery of renewable resources. These naturally regenerating resource areas were essentially an investment in biological capital to ensure future productivity. This relative underproduction provided the flexibility necessary to absorb sudden population immigrations and natural disasters (89).

Western Contact

Western contact in the Pacific began in 1521 with Ferdinand Magellan's arrival on Guam. The first Spanish colony established on Guam in 1565 served as a provisions stop for Spanish galleons sailing between Florida and the Philippines (67). Spain's primary interest in the Mariana islands was "saving souls" and little effort was spent in exploiting the islands' renewable resources.

Spain renewed its colonization efforts in the Mariana Islands nearly a century after the initial colony was established on Guam. With the arrival of Jesuit missionaries in 1668, Spain claimed the rest of the Mariana Islands. Missions were established on Rota, Tinian, and Saipan; and “Christianization” of the indigenous population began in earnest. The Jesuits instituted formal education, primarily of a vocational nature, with an emphasis on religion (67).

Western contact initially reduced the different indigenous Micronesia populations through introduction of disease (89) and conflicts that ensued over religious beliefs increased the toll. While Spain laid claim to most of Micronesia, they did not attempt to extend actual rule outside of the Marianas until other nations attempted to gain a foothold in the region (46).

American and English whaling vessels began to frequent the Micronesia islands in the 1830s and experienced a short-lived prosperity lasting for nearly two decades. Islanders became involved in world trade as they exchanged local commodities (e.g., sea cucumber, shells) for imported goods (e.g., iron, glass). During this period, American missionaries began arriving on some of the westernmost Micronesia islands (Kusaie—now Kosrae) to offer the Protestant religion to the indigenes. Throughout the Spanish period, various nations, including Germany, Japan, and the United States were present in the islands as traders and whalers.

The mid-19th century brought the beginning of the copra (dried coconut) industry. Successful copra operations were established by German traders in the Marshall Islands. The presence of the copra traders expanded the exposure of islanders to world markets and imported goods and encouraged islanders to develop coconut palm plantations. Several German companies were established in Micronesia by the 1860s and within 10 years copra was the primary export of Micronesia (76). Land remained in indigenous hands and Micronesians entered what was later to be called the era of the “coconut civilization” (69).

Development of the copra trade led to increasing German encroachment on previous Span-



Photo credit: Office of Technology Assessment

The copra industry still forms the basis of economies on many U.S.-affiliated Pacific islands.

ish territorial claims, ultimately resulting in a power struggle between Germany and Spain. Germany declared a protectorate over the Marshall Islands in 1885; took control of Yap; and claimed Truk, Kosrae, and Pohnpei. A papal decision, made in 1885, settled the conflict. Spain’s authority over the Caroline islands was reaffirmed. Germany retained authority over the Marshall Islands and received trade and fishing privileges within the Spanish islands and the right to establish fueling stops (67).

The Spanish-American War brought an end to Spanish authority in Micronesia. Guam was ceded to the United States in 1898, and Germany purchased the remainder of Spanish Micronesia, Japanese companies continued to be active in Micronesia commerce during the German period until 1901 when they were barred from the region for selling firearms (69).

The German administration of Micronesia brought increased commercial activity, primarily in the area of copra trade. However, phosphate mining on Angaur (Palau) was also a successful operation. The Germans instituted a system of “indirect rule” with the islands being administered by the Germans through the hereditary chiefs. This period furthered the breakdown of land tenure practices in favor of individual ownership. The German administration prohibited alien purchase of Micronesia

land. Any person or company interested in establishing a new business was required to negotiate a lease with the German Government, which in turn negotiated with the native owner. Mandatory education also was instituted, and although of a broader scope than Spanish schooling, the emphasis remained on religion (69).

Germany's rule ended in 1914 with the beginning of World War I and Japan seized control of Micronesia. Japan established a military administration which lasted from 1914 to 1920 when the League of Nations sanctioned Japanese authority by Mandate. Early in the military administration many of the old German policies were continued (e.g., tax system, mining operations) (89). A civilian government was established in 1922 and economic development based on resource exploitation began (89). Copra trade was further expanded, with islanders continuing to be the major producers, and commercial fishing increased in importance (46). A sugar industry was developed in the Marianas. Japanese nationals were brought in to cultivate and harvest sugar and soon outnumbered islanders. By 1940, 80 percent of the total labor force on the islands was Japanese or Okinawan (89).

The Japanese Mandate Period has been characterized as the most economically successful period in the history of the Micronesia islands. Fishing, sugarcane, copra, and pearl culture are a few of the many areas the Japanese developed (89,91). However, despite the increased economic success of the period, the benefits of the period went largely to the Japanese. Production skills remained concentrated in the hands of Japanese nationals. Traditional authority was greatly weakened and the Micronesians became accustomed to an authority imposed from outside. The Japanese era in Micronesia ended with World War II (46).

United States Administration

U.S. administrative involvement with the western Pacific islands began at the close of the Spanish-American War when the island of Guam was ceded to the United States. In 1947, the United States, in accordance with an agree-

ment with the United Nations Security Council, assumed administration of most of Micronesia as a United Nations Strategic Trusteeship. The trusteeship allowed the United States plenary control over the islands including the right to establish military bases and foreclose access. The United States was to protect the welfare of the inhabitants and eventually prepare the islands for self-government or independence (89).

The U.S. Navy assumed initial administrative responsibility for the islands at the end of World War II. Administrative policy was a slow-paced approach to development that extended through the first 15 years of U.S. administration, largely as a reaction to the Japanese Mandate Period (89). All Japanese were repatriated by the end of 1946, thus removing the bulk of prewar era production expertise. promotion of the welfare of the Micronesia people was the objective of the naval administration.² Large development projects were excluded from the islands on the grounds that they did not promote the welfare of the Micronesia people.

The United States Commercial Company (USCC) was created within a few months of the inauguration of U.S. Naval administration in order to supervise the economic development of the Trust Territory of the Pacific Islands (TTPI). USCC bought produce for export from islanders and offered a selection of import items. In an effort to develop the economic potential of Micronesia, the USCC conducted an economic survey of the territory (89). Rebuilding the copra industry, fishing, and agriculture activities, which were destroyed in the war, were the major USCC goals.

The USCC was replaced in late 1947 by the Island Trading Company (ITC), a corporation that was capitalized by the Navy and run by the Deputy High Commissioner. The purpose of ITC was to promote development by furnish-

²In a directive issued in December 1945 by Admiral Spruance, military governor of the islands, the American position was stated as follows: "indiscriminate exploitation of the meager resources of the area is to be avoided. . . . The establishment, for the profit of aliens, of enterprises which tend to maintain the island economy at the level of cheap labor and which do not permit the islanders to enjoy the full benefits of their own labor shall not be tolerated" (40).

ing technical assistance and services to locally owned businesses. It provided loans and subsidies to island businessmen to stimulate growth of industry, and provided warehousing and importing services. Under ITC, retail stores proliferated in Micronesia. ITC purchased and marketed copra, handicrafts, and other exports much as USCC had done. However, efforts to encourage production of new crops did not fare well and numerous enterprises failed. ITC was liquidated in 1954 and by that time several local import companies were strong enough to survive on their own. The other functions ITC performed were dispersed to other organizations (89).

Civilian administration of the TTPI began in 1951 when the U.S. Department of the Interior assumed the responsibility. Self-sufficiency for the TTPI remained the goal under the Department of the Interior. The objective was to duplicate the successes of the Japanese era without the associated exploitation and alienation of land and labor. U.S. authorities encouraged government investment in lieu of private capital investment, and government subsidies were carefully controlled so as not to undermine the goal of self-reliance. The annual subsidy at this time remained at a level of \$5 to \$6 million each year and the value of exports remained between \$2 to \$3 million each year. The system of taxation developed during naval administration, though largely an insignificant source of revenue, was retained. Municipalities were encouraged to develop tax systems and use the revenue to sustain municipal needs (e.g., teacher salaries, school repairs) (89).

The direction of U.S. administration changed in 1963 to a program of intensive development in Micronesia. U.S. appropriations for the Trust Territory increased from \$13 million in 1964 to over \$60 million in 1971 and continued to rise until the close of the 1970s. Funding during this period was directed largely toward administration, schools, and health services. Between 40 and 45 percent of the TTPI government's annual budget was allocated for health and education (89).

With increased assistance, the Trust Territory government began to assume many respon-

sibilities formerly handled by municipalities. The emergence of a bureaucracy was apparent. The government work force tripled during the 1960s and private sector service industries expanded accordingly. Concurrently, imported goods became available in unprecedented quantities and by 1970 import value had reached \$20 million. Exports, however, remained at the earlier levels (about \$3 million) with only minor fluctuations (89).

Capital improvement projects, with the goal of developing the solid infrastructure necessary for self-sufficiency, became a considerable budget item beginning in 1970. Construction of public buildings, roads, airports, and dock facilities, were some of the projects. The impact of these projects, however, was realized more in the nature of salaries than in an actual increase in productivity. Federal program grants also became available during this time, and much of this funding was directed toward improving social services. Total U.S. assistance peaked in 1979 at \$138 million (89).

Exports increased notably during the 1970s, and by the end of the decade export values had reached \$16 million annually. The increase was due largely to increasing tourism and industries producing tuna and coconut (copra and oil). Some of these gains were short-lived and, when considered with the rate of inflation, were near the 1948 levels of export income (89).

The Compact of Free Association, which was approved for the Federated States of Micronesia and the Republic of the Marshall Islands by the U.S. Congress and the United Nations Trusteeship Council in 1986, offers an opportunity for the islands as well as the United States to foster increased Micronesia self-reliance. The Compact is designed to give Micronesians control over their internal and external affairs, and funds to develop a means of increasing self-support within a 15-year period; the United States retains defense and security responsibilities. Local government emphasis is now on economic development (25).

The United States' financial support for economic development in Micronesia initially will increase under the Compact of Free Associa-

tion. Then, assistance will decline through the stipulated 15-year period, with decreases occurring every 5 years after the beginning of the compact. The Republic of Palau elected to maintain an even spread of funding throughout the 15-year period.³ Funding available for capital improvements will initially increase while funding for social welfare programs and government bureaucracy will decrease. This represents a major aim of the compact: to provide a base for future local productive industries and prepare Micronesia for increased economic self-reliance. Almost 40 percent of U.S. assistance is earmarked for infrastructure and development projects (89).

Micronesia's cash economy today is roughly 90 percent dependent on U.S. aid, thus, aid reductions stipulated in the compact will have a pronounced impact on the area. Previous policy trends of rapidly expanding aid largely for social programs and support of the public sector will change under the Compact of Free Association. The change in U.S. policy perhaps will foster development of an independent private sector economy; with increasing importance placed on services, light industry, and development and sustainable exploitation of local renewable resources (89).

American Samoa

American Samoa is the southernmost U. S.-affiliated polity. It lies within the region known as Polynesia and the inhabitants are culturally and racially related to Hawaiians, Tongans, and Maori (New Zealand). Archeological evidence suggests initial settlement of the Samoa islands occurred before 1,000 B. C., probably from eastern Melanesia (53).

American Samoa is comprised of a group of seven islands, the largest of which is Tutuila with a land area of 54 square miles and on which the capital city of Pago Pago is located. Ninety percent of the territory's population reside on Tutuila (106).

³The compact with Palau has not yet been approved.

Social Organization

The social organization of American Samoa was more flexible than that found in Micronesia. The largest social unit was the **aiga**, and it included all those people who could trace descent from the founder of the group. Descent could be traced through males or females, and any given individual belonged to a number of **aiga**. The **aiga** held land in a particular village and each village had one or more **matai** (titled chiefs). The **matai** were selected by consensus by the **aiga** membership. The **matai** of a village formed its governing council or **fono**. Individuals could live and work the land of his or her **aiga**, and since an individual belonged to many **aigas** a choice had to be made as to where he/she would actualize his/her potential rights. Thus, an individual selected to reside on land of one **aiga** to which he/she belonged and localized extended families formed within the **aiga** (46). Villages were self-sufficient entities and generally composed of one or more **aigas** (106).

The topography of American Samoa encouraged development of coastal settlements. Steep mountains, the relatively narrow band of flat lands adjacent to the shoreline, and accessibility of fresh stream water predicated the choice of coastal area (106). Samoan subsistence agriculture was similar in many ways to that of the



Photo credit: A. Vargo

Cultivation methods for steep hillsides were developed early in American Samoa's history; many of these techniques are still used today.

U.S.-affiliated western Pacific islands; tare, breadfruit, yams, coconut, banana, pineapple, and papaya were cultivated (53).

The Samoans also relied heavily on marine resources, and were excellent fishermen and navigators. The large sail-rigged double canoes in use by the Polynesians could hold nearly 100 people (69). Most fish and shellfish were collected in streams, lagoons, and along reefs. Reef fish were typically part of the traditional Sunday Samoan Feast called *fiafia* (106). However, offshore species such as bonito and tuna were also collected. Implements used for farming and fishing were fashioned from wood, stone, and shell (69).

Western Contact

American Samoa's contact with the West began with the Dutch arrival in 1722, nearly two centuries after Magellan arrived on Guam. By the 19th century the United States, Great Britain, and Germany had established commercial enterprises within the island group. Conflicts arose between the foreign interests and in 1899 the islands were divided with the United States assuming authority over the eastern Samoa islands (Tutuila, Aunu'u, Tau, Ofu, and Olosega).⁴ Germany assumed jurisdiction over the islands of Western Samoa which later became independent. The Cession of Tutuila and Aunu'u, signed in 1900, allowed for the traditional Samoan land-tenure system to remain in effect with allowances for government accession of land as necessary (106). Initial authority over the islands was held by the Department of the Navy. The Department of the Interior assumed oversight in 1951 and continues today in that capacity. The American Samoa Government operates under a constitution adopted in 1960.

The firmly established traditional lifestyle and social structure of American Samoa persevered throughout contact with western nations and continues today. This lifestyle, known as *Fa'a Samoa* ("The Samoan Way"), places considerable value on group dignity and achievements.

⁴Swains Atoll, 225 miles north of Tutuila, was annexed by the United States in 1925.

The extended family, *aiga*, remains the keystone of traditional communal lifestyle. Land tenure is based on the communal lands of the *aiga* and the selected chief, *matai*, manages the communal economy, and protects and distributes the lands (53,106). Nearly all land in American Samoa is held by indigenous Samoans. Ninety-two percent of the land is held by *aigas*, 7 percent by the American Samoan Government and churches, and a fraction of the remaining 1 percent is in a freehold status (106).

American Samoa has experienced problems similar to those of Micronesia in the shift from subsistence to cash economies, including a drop in local agricultural production. Although nearly 80 percent of American Samoan households practice some form of gardening, Samoans purchase 75 percent of their food requirements (46,53). This shift has been accompanied by increased economic dependence on the United States' for imported goods and services (53). The largest employer is the American Samoa Government, followed by the tuna canneries; a range of retail and service enterprises comprise the third major portion of the economy (46).

U.S.-Affiliated Caribbean Islands

Precontact cultures of the U.S.-affiliated Caribbean islands share some commonalities with those of the Pacific. The indigenous populations were subsistence economies dependent on the available land and sea resources.

The origin of the early inhabitants of Puerto Rico and U.S. Virgin Islands still is uncertain. They have been described as seminomadic peoples; primarily hunters and fishermen, establishing their settlements near the island's coastline and mangrove forests. Archeological excavation of settlement sites show no evidence of agricultural practices (61).

⁵In 1980, the American Samoa Government budget was nearly \$73 million, of which \$32 million came from Federal sources (30).

Subsequent migrants were of Arawak culture⁶ with origins in the Orinoco Basin in South America. Archeological sites date their arrival on Puerto Rico in the vicinity of 120 A.D. The early Arawak settlers also were hunters and fishermen. Coastal areas were the original settlement sites, however later settlements were established in the interior of the island. A more complex social organization had developed among the Arawak by the time Puerto Rico was settled by the Spaniards (61).

Arawak culture is characterized as peaceful and sedentary; energies were directed towards hunting, agriculture, and fishing. The primary agricultural tool was a primitive hoe, and crops such as cassava and arrowroot were cultivated (61,88). Swidden, or slash and burn, clearing, was employed and root crops commonly were interplanted in mounds of soil (knee high by several feet wide). This method—conuco cultivation—provided soil aeration and maximized the range of arable land (88).

Evidence exists that fishing played a significant part in the lives of Indians who inhabited Caribbean islands prior to European settlement, although it is not possible to assess the relative importance of fishing compared to other resource use activities (34). Fish, shellfish, turtles, marine mammals, and waterfowl were harvested from nearshore environments and offshore waters (88). Precontact Indians of Puerto Rico harvested forest products for a variety of uses including construction, canoes, fuel, foods, dyes, and medicines (119).

The social organization of the Indian culture included a chieftain (caique) who exercised authority over a higher class (nitainos) and a lower class of workers (naborias). There were regional chieftains as well as a paramount chieftain (61,88).

Puerto Rico and the U.S. Virgin Islands were encountered by Christopher Columbus in 1493. Juan Ponce de Leon claimed Puerto Rico for

⁶The term *Arawak* shall be used in this discussion to refer to the Indian population of the U.S. Caribbean area present after the early inhabitants. This culture has been further divided by many historians to differentiate various tribes of Arawak culture including Taino, Carib, and Borriquoeno.

Spain in 1509; the first colony was soon established in Puerto Rico. The island of St. Croix, in what was to become the Danish West Indies, was first colonized in the 1630s by several European nations.

Puerto Rico was inhabited by Arawak Indians at the time of colonization, and the population largely was decimated in the colonization process. The Virgin Islands, although populated by indigenes at the time of Columbus' arrival, were not inhabited at the time of colonization; the population having been eliminated largely through Spanish efforts during the 16th century (27).

Puerto Rico

Puerto Rico's forests were modified by the island's earliest inhabitants; however, population pressure was low enough to allow recovery of the exploited areas. Thus, essentially all of Puerto Rico was forested at the time of Spanish arrival (75,88,119).

Spain's interest in Puerto Rico was enhanced by the discovery of the island's gold resources. Gold was mined efficiently and deposits were essentially depleted by 1540 (61,75). Despite considerable outmigration at the end of the gold mining period, the colony was maintained (75, 97). The colonists that remained turned to an agricultural livelihood.

Forest clearing increased with the arrival of the Europeans, largely through efforts to access agricultural lands, although forest products also were harvested for construction and fuel (119). Highly valued Puerto Rican timber species became one of the early exports. Timber exports continued to rise and in 1815 the timber industry accounted for a large part of total exports.

Coastal areas provided the bulk of harvested timber, and mangrove species were popular for boat construction. The majority of forest products exported in the 19th century originated in coastal forests. Most wood harvested, up to the early 20th century, was used for fuel or construction; nevertheless, construction wood was being imported as early as the 1700s.

The small colonial population of Puerto Rico pursued an indigenous path of development until the late 1700s. A self-reliant, diversified agricultural economy evolved, geared toward production for domestic consumption rather than overseas markets. This economy was comprised of a large subsistence sector located primarily in the highlands, and an underdeveloped commercial sector concentrated on the coastal plains (92).

The subsistence sector was dominated by independent, small cultivators, who employed slash and burn agriculture to produce a variety of crops (plantains, rice, maize, beans, cassava, root crops) for home consumption and occasional exchange. Few of these peasants (*jibaros*) actually owned their land, many were squatters (*desacomodados*) on Crown land, or sharecroppers (*agredados*) on hacienda land (92).

The commercial sector consisted of large cattle ranches, plantations, and farms (*haciendas*), which produced an assortment of exportable cash crops, including sugarcane, ginger, tobacco, cacao, coffee, and cotton. Additionally tropical fruits, medicinal plants, and woods of high commercial value (*satinwood*, *lignum vitae*) were exported (61). While sugarcane, ginger, tobacco, and coffee each dominated the export sector at various times between 1550 and 1800, cattle raising proved to be the most stable agricultural enterprise throughout this period (61,97).

Sugarcane and sugar production became the island's major economic activity in the mid-16th century. The emerging sugar industry received royal assistance in the form of loans for mill construction, sugar transport to Spain, and the purchase of slave labor. Labor shortages, transportation problems, and default on loan payments all contributed to the gradual decline of the sugar industry (61).

Difficulties encountered by the sugar industry led to increasing cultivation of ginger or livestock raising—primarily cattle. Despite royal edicts forbidding ginger cultivation and urging return to a sugar economy, ginger became Puerto Rico's main crop. Eventually increased ginger production resulted in market price de-

crease and production efforts turned to tobacco and cacao (61). Livestock production remained an important part of the colonial economy; it provided for local consumption and hides were produced for export.

The Puerto Rican economy experienced little change until the end of the 18th century. Population remained small; external trade was limited to a few commodities. The constricted character of the export sector was reflected in the relatively small slave population, which was just over 5,000 in 1765 (97). Heavy taxes coupled with trade restrictions contributed to the island's limited economy.

Spanish colonial officials attempted to accelerate economic development after 1750. Reforms in existing tax laws and production restrictions emerged in 1813. Through a royal decree in 1815 (the *Real Cedula de Gracias*) the island's agriculture, industry, and commerce were promoted and immigration was encouraged. Uncultivated lands were distributed and some larger estates were divided resulting in an increase in the percentage of smallholders. Trade with friendly nations was liberalized. The sugar industry experienced a resurgence with increased worldwide demand for sugar (61).

These government efforts produced modest results prior to 1825; population increased substantially as did export crops. However, as late as 1828 less than 4 percent of the land was under cultivation, and the subsistence sector still dominated the agricultural economy, accounting for 71 percent of all cropland. At least 80 percent of the proprietors engaged in subsistence farming, as did nearly all of the *agredados* (92).

Expansion and transformation of the agricultural economy took place during the last seven decades of Spanish rule. Between 1828 and 1896 the amount of land under cultivation more than tripled, while pastureland doubled. Acreage devoted to export crops increased dramatically, overtaking acreage devoted to subsistence production (92).

Progression to a commercial economy based primarily on sugarcane production resulted in

creation of larger landholdings, displacing some smallholders who moved into the highlands, and brought new forest areas under cultivation (97). Price fluctuations in the world sugar market during the 19th century caused redirection of agriculture exports to coffee. Although generally cultivated on small landholdings, coffee eventually replaced sugar as the major export crop.

Puerto Rico was ceded to the United States at the end of the Spanish-American War in 1898. The U.S. Congress established a civilian government in 1900 and Puerto Ricans were granted U.S. citizenship in 1917.

In the 1930s, a program was instituted by the Government of Puerto Rico to provide landless farmers and farmers living within public forestlands small parcels of land on which they could cultivate subsistence crops, firewood, and forest products in exchange for planting and caring for the public forestlands (78). Once the forest areas were successfully planted, the squatters were relocated (118).

Establishment of a forest research station was authorized by Congress in 1927 and the Tropical Forest Experiment Station was created in 1939 on the University of Puerto Rico at Rio Piedras. The station was established to provide technical knowledge for forestry programs which largely had been unsuccessful during the previous 10-year period. Reforestation attempts had produced many failures.⁷ Agricultural colonization had reduced forest cover to only 9 percent of its original extent by 1950—4 percent government forests and 5 percent privately owned forests (99).

⁷The Tropical Forest Experiment Station was renamed the Institute of Tropical Forestry in 1961. The Institute's main research objective was timber management. Research has been conducted on: utilization of forest products, secondary forests, wildlife management, growth studies, and identification and description of promising tree species. Through Institute efforts, a technical base for forestland planning in Puerto Rico has been established. Various methods for postharvest treatment of timber products have been developed. The station was of regional significance, developing an information distribution network of more than 1,000 participants within 24 years of its inception. The Institute has accumulated a tropical forest library. Short courses, graduate-level teaching, and research planning assignments have been conducted by the Institute in several Caribbean, and South and Central American countries.

The 1900 Organic Act contained a resolution which limited corporate land ownership in Puerto Rico to 500 acres; however, this provision was not effectively enforced until 1941 (17,71). The Puerto Rico Land Authority was created in 1941 by the "Land Law" (Act No. 26 of 1941) to reorganize the island's land tenure. The law's purpose was to acquire and redistribute lands held in excess of 500 acres. Squatters were relocated on small plots where they could build homes and cultivate a small garden. Family size farms (15 to 20 acres) were established and large "proportional benefit" farms expropriated from large landholdings were to be managed by the Land Authority with workers sharing in the profits (17,116).

The program for relocating squatters was successful and most plots have been subdivided among descendants of the original owners. The "proportional benefit" farms, however, were inefficiently run and accumulated heavy losses. Most of these lands are now leased to private farmers for sugarcane and rice production (116). In 1978, the Land Authority owned a total of 94,943 acres of land which were devoted to various agricultural endeavors and real estate (111).

During World War II, Puerto Rico became important militarily, with naval bases established there (Roosevelt Roads) and on the nearby island of Culebra. The influx of military personnel substantially increased the local demand for fish, spawning the first commercial fishery development in Puerto Rico. The program was initiated by the U.S. Department of Agriculture. Authority for the program was transferred at the conclusion of World War II to the Puerto Rican Agricultural Development Corporation which emphasized offshore fisheries and conducted experimental operations. The program was terminated in 1947 (34).

A major shift in economic development strategy began in 1947, aimed at industrializing the island, diversifying agriculture, and providing full employment for the people (10). Diversification of the Puerto Rican economy was a goal of the program dubbed "Operation Bootstrap." Program goals included: 1) development of intensive and balanced use of the island's agri-



Photo credit: W.C. Lowdermilk

Puerto Rico's agricultural sector developed a substantial smallholder component following the creation of the Puerto Rican Land Authority in 1941.

cultural resources, 2) improvement of capital and credit availability for agricultural producers and industry, 3) development of efficient marketing systems, and 4) reorientation of fiscal policy to achieve these goals (10). Incentives offered to businesses included tax exemptions, technical assistance, labor training programs, and subsidized rental of government buildings (87). The construction industry prospered and government grew. This, and a large exodus of laborers to the U.S. mainland, removed capital and human resources from agriculture (116). Sugar, coffee, and tobacco contributed 64.3 percent of gross farm income in 1950, and only 14 percent in 1985 (9).

Industrial development led to more attractive employment opportunities in industry than in agriculture, lower priority for agricultural programs, and increased abandonment of farm land. The growth of the tourism industry also attracted capital and labor away from agriculture. These two factors contributed to the accelerated urbanization of major Puerto Rican cities.

The Puerto Rican electorate approved the island's newly drafted constitution in 1952 and the Commonwealth of Puerto Rico became a recognized entity. The Commonwealth is an autonomous government in voluntary associa-



Photo credit: William Balmer

The pine plantation in the background shows the timber production potential of these sloping, abandoned agricultural lands in the central highlands of Puerto Rico.

tion with the United States. Internal conflicts over political status have occurred, with factions divided over the issue of statehood, independence, or continuing as a Commonwealth.

U.S. Virgin Islands

The present-day U.S. Virgin Islands (USVI) were first colonized in the 1630s when settlements on St. Croix were established by the Dutch, English, and French. A period of colonial friction followed these early settlements, with the French finally gaining control in 1650. France retained sovereignty until 1695 when its colony was relocated to Hispaniola. The island of St. Croix remained virtually uninhabited until 1733 when France sold it to the Danish West India Company (DWIC), the exclusive Crown agent for settlement and trade in the West Indies (55).

St. Thomas was successfully colonized by the Danes in 1672. The islands represented an opportunity to produce highly valued agricultural commodities to supplement the homeland economy. Early colonial modification of the land included clearing of forests, primarily by slash and burn techniques, for plantation establishment and commercially valuable timber species (72). The early plantations produced a va-

riety of crops, including tobacco, indigo, coffee, cotton, foodstuffs, and sugarcane. Extensive forest clearing for agriculture, as well as introduced predators (e.g., mongoose), probably contributed to extermination of some indigenous fauna (e.g., agouti) (97).

At the close of the 17th century, slave labor (of African extraction) became increasingly important as Danish interest increasingly focused on sugarcane production. The population of St. Thomas rose from about 1,000 in 1691 to nearly 4,000 by 1715 and the proportion of slaves increased from roughly 60 to 85 percent. Agricultural terraces (sugarcane and bench) were constructed on the hillsides through the use of slave labor (97). Danish interests expanded in the early part of the 18th century with the DWIC acquisition of St. John in 1717, and again in 1733 when St. Croix was purchased from France. The company focused heavily on sugarcane production and plantation numbers increased dramatically. On St. Croix, nearly all arable land was under cultivation within a decade of its purchase by the DWIC.

St. Thomas became a free port in 1724 and the DWIC's activities—both in colonial staple exports and European imports—established the island as a major trade center in the Caribbean. Slave trade in particular became a thriving business, attracting buyers from America and other Caribbean plantations (55). However, financial and political difficulties led to DWIC bankruptcy in 1754. The Danish Crown purchased the Danish West Indies and continued control of the islands.

During the 18th century, diversified agriculture gave way to sugarcane monoculture, and the sugarcane plantations progressively enlarged their control over island resources. By the end of the 18th century, these plantations comprised 67 percent of all plantations and sugarcane accounted for nearly 80 percent of all cropland. The majority of pastureland was also held by the plantations (97). Sugarcane was cultivated extensively on all three major islands of the Danish West Indies, and at one time or another nearly all of the land was in sugarcane production (72,100).



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The sugarcane plantations flourished until the 1830s. Thereafter, falling prices, rising production costs, scarcity of investment capital and labor problems aggravated by slave emancipation in 1848 combined to debilitate the industry (97). Limitations such as contract wage labor and harsh vagrancy laws were instituted and effectively tied many newly freed slaves to the land (56,97).

The postemancipation decline of sugar export in St. Croix was exacerbated by the emergence of intercontinental steamships which could bypass St. Thomas as a fueling station (56). However, the sugar industry struggled on despite declining acreage, primarily by incorporating technological improvements such as steam mills and central factories.

Many St. Thomas and St. John plantations progressively were abandoned after emancipation, and their cleared areas were allowed to revert to brush forest. Nonetheless, on St. Thomas extensive deforestation occurred during the middle of the 19th century, as secondary forests were cleared to supply the growing fuel and construction needs of the Port of Charlotte Amalie (97).

The structure of the plantation system changed significantly after 1848. The emerging system primarily was one of small-scale, less labor-intensive, more diversified agricultural activities (97). Crops such as sea-island cotton, sisal, fruits, coconuts, and foodstuffs were cultivated and livestock (cattle and sheep) production increased. Many large landowners who chose to

discontinue agricultural activity nonetheless held onto their properties for speculative purposes (20,97). Thus, while the total number of plantations (units with more than 50 acres) declined only slightly between 1796 and 1915, land use shifted away from caneland and cropland toward increased pastureland and woodland.

During the second half of the 19th century some control over plantation-land resources was relinquished to ex-slave smallholders. The number of smallholdings (plots under 50 acres) rose from 4 in 1796 to 594 in 1915. This process went furthest on St. John, where by 1915 there was a total of 244 smallholdings covering 1,148 acres, or 9 percent of the land area (98). The St. John smallholders practiced a subsistence economy that combined subsistence farming, animal husbandry, fishing, charcoal production, and part-time labor on the plantations (70,98).

On St. Thomas most of the smallholders were French immigrants from St. Barthelemy (St. Barts), who settled on the north side of the island during the 1860s and either rented garden plots or entered into sharecropping agreements. Some managed to acquire title to their land by the beginning of the 20th century. Like their counterparts on St. John, their subsistence strategy combined farming with fishing and charcoal production (62).

St. Thomas increased its specialization as a point of international commerce and center of regional finance because of its deepwater harbor, free-port status, political neutrality, and strategic location (56). A dual economy developed during this period, with St. Thomas emerging as a trade center and extensive plantation agriculture characterizing St. Croix (56).

Prior to the decimation of St. Thomas' forests in the latter half of the 19th century, Danish colonial authorities showed little concern over deforestation and its impact on soil productivity or freshwater supplies. The only law touching on this subject required Cruzan planters to leave shade trees, or trees bordering the main roads, untouched (97). A Danish resource survey in 1903 indicated that there was no forest on St. Thomas and St. Croix and little forest of commercial value on St. John.

Although fish were an important dietary component, commercial fisheries were slow to develop in the Danish West Indies. More commonly, tropical produce was exchanged for imported saltfish—a preference that continues today. There were, however, some local fishing activities. Early 19th century accounts indicate an abundance of marine life near the Virgin Islands (97).

Archeological excavations uncovered shellfish middens on plantation sites, indicating that some harvest of clams, conch, and mangrove oysters occurred historically (97). While most fishing was undertaken to satisfy plantation consumption needs, descriptions by local visitors during the slave era indicate that slaves and free fishermen were selling some portion of their catch in fish markets near the urban centers (84).

Throughout the colonial period, fishing technology was similar to that of the indigenous islanders. Shellfish and turtles were taken along the shorelines (88). Offshore fishing was done from skiffs and dugouts. Woven fishpots constituted the primary catch technology; however, handlines, nets, seines, and harpoons were also employed (84).

Emancipation marked a decline in the number of fishermen employed by the plantations and corresponding expansion of fishing activity by those persons living outside the plantations. Fishing communities were established on St. Thomas by French emigrants from St. Barts. Fishing was a common component of subsistence strategies in the Danish West Indies.

The Danish Government exhibited some interest in colonial fishery development in the early 1900s. The first fishery law was passed in 1908; it regulated the right to fish; protected fishpots; and prohibited the taking of juvenile fish, lobsters with eggs, and female turtles in certain seasons (28).

Negotiations over the sale of the Danish West Indies to the United States began in 1865 and the islands were finally purchased in 1917. The U.S. Navy assumed initial administrative authority over the newly named Virgin Islands of the United States (USVI). U.S. citizenship

was granted to most Virgin Islanders in 1927 and within 2 years universal suffrage was granted (114).

The first 40 years of U.S. administration did little to alter the prevailing patterns of land distribution or land use. Agricultural policy encouraged sugarcane cultivation for export and virtually ignored the subsistence sector. Consequently, land resources were consolidated in the hands of a few plantation owners and land speculators, with an associated decline in the amount of land distributed to smallholders (97).

Most privately owned plantations began to fail in the late 1920s. This led to the formation of the federally run Virgin Islands Co. (later becoming the Virgin Islands Corp., VICORP), which held nearly all the sugarcane land on St. Croix, and operated the only sugar factory. With its focus on sugar and rum production, VICORP did little to encourage alternative crops or the production of foodstuffs for local consumption (97).

Sugar production experienced a slight resurgence with the repeal of U.S. prohibition and concurrently the demand for cane cutters rose, resulting in large-scale immigration from nearby islands (56). Among VICORP's later projects were the development of a small forestry program (118) and the beginnings of the infrastructure necessary to support a tourist industry. Commercial difficulties finally resulted in VICORP's dissolution.

A sector of full-time fishermen existed in 1917, but little was done to promote the local fisheries. The Naval Administration requested a survey of the local fisheries in 1932 (28) which included the numbers of local fishermen, technologies employed, and harvest amount. The survey concluded that the fishery was operating at 50 percent capacity and recommended various government supports to foster development. Except for promotion of cooperatives little seems to have been done. A 1950 economic report noted that local fishermen still relied on primitive technologies and marketing, and little had been done to take advantage of marine resources (72).

Administration of the islands was transferred to the Department of the Interior in 1931 and a civilian governor was installed. A homesteading program was put into effect. Although many could not afford the initial downpayment, the program met with some success, as evidenced by an increase in small farms (56). Overall, however, activities to promote the viability of a small farmer sector received little attention (97). The self-reliant, subsistence community on St. John declined, many on St. Croix abandoned working their land, and on St. Thomas only the northside agricultural community persevered.

The First Organic Act for the Virgin Islands was passed in 1936. St. Thomas became the capital of the USVI (114). A revised Organic Act was passed in 1954 and contained numerous fiscal and economic provisions of benefit to the USVI.

The Virgin Islands Tourist Board was established in 1952, evidence of the beginning of tourism-focused development. Between 1950 and 1970, the USVI experienced a massive economic boom based on tourism in St. Thomas and St. John, and heavy industry in St. Croix. The islands became the fastest growing tourist haven in the Caribbean and the site of the largest oil refinery in the Western Hemisphere (Hess Oil in St. Croix) and of Martin Marietta aluminum processing. During this period 42,000 acres were absorbed by increasing tourist, residential, and industrial development (56),

This period coincided with the phase-out of commercial sugar production, intense resource competition from the tourism sector, construction and government employment, and export manufacturing. To accommodate rising population densities and immigration from surrounding West Indian islands, the territory experienced a widespread pattern of suburbanization (55).

Tourism has been actively promoted since the 1960s and is currently the most significant economic activity. As a result, the current economy is primarily based on tourism and related enterprises (110). Presently tourism accounts for approximately 40 percent of the gross ter-



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ritorial product and employment while local government absorbs another one-third of territorial activity (56). Historically, the majority of desirable land has not been available for small scale subsistence agriculture. Initially, the majority of highest quality land was in large plantations while currently, with the emergence of the tourism industry, increased real estate prices have made much of the land inaccessible (97).

REPRESENTATIVE RESOURCE PROBLEMS OF THE U.S.-AFFILIATED TROPICAL ISLANDS

introduction

The renewable resources of U.S.-affiliated islands in the Pacific and the Caribbean supply their inhabitants with many important goods and services as they did in the past. Yet, human activities have jeopardized the renewability of some of these island resources. Despite their differing histories and cultures, these islands share some common resource problems, including that of resource overexploitation. Another major problem is related to impacts of human activities when a particular resource is developed or exploited. Such problems and their underlying causes commonly are more apparent on small islands than they are on large continental areas.

Certain naturally occurring hazards, although not unique to islands, often represent a significant problem. The relatively small size of islands often makes them less able to absorb the impact of a natural disaster than a large continental area. Agricultural or fishery capacity may be reduced temporarily, resulting in increased dependence on imports. Cyclonic storms, asso-

ciated flooding, and landslides occur on many of the islands. In American Samoa, for example, flooding is ranked as a major problem. The majority of development has occurred in the narrow flatlands which lie between the steep volcanic mountains and the shore. The watersheds typically are comprised of steep valleys flanked by sharp ridges with underlying permeable rocks. Although the watershed is heavily vegetated, landslides still occur, posing a clear hazard for villages located in the coastal valleys.

Episodic catastrophes have been related to tidal phenomena. Rainstorms coinciding with spring low tides killed up to 92 percent of reef invertebrates at Enewetak Atoll, Marshall Islands (47). Other natural stresses are less common in the Pacific. Active volcanoes are limited to the Northern Mariana Islands, where eruptions may severely disrupt intertidal and shallow-water habitats (24). Many of the U.S.-affiliated islands are in or near seismically active areas and occasionally experience earthquakes (106,107,108,109,110,111). Shoreline erosion is another naturally occurring problem. Well-de-

veloped coral reef, seagrass meadows, and littoral vegetation systems provide some protection; however, where these systems have been removed or degraded, natural protection is limited or nonexistent.

Terrestrial Resource Damage and Depletion

Damage to the terrestrial resource base largely has been a function of human activity. Resource depletion is apparent in many of the islands' early colonial histories and continues today, further reducing the islands' productive capacity. Loss of forest area on many islands has adversely affected groundwater resources, wildlife habitat, soil fertility, and has exacerbated soil erosion. Habitat loss, introduced competitors and predators, introduced disease, and overexploitation all have contributed to depletion of many island wildlife populations.

Island freshwater resources are inherently limited and on many islands these resources are threatened by such factors as infiltration of agricultural chemicals and industrial wastes into the aquifer. Further, distribution of existing freshwater resources to inhabitants poses a problem in some island areas. Hazardous waste from military activities remains a problem on some Pacific islands. Islands in both the Pacific and Caribbean still are used as impact areas for military weapons,

Flora and Fauna Resources

Past, poor landuse practices have degraded forest resources in the U.S. Pacific and Caribbean tropical territories and have resulted in significant amounts of degraded and abandoned land and relatively unproductive secondary forest. Island fauna similarly have been threatened by such landuse practices. Related resources (e. g., water supplies and coastal marine resources) in many places are threatened by forest loss. Reliable information on the original extent of forests of the Western Pacific islands does not exist but forests probably covered most of the islands. The Caribbean islands were forest covered at the time of European contact.

Forests.—On many islands, deforestation has resulted in turbid, erratic, and seasonally disappearing streams (99). For example, older inhabitants of northern Babelthau (Palau) remember when the streams ran year long. Now, the forest cover has been destroyed through repeated burning and the streams flow only when it rains, at which time they often are muddy and flow very fast (99).

At one time Guam was entirely forest-covered, but human disturbances, frequent typhoons, and the adverse impacts during and after World War II have left little undisturbed forest on the southern part of the island. Only scattered patches remain in largely inaccessible areas in ravines and on steep slopes. Savannas on the southern part of the island are believed to be mostly the result of repeated burning. Some of the open land is barren and actively eroding.

Accelerated clearing and burning of forests on old volcanic soils in recent centuries have created a secondary forest in some areas and much secondary savanna. Erosion and soil deterioration have been accelerated in some areas by frequent burning, making natural forest regeneration a slow process (99).

Fire is the biggest technical problem to overcome in rehabilitating grasslands. Fires sweep through grasses to the edge of the forest, destroying forest along the margin. The Guam Division of Forestry estimates as much as 80 percent of the fires on Guam are caused by arson (38).

Most abandoned agricultural land revegetates naturally to savanna or to secondary forest. Little of the secondary forest is suitable for immediate commercial timber exploitation due to poor quality and low volume of commercial tree species (99). Nearly two-thirds of American Samoa's rainforest has been damaged or destroyed by man's activities, leaving undisturbed forests only on steep slopes (106). Man has influenced the vegetation of the Marianas for at least 3,500 years. Observations in Puerto Rico indicate that the forest area is increasing slightly or has stabilized (99).

Vegetation removal during construction activities and the exposure of loosened soil to



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heavy rainfall also leads to soil erosion. For example, the largest part of the erosion problem in the Virgin Islands is attributable to the clearing of large tracts of land, construction of homes and roads on steep slopes, and the filling or destruction of natural water courses (117). After heavy rains on St. Croix, it is common to see a red-brown plume of sediment discoloring the sea at the mouths of streams situated below construction sites (110). Similar sediment discharge may be observed in Puerto Rico (63). A critical problem in American Samoa is the erosion of soils. The sediment is carried to the nearshore waters where it adversely affects water quality as well as marine populations such as corals (106).

Protected Species.—Several species of island flora and fauna are on the verge of extinction

or have not been seen in years and thus are presumed to be extinct. This problem is critical on Guam where recovery programs concentrating on birds are carried out in conjunction with the U.S. Fish and Wildlife Service (USFWS) (39). Guam's avian population has declined rapidly since World War II. The Guam Division of Aquatic and Wildlife Resources has identified several causes for this decline including, loss of habitat, pesticides, avian disease, and predation. Predation, particularly by the brown tree snake, appears to be a primary factor. Research on the brown tree snake indicates a correlation between expansion of the snakes' range and decline of avian populations (38). The Philadelphia Zoo, National Zoo, and zoos in Denver, New York, and San Antonio have begun a "bird lift" and breeding programs to save several endangered avian species (39). Cur-



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rently, seven species of Guamanian birds are listed under the Federal Endangered Species Act. An avifauna survey was recently completed by USFWS on Pohnpei and other high islands of Micronesia (26,31).

USFWS, the U.S. Forest Service (USFS), and Yap Institute of Natural Science (YINS) have conducted two censuses of the Mariana fruit bat (*Pteropus mariannus mariannus*) population on Yap. Yap banned the hunting and exportation of fruit bats in the early 1980s because of the decrease of the bat population due to its export to Guam. Fruit bat populations on Guam were severely reduced during the 1960s; among the causes were: increased exploitation, loss of habitat, economic importance of the species, and lack of adequate protection (38). The Mariana fruit bat and the Little Mariana fruit bat

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(*Pteropus tokudae*⁸) currently are protected under the Federal Endangered Species Act. The Yapese ban on hunting and exportation of fruit bats still is in effect and the fruit bat population is recovering (39).

A high incidence of seabird mortality at Midway is due to air strikes with planes and collisions with radio antennae. The seabird population at Wake Island was severely decimated during the Japanese occupation. During this period the Wake rail became extinct. A potentially rare plant species, *Lepidium wahiense*, from Wake has been proposed for listing by USFWS as an endangered species. The monk seal has been adversely affected by human pres-

⁸The Little Mariana fruit bat (*Pteropus tokudae*), endemic to Guam, is believed to have become extinct recently [122].

ence and populations have declined at Midway and other islands of the Leeward chain (53).

Introduced Species.—Certain introduced species have had unexpected negative impacts on island renewable resources. Harmful insects and plant diseases have been introduced in the Pacific islands over the last 10 to 15 years as travel to and from the islands has become easier. Two of the most harmful introductions have been the Rhinoceros beetle and the Giant African snail which now populate many islands. The Giant African snail inhibits nursery production for horticulture and forestry. The Rhinoceros beetle causes extensive damage to coconut palms in several island groups (99), but does not exist in the Marshall Islands (76), Yap, Truk, Pohnpei, Kosrae, or on atolls (26).

A recent introduction that threatens some young *Leucaena* forests on Saipan, Guam, Palau, and Yap is the insect Psyllid (39). This insect seems to be controlled on Yap by the native bird, the bridled white eye (26). On some atolls, rats significantly damage young coconuts; control efforts have included trapping, poisoning, and bringing in additional cats to the affected islands (76).

Tilapia is an exotic species of fish that was introduced into the wild in Puerto Rico. The introduced *Oreochromis mossambica* is now considered a pest because it is viewed by the consumer as inferior quality human food and as such has created consumer resistance to the consumption of the cultured species *Tilapia nilotica* (34).

Some introduced animals have become public health problems in the U.S.-affiliated Pacific islands. Foremost among these pests are snails and toads which, in extreme cases, have been linked to some human deaths. Rats, birds, and fish are known to carry human and animal parasites (23).

The Giant African snail (*A. fulica*) hosts organisms which cause human diseases. For example, the rat lungworm (*Angiostrongylus cantonensis*), which parasitizes the African snail, has been recognized as the cause of cerebral angiostrongylosis in humans. The parasite is most commonly found in *A. fulica*; however, it has also been found in some rats, land crabs,

coconut crabs, and freshwater prawns. Infection is acquired by ingesting raw or improperly cooked meat containing the parasite. The African snail also carries the gram-negative bacterium *Aeromonas hydrophila* (60).

Toads (*Bufo marinus*) are another introduced nuisance and have poisonous parotid glands behind the head which secrete toxins. The toad has caused numerous cat and dog deaths and human deaths have also been recorded (96). Circumstantial evidence indicates that increased salmonella outbreaks occur in areas of large toad populations. The high incidence of polluted drinking water and dysentery in American Samoa may be connected to the high densities of toads in areas of human habitation (4).

Freshwater Resources

A major health concern on islands is water quality. Islands commonly have a limited supply of freshwater and experience an increase in health problems when water sources are degraded or contaminated. Water quality may be affected by many factors, including infiltration of agricultural chemicals and industrial wastes into aquifers, and insufficient treatment and inadequate disposal of sewage. Islands with extremely porous soils generally are more likely to experience infiltration of undesirable agents, such as chemicals or sewage, into the aquifer.

As human populations have increased on many islands, the demand for increased freshwater supplies has grown. Until relatively recently, the quality of surface water and groundwater in Puerto Rico and the U.S. Virgin Islands was excellent. However, unregulated pumping of water from aquifers underlying the coastal lowlands has led to saltwater intrusion into some parts of the aquifers. The resulting saltwater or brackish water in the wells renders these parts of the aquifer unfit for human consumption, agriculture, and many industrial uses (64,73).

In the U.S. Virgin Islands, every structure must have its own rooftop water-collection system feeding into a cistern. In addition, extensive paved catchments exist on some hillsides leading to large cisterns that feed public water



Photo credit: Office of Technology Assessment

This rooftop water catchment system in Majuro (Marshalls) serves as a supplementary freshwater source. However, few such rainwater collection systems exist in the U. S.-affiliated Pacific islands, but are commonplace in the Caribbean.

mains. Rapid population growth, however, has exceeded the capacity of the public catchments and cisterns and as a consequence, desalination plants have been built to increase freshwater resources (73). In the recent past, St. Thomas Island had to import water by barge from Puerto Rico to supplement local water supplies.

Nearly all of Guam is served by a piped water system. Groundwater resources from the northern half of the island supply as much as 70 percent of the island's potable water. Since 1983 Guam has implemented a comprehensive groundwater management program designed to protect groundwater quality and direct groundwater extraction to avoid salinization. American Samoa, the Commonwealth of the Northern Mariana Islands (CNMI), the Marshall Islands, Federated States of Micronesia (FSM), and Palau are in varying stages of developing similar programs. Salinization is a particularly important problem in the CNMI which relies on groundwater supplies for 90 percent of its potable water. Catchments are used to supplement groundwater in areas where salinization or undependable water service is a problem. Many areas in the former TTPI (FSM, RMI, and Palau) do not have sufficient infrastructure for comprehensive groundwater management (49),

Puerto Rico's principal water-supply problem is the deterioration in service from irrigation districts serving 40,000 acres. Deliveries from the four districts have fallen below half of their pre-1920 design capacity of 4 inches per month to the serviced land. The decline continues because of archaic operating rules that were designed originally to service a sugarcane monoculture no longer in existence; and because of reduced irrigation demand, and continuing reservoir sedimentation. Declining surface water availability has led many farmers to rely exclusively on groundwater. Because deliveries from irrigation district reservoirs constitute the single most important source of groundwater recharge, this trend of changing irrigation water use eventually will cause an unfavorable balance and the intrusion of seawater into the freshwater aquifer (64). No action has been taken yet to manage the surface water system to ensure that adequate amounts of recharge are provided (64). The irrigation practices still in use on a majority of the farms are wasteful, inefficient and costly (73).

Increased population levels or overcrowding may also cause water quality degradation. Treatment systems, sponsored by the Environmental Protection Agency (EPA), have been or are being constructed in population centers in the U.S.-affiliated Pacific islands (49). However, in some areas sewage systems are still under construction, or facilities still need to be extended to all structures (49,53). Overcrowded conditions on Moen, and to a lesser extent on Tel, Dublon, Fefan, and Uman (Truk) have led to unsanitary wastewater disposal practices. Although a sewage treatment plant and outfall on Moen have been in operation for many years, hookups with residences are few (53). Through a series of EPA projects (Rural Sanitation Programs) remote areas are now being provided with basic wastewater and water supply facilities (49).

Coastal Resource Damage

Sand, a renewable resource of beaches, in certain cases has undergone extreme depletion through mining. Some of the calcium carbonate beach sands of St. Croix in the U.S. Virgin Is-



Photo credit: Office of Technology Assessment

Hillside mining for construction materials is an alternative to beach sand mining, however, the associated adverse environmental impacts to terrestrial and marine ecosystems may rival those caused by beach sand mining.

lands came under heavy mining for construction purposes in the early 1960s. The sand was mined for government and private use, leading to nearly complete stripping of some beaches. As more seaside hotels were built it became evident that maintaining beaches was more valuable than using the beach sand for construction. Subsequently, dredged sand replaced beach sand for construction (114). Mining or collecting beach sand for personal use has been a practice among Samoans for centuries. Now, however, some beaches are being depleted for commercial construction purposes. On Truk, removal of beach sand for construction fill has led to some shoreline erosion (53). Beach sand mining is a problem in most Pacific areas (49).

Hazardous Waste

Johnston Island has served as a temporary repository for chemical defoliants and chemical munitions since the early 1970s. Agent Orange was stockpiled at Johnston after the U.S. involvement in Vietnam and finally was incinerated at sea away from Johnston in 1976. During years of storage, however, some drums leaked into the ground. The extent of contamination has been analyzed and remedial actions have begun (82). Some chemical munitions deteriorated and started to leak as well. This led

the Army to embark on a program to incinerate and destroy the chemical munitions in an explosive-proof facility to be constructed on Johnston (53).

U.S. nuclear testing took place on Bikini Atoll between 1946 and 1954 and weapons testing took place on Enewetak between 1948 and 1958. Blast effects and contamination from radioactive materials severely damaged or destroyed parts of these atolls. Today, plans suggest that the radioactive soil from Bikini may be removed and deposited on another atoll, in a lagoon crater, or used for landfill along the shoreline. Agriculture will not be allowed on Bikini for obvious health and safety reasons (53). Enewetak underwent a similar cleanup during 1976 to 1978. Low-level radioactivity still was present in the soil of several large islands in the atoll after the cleanup. Recent radiological tests indicate that coconuts from trees replanted in the northern islands are not fit to eat due to excessive levels of radiation (53).

American and Japanese military ordnance from the World War II era still litter some Pacific islands. Unexploded bombs and shells still are found on parts of Guam, Saipan, the Marshalls (31), Truk, and Peleliu (Palau). The presence of such explosives inhibits the use of certain lands and provides a lingering hazard to island residents. Recovery of corals in previously blasted or bombed holes that resulted from air raids on Moen (Truk) seems relatively minor (53).

Some U.S.-affiliated islands are still used as impact areas for military weapons. Parts of the island of Vieques just east of Puerto Rico serves as a bombing and gunnery range for the U.S. Navy. In order to offset the negative environmental impacts, the U.S. Navy has recently reforested 100 acres of abandoned/eroded pastureland on Vieques. The U.S. Navy and the Commonwealth of Puerto Rico (Memorandum of Understanding) cooperatively fund projects to enhance employment prospects and create long-term benefits for the inhabitants of Vieques (77). Farallon de Medinilla, a small raised limestone island north of Saipan, is used as a bombing and gunnery target by U.S. Pacific na-

val forces and by the U.S. Air Force tactical air squadron on Guam. Exercises on this island are said to be sporadic (48,53).

Marine Resource Damage and Depletion

Degradation of the marine resource bases of the U.S.-affiliated islands follows a pattern similar to that of the terrestrial resources. Many human activities, on-island and at sea, have adversely affected the marine resource base of many islands. Some on-island development activities have had adverse impacts on near-shore marine life. Destructive fishing practices and overharvesting of certain marine species has adversely impacted the marine resource base. Despite such damage, however, the marine resource base continues to provide essential products to island inhabitants.

Nearshore Fisheries

Because of past over-optimism as to the commercial potential of nearshore fishing resources, a rather consistent scenario of fisheries development and depletion seems to be emerging. The scenario is in various stages of realization throughout the U.S.-affiliated Pacific and Caribbean islands. Urban center populations grow with rural or outer island migrations (101,102, 103,104,105). As urbanization continues, the reef resources are over-harvested in an ever widening area emanating from the urban center (34,65).

The number of fishermen in Puerto Rico increased from 1,230 to 1,872 between 1976 and 1982 while the number of fishing vessels increased from 865 to 1,449 (8,43). This development pattern has had a striking impact on Puerto Rico's nearshore resources. Because of rising fuel costs, larger "offshore" boats have tended to fish closer to shore. In 1974, the waters of Puerto Rico were characterized as "very nearly overfished" and "heavily exploited" (43,44). The increase in total effort expended within the fishery was accompanied by a nearly 50 percent decline in catch per unit of effort; a classic indication of overfishing (8).

Increases in local population and tourist trade in the USVI has been accompanied by increased demand for fish, conch, lobsters, and other seafoods. Adult fish of the shallow coastal waters have become increasingly scarce resulting in the decreased effectiveness of fish pots as a harvest mechanism. In easily accessible sites, conchs and lobsters are heavily depleted (114). The USVI Government has deployed artificial reefs constructed of old automobile tires in an effort to increase shallow-water fish habitat and thereby enhance fishery potential (34).

Destructive Practices.—The history of coral and mollusk fisheries is one of progressive exploitation leading to chronic depletions (36,37, 51,85,86,121). Conchs and black corals are heavily overfished throughout the Caribbean, including populations among the U.S.-affiliated islands (51,112,120).

Pearl oysters have been important items of commerce for centuries in certain parts of the Pacific. The pearl shell industry had a major impact on some islands as a result of the activities of the foreign traders and fishermen drawn to exploit the stocks of the Golden Lipped and the smaller Black Lipped pearl shell (69). As stocks of pearl oysters were depleted, the top shell, *Trochus niloticus*, came to be used as a source for buttons and other similar items (66,69). *Trochus* recovered after World War II from its pre-war depletion. However, populations began to decline from over-exploitation again by the mid-1950s, leading to establishment of reef sanctuaries in which no harvest was permitted (53,59,91). Despite closed seasons, however, trochus populations remain low from overharvesting in Pohnpei and Truk (31).

Fishing with explosives was contrived by islanders during World War II with the readily available supply of military ordnance (7). This type of "fishing" still is widespread throughout the South Pacific. Destructive fishing methods such as dynamiting pose a severe problem in Truk lagoon (31). The availability of unexploded ordnance on many of the Japanese sunken ships near some islands and the illegal acquisition of dynamite from local construction activities are factors which may foster this

activity. This technique is without question responsible for considerable destruction of reef corals and reef fish habitat (53).

Chlorine bleach and water purification powder have been and are being used by some islanders to kill reef fish and bring them to the surface where they can be collected for sale or for the fisherman's consumption. Bleach sometimes is used on Yap for such purposes (41). The bleach has such severe negative impacts on fish, corals, seagrass beds, and algae that some populations are permanently reduced (7).

The exploitation of nearshore resources by subsistence fisheries of American Samoa is heavy in places and occasionally destructive methods using dynamite and chlorine bleach are employed. As human populations continue to rise, increased fishing pressure and overfishing of preferred species, especially in reef and lagoon waters, are major emerging problems in Pohnpei, Kosrae, Truk, and Yap (31).

Tourism has certain inadvertent but direct negative impacts on marine resources. One study shows that the trampling effect of corals by humans is significant. At one site, 18 traverses by individuals reduced living coral from 41 to 8 percent (117). Certain fragile species like *Acropora* suffered the greatest damage. Shells, used extensively in handicrafts in American Samoa, the eastern Carolines, and the Marshall Islands, have become increasingly scarce. Supplies of shell and coral are being adversely affected not only by the handicraft industry but also by builders and divers (117).

Protected Species.—Natural stocks of giant clam F, Tridacnidae have been seriously depleted in their natural range. *Tridacna gigas* populations are believed to be extirpated from marine habitats of many of the U.S.-affiliated Pacific islands. Two varieties of giant clam, *Tridacna gigas* and *Tridacna derasa*, have been placed on the International Union for the Conservation of Nature and Natural Resources (IUCN) endangered species list (95).

Currently, the harvesting of corals and other sessile or sedentary animals is restricted in the U.S.-affiliated Caribbean islands by various

Federal and Commonwealth statutes. Exceptions are made for small-scale collections for scientific, educational, or personal use (29,120). Despite this level of protection, the poaching of corals for the tourist and aquarium trade is ubiquitous throughout the Caribbean region, and seems unlikely to diminish. Mollusks are not protected, with the exception of conchs and species living within the Federal waters and parks (112).

The two most common marine turtles among U.S. insular areas of the Pacific—the green turtle and the hawksbill turtle—have been declared “threatened” and “endangered” respectively and are protected under provisions of the U.S. Endangered Species Act. Harvest of these turtles is prohibited in Guam, the Commonwealth of the Northern Mariana Islands, and American Samoa. Despite protected status, hawksbill turtles are killed in some islands, as evidenced by the large number of well-crafted tortoise shell combs, earrings, and bracelets on the market. Residents of some U.S.-affiliated islands are permitted to harvest marine turtles on a subsistence and traditional basis as a protein resource (91).

Four species of sea turtle occur commonly in the Caribbean: hawksbill, green, leatherback, and loggerhead. All are variously protected from harvesting or molestation by living within Federal waters or by their status as endangered or threatened species (112,113). Moreover, strict import controls apply to the mere possession of turtle products in the United States. Nevertheless, turtles have been hunted intensely in the Caribbean and continue to be poached and sold, even among U.S. islands, for food and fine jewelry (29,112). Turtles are easily caught in nets, by hand, or on the beach while laying eggs. The general availability of outboard motorboats and synthetic netting exacerbates the problem, and the economic value of turtles ensures that low-level poaching likely will continue (120).

In December 1985, a 400-ton ferryboat ran aground on Mona Island Reef off the coast of Puerto Rico, a reef that is a marine preserve and habitat for several protected turtle species and marine birds. The ship was still aground

on the reef as of March 1986, breaking up, leaking oil, and crushing the coral (21).

Degradation of Nearshore Resources

Large-scale destruction of coral reef communities from sedimentation is well documented (25,30). Dredging and filling operations in the nearshore environment are significant contributors to marine resource destruction. Dredging and filling associated with the military buildup in Guam before, during, and after World War II resulted in considerable adverse impacts to reefs in Apra Harbor and other coastal resources; battle activities added to these problems. Centuries of slash-and-burn agriculture and intentionally set savanna range-fires have aggravated soil erosion and contributed sedi-

ment to riverine, estuarine, and reef systems (53).

Since 1980, excessive dredging and filling related to an airfield-port construction at Okaht on Kosrae has caused major sedimentation damage to coral reefs and seagrass beds. The fishery catch has declined in Okaht's coastal habitats. On Pohnpei, considerable mangrove, lagoon, reef, and perhaps seagrass habitat has been destroyed or degraded by recent dredge and fill operations (26). Sedimentation from upland construction also has contributed to reef degradation. Part of the reef itself has been used as a source of fill material. Some of the shoreline filling is to accommodate immigrants from outer islands because of unavailability of land. Yap has no exposed limestones or other suit-



Photo credit: Office of Technology Assessment

Dredge and fill operations often take heavy tolls on nearshore marine ecosystems: heavy machinery may break up the coral reef, associated sedimentation may smother bottom communities, and loss of habitat can adversely affect nearshore fishery potential.

able rock available for fill, roadwork, and other construction activities and, therefore, most material must be dredged from lagoon reefs.

Perhaps the single most significant impact to coral reefs in American Samoa resulted when the commercial airfield was extended out into Pala Lagoon, resulting in severe restriction in tidal circulation, and dredging and quarrying on once important reefs. In addition, the Government relied on filling of reef lagoons in inner Pago Pago Harbor to expand its landholdings (53).

Dredging and shoreline modification associated with tourist developments are a major threat to nearshore resources in Puerto Rico and the U.S. Virgin Islands. Coral reefs in Puerto Rico are seriously threatened by human development activities including dredging, land erosion, oil spills, industrial and thermal pollution, and direct harvest for curios (43). Alteration of the coral reef ecosystem may produce adverse changes that are essentially irreversible (34).

St. Croix Island has not escaped dredging impacts. Prior to 1968, release of dredging spoil to Christiansted Harbor damaged coral communities on nearby reefs. From 1968 at least to 1974, no new dredging permits were issued in the U.S. Virgin Islands largely because of negative public opinion about damage to the marine environment. The retail price of one cubic yard of sand in 1968 was \$3.50 but the price has now reached \$50.00. Thus, strong economic incentives exist to resume dredging (68).

Waste Management.—Damage of nearshore resources from dumping solid wastes, sewage releases, thermal pollution, and oil spills are common on the islands just as they are in the continental United States. Solid waste management is a serious emerging problem in Pohnpei and the FSM in general and is cited as a serious problem on Majuro in the Marshall Islands. There seems to be little planning to designate sites and landfill operations, and rubbish and solid waste is dumped indiscriminately, commonly at the shoreline environment (53). Guam has recently instituted a litter control pro-

gram which sets fines for littering; the funds will be used to clean up open dumps (49).

Sewage, oil, and cannery waste pollution has long been a serious problem in Pago Pago Harbor in American Samoa. Sewage treatment plants at Utulei and elsewhere have largely eliminated degradation from domestic wastes. Oil handling and storage facilities also have been improved although the unauthorized dumping of bilge waters into the bay continues to be a problem. Presently, no pumpout facilities exist for ships and yachts calling at the bay (53).

Pala Lagoon on Tutuila has high fecal coliform concentrations presenting a public health hazard. The construction of the airport runway over the opening of the lagoon to the ocean has reduced water exchange with the ocean. This problem is exacerbated by stream runoff, which is high in nutrients and sewage tank overflows (106). A sewage collection system with associated individual dwelling service is currently under construction there to mitigate the adverse environmental impacts (49). Traditional discharge of raw sewage into nearshore waters still occurs in some areas, resulting in severe water degradation.

Similar problems exist in the Caribbean area. Solid waste on St. Croix was pushed into the sea at a site near their airport until 1974. This practice has ceased but the old dump remains a source of nearshore water pollution. A chance exists that wave action from a tropical storm could spread the debris widely. Overflow from the tailings ponds of a bauxite processing plant reached the sea in the past during periods of heavy rainfall. Waste heat and brine are carried into the sea from water used for cooling purposes.

Oil Spill Hazards.—Oil spills and oil discharges by ships adversely affect nearshore resources in many parts of the world. An oil spill damaged a section of mangrove on Guam (91); another in 1971 affected Sandy Point on St. Croix. In addition, oil and tar from tankers floats in from the open ocean to the beaches of Puerto Rico and U.S. Virgin Islands (22,81). Globes of tar floating on the sea in the Carib-

bean and off Florida mistakenly have been taken for food by hawksbill turtles. Dead and dying tar-laden turtles are reported on the region's beaches (22). Oil spills also are problematic throughout the Pacific. Enforcement of ex-

isting laws (e.g., Clean Water Act) is difficult because of the need to observe the incident or prove guilt through relatively complex procedures (49).

THE ISLAND SOCIOECONOMIC CONTEXT

Introduction

Sustainable renewable resource management depends not only on the capability of ecological resources, but also on the availability of skilled labor and desire to engage in resource management and development activities. Human resources are critical to renewable resource management. Indispensable human components include: laborers with special skills; farmers, foresters, fishermen, and aquaculturists with entrepreneurial abilities and a knowledge of modern-technology; technicians who combine scientific training with practical experience; and strong resource management leadership with a sense of mission and background not only in natural sciences but also in cultural and economic areas.

All of the U.S.-affiliated islands have rapidly growing populations and many have high rates of out-migration to the U.S. mainland and immigration of mainlanders and foreign nationals. This has led to heterogeneous island populations with a multiplicity of ethnic groups and cultures. These groups may have different aspirations, different demands for products, different attitudes towards and values for resources, and different techniques for resource use.

The level of development of the U.S.-affiliated islands is considerably behind that of the United States, with Puerto Rico being the most developed of the islands. While gross domestic product (GDP) and per capita incomes are low compared to U.S. levels, they are generally high compared to regional levels.

The public sectors are large in comparison to private sectors on most islands, reflecting a common preference for the security, prestige, and fringe benefits of local government employ-

ment. Most private sector development has occurred in service industries; however, industrialization has grown in Puerto Rico and tourism and related enterprises have grown in the U.S. Virgin Islands. On most islands, agriculture and fisheries have nonetheless declined. Many island residents are multi-occupational: they engage in several occupations, part-time or seasonally. Similarly, island institutions tend to be multidisciplinary and general in approach (81).

The common recommendations of economic development plans have aimed at establishing more self-reliant economies primarily by expanding agriculture, fisheries, and tourism (and to a lesser extent light industry), although the order of preference may vary among island areas. The prospects for industrial development in the U.S.-affiliated Pacific islands are almost nonexistent because of small size of domestic economies, high wage levels, the lack of natural resources, and proximity to major Asian competitors. The limited nature of economic development opportunities is illustrated in Palau where, as recently as the late 1950s, the most valuable export was scrap metal, mainly relics of World War II (14).

Import substitution has become increasingly important in light of rising transport costs and desire to encourage private sector development. A number of plans also have called for a reduction in government employment and expenditure to allow the productive components of the economies to catch up with consumption and to reduce the trade gap (11).

Pacific

The U.S.-affiliated Pacific islands are characterized by high population growth rates, in-

creasing emigration to the U.S. mainland and to other Pacific islands, and growing numbers of alien immigrants. The latter group have, to a certain extent, been encouraged to enter islands such as American Samoa and Guam to fill jobs for which local residents lack the necessary skills or which they are unwilling to accept. A combination of these factors has led to the development of bimodal societies, or trimodal societies—in which a significant subsistence sector still exists. The private commercial sector on most of these islands is small or nonexistent.

The private sectors that have developed have been oriented primarily to services supporting the public sector and public sector employees; the productive components of the economies—agriculture, fisheries, and manufacturing—have declined, or failed to develop. For example, government employment and service industries (general merchandising, transportation, food services, and construction) account for at least 90 percent of formal employment in the Federated States of Micronesia while the labor force employed in direct production accounts for only 1.3 percent (11).

In the absence of a significant productive component to their economies, the U.S.-affiliated Pacific islands have become highly dependent on U.S. expenditure to contribute to local economies. For example, Palau's GDP was estimated to be \$20 million in 1979, of which \$9 million was contributed by the United States in public sector support payments (14). Only 9 percent of the Trust Territory funds for 1980 were derived from tax revenues while U.S. grant and Federal program funds contributed 87 percent (11).

Unemployment is high—estimates range from 16 (Palau) to 22 percent (Majuro)—but accurate data on unemployment levels or trends are unavailable, especially for rural areas.

The skills required to develop the productive sectors of the economies are being lost at a rapid rate, and few young islanders are seeking education or employment in agriculture or fisheries. Rapid population growth in some places has accelerated the move away from local food production. The increased population pressure

on limited resources may eventually preclude self-sufficiency and necessitate emigration or family planning (11). This situation has already been reached by most of the U.S.-affiliated islands.

Wages also are sharply bimodal. Wages in the public sector tend to be considerably higher than those available through the private sector. For example, the minimum wage in Palau in 1982 was \$1.94 per hour. In the private sector, for which there is no legal minimum wage, some wages were as low as 40 cents per hour (14). This incentive to obtain government employment results in further withdrawal from local production. An associated effect is demand for educational opportunities which may not transfer into employment opportunities, resulting in increased unemployment (11).

Caribbean

Nearly 3.4 million people reside in Puerto Rico (3,417 square miles) and 107,500 reside in the U.S. Virgin Islands [132 square miles), representing some of the world's highest population densities. As a result of improved health care, family planning programs, and general economic affluence, birth rates in Puerto Rico and the U.S. Virgin Islands have declined in the past three decades while death rates have dropped or remained stable (73).

The cultural heritage of the U.S.-affiliated Caribbean islands is largely influenced by prior colonial presence as well as cultural influences from other European, African, and Caribbean nations. This mixing results in a largely heterogeneous society with varying cultural ties (79). Further, the close relationship with the mainland United States strongly affects these island cultures.

The United States is the primary commercial partner of the Caribbean islands. The United States' purchase of major U.S. Virgin Islands exports (i.e., tourism, petroleum, rum, and light industrials) and supply of consumptive goods comprises a large part of island trade⁹ (57). The

⁹During the period of 1970 to 1979, U.S. Virgin Islands' exports to the United States averaged 89 percent of total exports, U.S. citizens reached above 85 percent of total tourists and U.S. goods comprised 72 percent of U.S. Virgin Islands imports (56).

United States' investment in the Puerto Rican economy totaled some \$15 billion in 1982 (90). North American capital controlled the highest percentage of assets in manufacturing, retail sales, exported industrial production, marine and air transport, labor force, housing construction, and banking and finance¹⁰ [90]. Thus, the economies of Puerto Rico and the U.S. Virgin Islands are closely tied with the United States and react to U.S. economic changes. Similarly, associated employment sectors react to economic trends within the United States.

Traditional Cultures and Economic Development

Pacific

Many U.S.-affiliated Pacific islands are shifting from a traditional subsistence economy towards a modern cash economy; in Pohnpei, 70 percent of wages are earned by only 2,120 government employees (no more than 10 percent of the population). Obviously, many people make a living outside the cash economy. In a properly functioning subsistence economy, production equals demand and the agent of both is the family. Family needs in such an economy can be met with about 3 or 4 labor hours per day (89). Cash is neither plentiful nor needed, and consumer goods on the island are limited (although the number, price, and quality of products have increased in recent years).

On Pacific high islands, most family needs for food and shelter can be obtained from the land and surrounding ocean, and available resources seem to be underused. Most farmers produce just enough products to sell to meet their immediate cash needs. Farmers have little incentive to increase cash crop production, such as Pohnpei pepper, even though both land and labor may be available. Pepper has gone unharvested when farmers have not needed or wanted to convert the crop into cash.

In most traditional Pacific cultures, the concept of "borrowing" displaces that of "saving."

¹⁰Percent assets controlled: manufacturing—81 percent, retail sales—85 percent, labor force—81 percent, housing construction—65 percent, banking and finance—60 percent, exported industrial production—90 percent, most means of mass communication, and virtually all marine and air transport (90).

Those who have are supposed to share with those who have less, particularly within family and clan. One who accumulates savings may have to deal with frequent requests from family and friends and contribute to the lifestyle of less industrious individuals with little likelihood of repayment in cash. This removes personal incentive to earn more than one immediately needs and may be a major deterrent to development (32).

As traditional economies have shifted toward cash economies, the lack of a dependable labor force (in terms of cash economies) has inhibited economic development. Tropical climate characteristics generally prevent agriculture workers from putting in an 8 hour day; more commonly, 4 or 5 hours constitute a day's work.

Acquisition of temporary jobs for an immediate monetary goal is common. This complicates training and supervision, and results in lower than expected productivity. Per capita income is high compared to regional levels, resulting in reluctance on the part of the working-age population to accept low-paying employment and further influencing the use of alien labor.

Caribbean

The structure of U.S.-affiliated Caribbean island economies has changed significantly in the past three decades, from primarily agricultural economies to highly industrialized (Puerto Rico) and tourism [U. S. Virgin Islands) based economies. This change in focus has influenced people to seek employment in fields other than agriculture and fisheries.

The structure of the agricultural industry and profile of the present day farmer have changed¹¹

¹¹Agriculture is still dominated by part-time workers. Total amount of farmland in Puerto Rico increased by 4 percent between 1978 and 1982, but was still only half of 1950 levels. There has also been an increase in the number of farms, largely in the less than 10 acre bracket; 53 percent of farmland is owned by operators. The average age of individuals whose primary activity was agriculture was 56.1 years, secondary was 53.7 years. Puerto Rican agriculture is dominated by small farm units run by an aging population. A small but growing group of educated Puerto Ricans farm as a secondary occupation (116). Similar circumstances exist in the U.S. Virgin Islands, with 45.5 percent of farmers spending 200 days in off-farm employment (57). There has been an increase in the number of small farms, and increase in the education level of farmers.

sidered temporary (until education is completed or until job-holders claim retirement benefits or save enough to open a business on the home island). However, many do not return because local employment opportunities that match acquired skills are scarce; starting a new home-island business can be difficult, and standards of living fall below the aspirations developed off-island (14,16).

The public sector/private sector disparity in wage levels, moreover, leads to underemployment in the private sector. This increases the demand for education, encourages the dependence on alien labor, and increases the capital investment requirements for job creation (11).

Attempts to retain skilled islanders may necessitate bonding students to return (perhaps to guaranteed jobs or other fringe benefits) or providing salaries at close to U.S. levels. The former approach requires careful planning of the manpower needs of the economy, considerable administrative cost in scrutiny of curricula, and may require termination of financial support for students choosing alternate educations—a difficult choice when skills are needed in many fields. It may also be necessary to redirect students from U.S. institutions towards regional academic institutions, such as the University of Guam or the University of the South Pacific (Fiji), which may cater more appropriately to the needs of small, tropical islands (13).

On the other hand, bringing salaries more closely in line with U.S. levels may lead to even greater disparities between the incomes of the government employees and those of other Micronesians (11). The remaining alternative is to provide an environment on the home islands favorable to the satisfaction of the desires of returning migrants; this will not be easy at prevailing population growth rates (11,12,13).

Caribbean

The availability and diversity of educational programs have increased; however a shortage of skilled labor still exists at all levels. Generally, local educational and training institution efforts are not directed toward creating a la-

bor force with appropriate skills for the current (or future) direction of the employment market (33,73). The generally inadequate level of education and skills among graduates, as perceived by employers, as well as shortage of personnel in particular specialties (33), in turn, exacerbates unemployment problems.

For example, the Tahal Report commissioned by the Government of Puerto Rico (94) indicated that the existing agricultural production system lacks adequate knowledge of commercialization required to achieve a reliable and high-volume production and delivery to markets. A gap exists between the systems of wholesale marketing and production; while the marketing system has undergone rapid modernization in the past decades, the production system has not developed in a parallel manner. Despite numerous government and private agricultural organizations (including the Agricultural College, Extension Service, and the Agricultural Experiment Station) which possess professional personnel, a need still exists for such specialized training. Research and extension personnel rarely have appropriate prior experience with high yield technology and modern commercialized markets to guide farmers (64).

Rapid development often exceeds the capacity of an education system to supply an appropriately skilled labor force. Efforts to increase profitability in the productive sector often requires specialized skills and training which often are not immediately available. For example, increased mechanization commonly is necessary for farms to be profitable, requiring employees with specialized skills (34). Thus, a need exists to train young, fairly well-educated people for agricultural pursuits; although nearly one-half of the Puerto Rico's work force has a high school education, the approximately 40,000 agricultural laborers average a fourth grade education and one-half are over 40 years of age (116).

Wage Rates and Unemployment

The Fair Labor Standards Act (FLSA), which sets minimum wage and workweek standards, applies to the U.S. Caribbean and some of the

U.S. Pacific islands. Local economies commonly are tied to regional location. Consequently, these labor laws, while improving wage rates, may hinder the regional competitiveness of the island. For example, tourism is more costly in the Caribbean than in neighboring non-U.S. islands; consequently some economy-conscious tourists may avoid the U.S. islands (57,79).

Pacific

In Micronesia, cash and subsistence economies sometimes conflict. In general, the production and distribution of goods in Micronesia and American Samoan subsistence economies are not determined by wages, prices, and profits in the western sense, but by such nonquantifiable factors as satisfaction of fulfilling kinship and other traditional responsibilities, the status and recognition this brings and the inconvenience that work entails. Production ceases when family needs are met. Total production and consumption may grow with the population, but per capita production remains constant for long periods.

Thus, many Pacific islanders are usually not productive in a cash economy unless wages are quite high (i.e., in government and military employment). It is difficult to attract Micronesians to lower paying commercial jobs. Such employment is usually short-term and undertaken to obtain a certain amount of cash for a particular item. Most employers prefer workers who can be relied onto stay long-term and develop the experience and skills needed to improve their productivity; however, the discrepancy between private and public sector wages does not promote long-term private sector employment. Often this results in the private sector turning to alien labor.

The FLSA sets minimum wage rates and workweek standards on Guam, but not on neighboring islands or nearby countries. As a result, Guam cannot offer tourists the prices and values that its neighbors, with lower wage rates, can. Guam's proposed Commonwealth Act suggests that U.S. labor laws be amenda-

ble by local legislative action as deemed appropriate.

Caribbean

Evidence exists that the minimum wage increases in Puerto Rico have strongly affected local production and employment. The higher wage rates associated with the FLSA tend to curb employment of unskilled workers particularly in labor-intensive industries. Since many economic activities related to renewable resources are labor-intensive, they are especially affected by minimum wage increases (73). Higher than regional wage levels, combined with the capital-intensive industrial development in Puerto Rico, have been postulated as a factor in the high unemployment on the islands (79,80).

Unemployment increased sharply after 1975 in Puerto Rico; it currently exceeds 20 percent officially (90,116) and may be as high as 25 to 30 percent in rural areas. Unemployment is heavily concentrated in ages from 16 to 34 years (6,35). From 1982 to 1984 the Puerto Rican labor force increased largely as a result of women and young people entering the work force (6). Labor force growth currently has exceeded the local economy's ability to generate new jobs. Alternative employment opportunities for displaced workers have not materialized and unemployment remains a large problem despite out-migration to the U.S. mainland, which continues from Puerto Rico at a fairly rapid pace despite industrial growth (73).

Historically, immigration to the United States from the U.S. Virgin Islands has fluctuated with insular economic changes. During periods of rapid economic growth, such as the 1960s, there was widespread immigration to the U.S. Virgin Islands from both the mainland United States and nearby islands. During the economic slowdowns of the 1970s and early 1980s, however, these inflows were significantly reduced and in some cases reversed. Close ties with the U.S. mainland and easy access to the wide variety of U.S. employment markets has encouraged out-migration, particularly in periods of economic adversity.

Social Support Programs

Pacific

Although Federal subsidies to Micronesia, especially in social services, were carefully controlled in the 1950s so as not to compromise the goal of self-sufficiency, during the latter part of the Trustee period (after 1963) this changed. Federal appropriations rose from almost \$7 million in 1963 to at least \$60 million in 1971 and continued to rise steadily throughout the 1970s. Most funds were channeled into administration, schools, and health services (89).

Even during a time of rapid economic growth in the early 1970s, the number of welfare recipients steadily increased (14). Nearly one-quarter of Guam's civilian population received food stamps in 1980, although many of these may have been aliens. The decline in FSM agriculture and fisheries production has been attributed, in part, to Federal surplus food distribution programs (11). Cases of condensed milk and cheese were distributed freely in the Commonwealth of the Northern Marianas (CNMI) while a dairy ranch on Tinian exported 80 percent of its milk and 92 percent of its meat to Guam (12). The inhabitants of Agrihan (CNMI) produced papayas, mango, and coconuts but were otherwise entirely dependent on U.S. Department of Agriculture supplies (12).

A Nutrition Assistance Program was established in the CNMI in mid-1982 with about 28 percent of the Mariana citizens participating (819 households). One condition of this program was that 15 percent of all coupons were to be used for the purchase of locally grown food. The ability of local producers to supply the required volume was uncertain at the institution of the program (12) but, while data are unavailable to indicate the program's success in increasing agricultural production, indications suggest that this has been accomplished (74).

Caribbean

Social support programs grew rapidly in the U.S.-affiliated Caribbean islands with the expansion of the "Great Society" programs on the U.S. mainland. However, this has moderated

since 1981 as the U.S. administration generally has slowed Federal spending. Federal transfer payments have recently been providing close to 30 percent of Puerto Rico's disposable income and roughly 50 percent of island households have been receiving food stamp payments. A 1980 U.S. Department of Commerce study found that approximately two-thirds of Puerto Rican families lived below U.S. poverty levels (90). Puerto Rico was removed from full coverage under the Food Stamp program in 1983 and placed under a special block grant of \$825 million. Puerto Rico administers its own nutrition assistance program with these funds, paying beneficiaries with checks instead of food coupons (73).

Preference for Government Employment

Pacific

On most U.S.-affiliated Pacific islands, jobs with the U.S. Government (e. g., military) are preferred over jobs with the local governments, which in turn are preferred to employment in the private sector. Local government wage and salary levels are nearly twice those of the private sector. (Data from Palau indicate that public and private sector wages and salaries are increasing; while the differential has remained the same, the absolute difference in levels has increased.) Living in more urban centers, in which most infrastructure development has occurred, also is preferred to village living. Government employment absorbs at least than one-half of all wage earners on many islands and a large proportion of the private sector (devoted to services) is dependent on expenditure generated by the public sector (14). The large size of the public sector may, however, reflect hiring because of available funds, irrespective of necessity, and not necessarily an underdeveloped private sector (11).

Attempts by the private sector to match public sector wages places an economy at a comparative disadvantage for many import-substitution activities and export-oriented development strategies (11). However, because government

salaries are subject to much redistribution through family ties, public sector employment can be regarded more as a channel through which public money is distributed than as a means of increasing productivity and improving public services (15). This may partly justify low productivity at high wages (15).

Because of U.S. fiscal restraints and the approval of the Compact of Free Association, public sector employment probably will tend to decline in the next few years on many U. S.-affiliated Pacific islands. This will have a similar impact on some parts of the private sector, notably general merchandising, transportation, food services, and construction, which, with government employment, account for most formal employment in the islands.

Caribbean

Public service comprises the largest employment sector in the U.S. Caribbean islands; this sector, however, includes some "productive" services which in other economies maybe provided by the private sector (110,111). Public sector employment in 1977 to 1978 was estimated to be 25 percent in the U.S. Virgin Islands (110) and 23 percent in Puerto Rico (111). Recent figures for the U.S. Virgin Islands indicate that the public sector comprises over 30 percent of the total labor force and 33 percent of all employed workers (55). Employment in the public administration sector alone comprises nearly 33 percent of Puerto Rico's total labor force; this percentage does not include those public employees in health, recreational, transportation, or communication services or public utilities (35). Current fiscal limitations within the U.S. Virgin Islands Government are expected to constrain further employment growth. Consequently, increasing concern exists for training the local labor force for private sector employment (79).

Shortage of Rural labor

Pacific

A major constraint to productive rural development is rural labor shortage, especially of skilled labor. Most rural/outer island residents

have relatives in the urban centers, who provide the reason and means to migrate (14). The periodic food supplies once sent from rural islanders to urban relatives are superseded by imports (14). Rural population totals disguise high ratios of dependent population to productive work force. Rural to urban/off-island migration has left many island rural areas with an hour-glass shaped population pyramid—a population heavily biased towards the very old and the very young (14). Moreover, while there may be many islanders with skills relevant to the economy, their aspirations generally are directed towards government and retail employment, resulting in a labor constraint to productive employment.

No shortage exists of people, especially young people, to form a labor pool in U.S.-affiliated Pacific islands; however, agricultural labor shortage is a problem in several areas. In general, there is a low esteem for farm work, and wages and benefits are low compared to other types of employment. Guam has considered importing foreign labor under the Federal H-2 temporary alien program, but the Labor Department apparently blocked this (54). Since the Government of Guam was granted the authority to certify and import alien workers in 1984, they may reconsider this proposal (45). In American Samoa, much of the agriculture depends on aiga family members from Western Samoa, and Taiwanese and Koreans who have jumped ship at Pago Pago (54,83).

Caribbean

Today the social situation has changed significantly in the rural interior of Puerto Rico. Large numbers of the population have migrated from the rural interior to urban centers or off-island. The remaining rural population is employed as seasonal labor for coffee harvest and supplements its income with food stamps and occasional part-time jobs. The "old timers" have rapidly disappeared and the younger generation is usually unskilled labor (78). Although rural unemployment is high (25 to 30 percent in some municipalities), alternative employment opportunities, food stamps, and social security from extended families all contribute

to an underground economy, which, in some cases, can provide \$2,000 per month in non-taxable family income.

Agricultural development in the U.S. Virgin Islands is constrained by lack of trained personnel and reliable labor and available agricultural labor is generally expensive and unproductive (116). Perhaps correspondingly, the percentage of farms with hired labor has declined in the U.S. Virgin Islands from 33.9 percent in 1975 to 27.7 percent in 1983 (57).

Despite the high unemployment rates, Puerto Rican farmers have reported it difficult to obtain large numbers of part-time laborers (116). Farmers reportedly locate only 90 percent of the workers they need; 52 percent of farmers report difficulty locating experienced workers and 39 percent say that the shortage of labor forces them to employ inexperienced farm workers (123). No migrant labor is available in Puerto Rico (116).

Alien Labor

Pacific

At the same time islanders are leaving their islands for education, employment, or other enticements, considerable numbers of aliens are entering the island economies. Some of these are U.S. mainlanders or Europeans who enter local government positions while an increasing number are Filipinos and other Asians filling largely unskilled positions, predominantly in construction, fishing, and to a lesser extent, agriculture. For example, alien employees currently comprise at least one-third of the Palauan private sector and some economic sectors are almost entirely dependent on Asian labor (14).

Alien workers offer employers substantial advantages in high productivity and reliability, obtaining overtime work, and in flexibility in discharging unsatisfactory workers (11). However, the cost of employing U.S. expatriates is high and there are large costs, and potential benefits, in the impact of the expatriates on consumption (15). For example, the preference for “western-style” foods may increase imports but

it can also signal a potential market for locally grown, non-traditional crops.

The question of whether or not to import foreign labor is a difficult one. Agricultural industries such as Hawaii’s were built with cheap foreign labor, but there can be resulting social tension when large numbers of foreigners are imported into a relatively closed society, as in many of the U.S.-affiliated islands. Pohnpei has rejected two development proposals—one to bring in Vietnamese refugees to grow rice—for these reasons (83). On the other hand, importing labor may be better than importing food—the agricultural industry will develop, dependence on imported food is reduced, and foreign workers generate tax revenues through payment of taxes on their wages (45). Alternatively, agriculture might be made more profitable for local producers and workers through increased research, development, and extension (83).

Despite the current lack of economic growth in the U.S.-affiliated Pacific islands, the proportion of aliens in the local work forces probably will not diminish in the near future (11). In the FAS islands, it is increasingly likely that local islanders will seek government employment or move overseas, while all other sectors of the economy will become increasingly dominated by alien workers. Most will come from Asia and work for lower wages than are offered by government employment (14).

Substantial out-migration of the few skilled professionals now in the FSM and their replacement by alien professionals is likely to continue. Adoption of a wage and salary structure commensurate with the U.S. mainland may reverse these trends, but goes directly against United Nations’ recommendations and is likely to exacerbate existing income inequalities. The FSM is becoming more like Guam, the Northern Marianas and American Samoa (and also the U.S. Virgin Islands), where government employment is predominantly indigenous, while employment in other sectors is increasingly taken up by lower paid aliens, a situation made possible only with substantial external financial assistance (11).

Caribbean

While the Puerto Rican labor force is almost exclusively comprised of residents, the U.S. Virgin Islands has developed a relatively large alien labor force. Local application of the special Temporary Foreign Worker Program in the U.S. Virgin Islands has created a labor base largely comprised of British West Indians. This labor force generally increases in periods of economic prosperity, and decreases only minimally during periods of recession. The net results are: rise of unemployment, increase in individual's multiplicity of jobs, increased reliance on savings, and reductions in remittances (57). Displacement of local workers by aliens currently does not seem to be a concern in the U.S. Virgin Islands.

Immigrants from neighboring islands are accustomed to rural lifestyles and prefer working in agriculture, but often lack capital and land and generally earn most of their income from industry or tourism (78). Consequently, the aliens generally are employed in a large variety of low-level jobs that U.S. Virgin Islanders have traditionally avoided (79), thereby creating a bimodal society which promotes internal cleavage in U.S. Virgin Islands society (58).

Conclusions

If the islands are not to suffer a decline in living standards, they must either find new sources of aid, reduce government expenditure, or develop greater self-reliance. Increasing self-reliance means reducing dependence on imported goods and expertise, and probably will require some changes in consumption patterns as well as increased local productive capacity (15).

The small size and limited skilled labor force of the polities virtually preclude accelerated socioeconomic development towards a mainland U.S. standard of living without outside inputs of technical assistance and skills (12). Economic development probably cannot be achieved simply by reallocating resources towards improved infrastructure or agricultural investment. It may also require a fundamental change in attitudes, demanding such policies as wage

constraints and raised taxation (on imports and income). This may be extremely difficult to achieve on small, democratic islands (14). The combination of relatively high educational standards and aspirations, limited opportunities for formal sector employment, and the possibility of free movement to the United States, suggests that out-migration from the U. S.-affiliated islands is likely to become increasingly important in the future (14).

The application of technologies is many times hindered by the lack of properly trained personnel. Training in some specialties is not available in local academic institutions and students must travel to off-island institutions for such training. Few island residents can afford this. Those students who attend off-island institutions often remain there, enticed by better jobs, opportunities for further training, and career advancement. The lack of trained personnel may have adverse effects on all aspects of renewable resource management, including research, law enforcement, project implementation, and education in academic institutions (19).

Adequately trained, dedicated staff are needed at all levels. Individuals with appropriate attitudes and aptitudes must be identified and given technical or professional training and continuing education, so they may keep abreast of new resource management and development strategies and technologies. Short courses could be organized locally, and key staff encouraged to travel to conferences and summer programs abroad. Where human resources are scarce, they could be directed to the most critical areas or problems (19).

Suitable working conditions must be provided. Flexibility is needed in personnel regulations and incentives programs, especially of the insular governments. Salary scales could be upgraded on a regular basis to remain competitive with the private sector. Public corporations might replace more successful government programs to provide professionals with secure, well-remunerated positions.

The Federal Government could raise the limit for exemption from minimum Federal wage

payment for nonmechanizable agricultural operations. It also could assign a specific proportion of the food stamp funds and/or any increases in these funds to increase employment and local food production. Increased income to laborers could reduce payments for food stamps and for unemployment compensation and reduce migration to the mainland (116).

Agriculture and other renewable resource-related enterprises can be an important source

of employment, but unless production is increased, greater employment may be accompanied by lower wages, higher prices, more government subsidies, losses to farmers or some combination of these. On the other hand, in Puerto Rico every job in agriculture is estimated to create at least one other job in the island's economy, considerably more than that created by industry or construction (116).

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