Studies in Avian Biology No. 22:329–337, 2001.

AN ECOSYSTEM-BASED MANAGEMENT APPROACH TO ENHANCING ENDANGERED WATERBIRD HABITAT ON A MILITARY BASE

DIANE DRIGOT

Abstract. Improving and sustaining endangered waterbird habitat has proven challenging but possible at Marine Corps Base Hawaii (MCBH), an active military installation on Hawai'i's most urbanized island of O'ahu. Such results have been possible through an ecosystem-based approach to resource management. This approach integrates stakeholder involvement into habitat enhancement schemes. Annual military maneuvers and frequent community volunteer assistance in invasive vegetation control have become an integral part of MCBH's waterbird habitat management routine for more than fifteen years. This approach has contributed to a doubling of Hawaiian Stilts (*Himantopus mexicanus knudseni*) counted, increased habitat availability for stilt nesting, and improved awareness among involved stakeholders of collaborative stewardship efforts needed to sustain these gains. This approach is applicable elsewhere.

Key Words: Black-necked Stilt; ecosystem health recovery; ecosystem management; endangered waterbird habitat; Hawaiian Stilt; military training; U.S. Marine Corps.

Improving and sustaining endangered waterbird habitat has proven challenging but possible at Marine Corps Base Hawaii (MCBH), an active military installation in the Hawaiian Islands. In 15 years, the Hawaiian Stilt, an endemic subspecies of the Black-necked Stilt (*Himantopus mexicanus knudseni*), population at the base's Nu'upia Ponds grew from about 60 to over 130 birds—10% of the state's entire population (Rauzon et al. 1997). MCBH resource managers are working to minimize stilt exposure to predators, alien plant habitat intrusions, competitors, disease vectors, and human disturbances. They have the added challenge of doing this in the context of military mission priorities and other resource use pressures.

This case study will show how an ecosystem-based management approach integrates the seemingly conflicting management priorities of combat readiness at a military installation and species preservation. Multiple objectives have been achieved, such as habitat enhancement through military training maneuvers and the development of a shared regional vision of restored ecosystem health through a sustained community volunteer weed removal program. The lasting success of MCBH projects such as alien pickleweed (*Batis maritima*) and red mangrove (*Rhizophora mangle*) control to recover endangered species habitat is the result of using this approach. Lessons learned are applicable elsewhere.

GEOGRAPHIC SETTING AND MANAGEMENT CONTEXT

The site of this case study is Mōkapu, a 1,194 ha peninsula on the northeast, windward side of O'ahu, separated from downtown Honolulu by the 35 km Ko'olau Range (Fig. 1).

Although relatively small in size, this peninsula supports a surprising diversity of wildlife and other natural and cultural resources, besides being a busy military community of over 17,000 residents. The base's Ulupa'u Crater supports a colony of over 3,000 Red-footed Boobies (*Sula sula rubripes*) within an active weapons firing range (Rauzon 1992). Within the cliffs below the crater, next to a grenade range, the oldest fossil bird deposit yet found in the Hawaiian Islands has attracted national scientific interest (James 1987, Olson and James 1991).

Along the 17.6 km shoreline of Mōkapu peninsula, over 50 different species of waterbirds, migratory shorebirds, and seabirds have been noted in 50 years of bird count records (Rauzon 1992). Legally protected sand dunes contain thousands of ancient Native Hawaiian burials and support a variety of native seastrand vegetation. Sixty-two cultural resources have been recorded, 50 of which are archaeological or historic World War II sites eligible for or already listed in the National Register of Historic Places (Schilz 1996). The peninsula has a storied landscape, rich in Hawaiian legends and considered sacred by some contemporary Hawaiians (Maly and Rosendahl 1995). Like many other military bases on the continental United States, MCBH has become a de facto refuge of diverse natural and cultural resources surrounded by an urbanized region (e.g., Advisory Council on Historic Preservation 1994, Steinitz 1996, Leslie et al. 1996).

The base contains a busy military airfield, whose aircraft flight paths, noise limitations, accident risks to nearby communities, and bird-

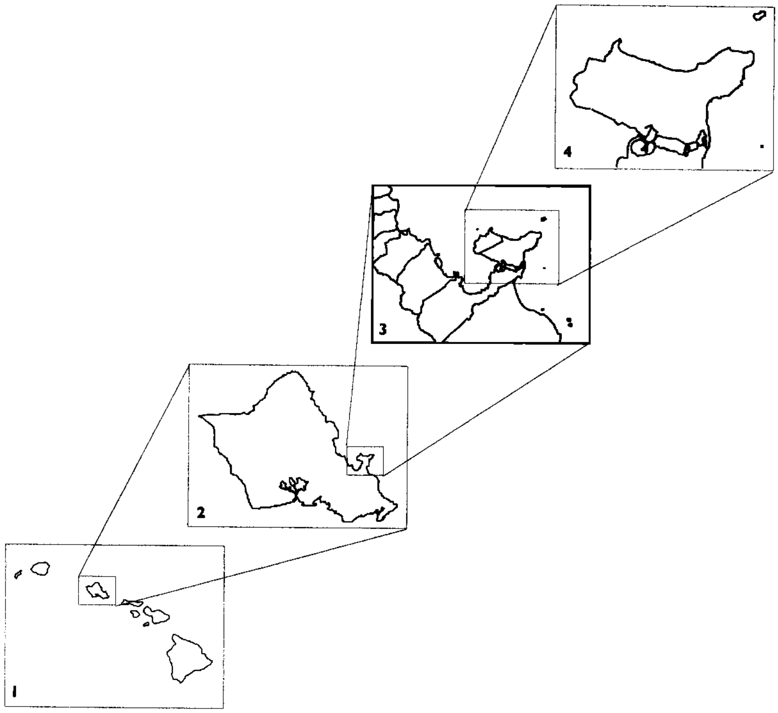

FIGURE 1. Map of (1) Hawaiian Islands; (2) island of O'ahu; (3) Ko'olau Poko District; and (4) Mōkapu Peninsula (from Wilcox et al. 1998).

aircraft strike hazards must be carefully managed in a manner that considers the surrounding environment and community concerns. Marine training operations occur around the peninsula in water assigned the most stringent water quality standards in the state (Hawai'i State Administrative Rules Chapters 11–54). Marines share this water space with public boating, fishing, swimming, and protected species such as coral reefs, threatened green sea turtles (*Chelonia mydas*), endangered Hawaiian monk seals (*Monachus schauinslandi*), and humpback whales (*Megaptera novaeangliae*; Drigot et al. 1991).

In addition to these many and varied resources, uses, and demands, Mōkapu supports a major breeding population of Hawaiian Stilt. This bird is currently listed as endangered by the U.S. Fish and Wildlife Service (35 Federal Register 16047). The peninsula's primary stilt habitat is mudflat shoreline around the Nu'upia Ponds, originally part of an ancient Hawaiian aquaculture complex and now an MCBH-designated Wildlife Management Area (WMA). This 195-ha area is comprised of an interconnected complex of eight shallow ponds, associated wetland areas, and a vegetative buffer zone, which links the peninsula to the rest of the island of O'ahu (Fig. 2). In the past 15 years, biannual censuses of Hawaiian Stilt at these ponds have shown growth from about 60 to over 130 birds. The pond stilt population now comprises nearly 10% of the state's total estimated population of 1,500–1,800 birds (Rauzon et al. 1997). Recent (1994–1996) intensive MCBH stilt monitoring surveys have confirmed this growth, with band returns showing some dispersal to other habitats off the base. Increases in number of nests made, eggs laid, and chicks hatched have been particularly noted in pond areas subject to deliberate vegetation manipulation (Rauzon and Tanino 1995, Rauzon et al. 1997).

This aspect of the increased breeding success of MCBH Hawaiian Stilt is the result of the application of ecosystem-based management principles. These principles emphasize that resource management decisions should be based not only on the "best science" but on the recognition that resource "management objectives are a matter of social choice," and that "ecosystems must be managed in a human context" (McDowell 1997).

BACKGROUND AND METHODS

Ecosystem management (EM) is an important priority for federal agencies (Grumbine 1997). The Department of Defense (DoD) is one of 14

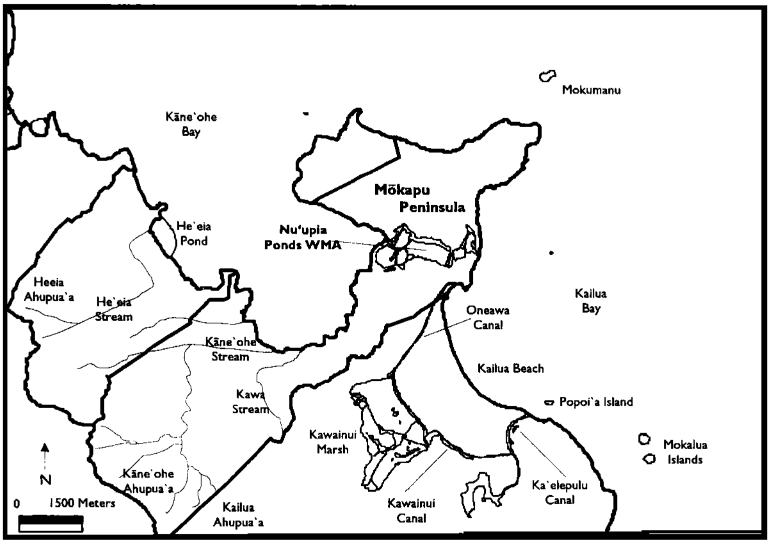

FIGURE 2. Nu'upia Ponds Wildlife Management Area (WMA) in regional context modified from Wilcox et al. (1998).

federal land management agencies that on December 15, 1995, signed an interagency "Memorandum of Understanding to Foster the Ecosystem Approach" to resource management (Council on Environmental Quality et al. 1995). The goal of EM as stated in the Memorandum of Understanding (MOU) is:

> . . . to restore and sustain the health, productivity, and biological diversity of ecosystems and their overall quality of life through a natural resource management approach that is fully integrated with social and economic goals . . .

The MOU further defines an ecosystem approach as:

> . . . a method for sustaining or restoring ecological systems and their functions and values. It is goal driven, and it is based on a collaboratively developed vision of desired future conditions that integrates ecological, economic, and social factors. It is applied within a geographic framework defined primarily by ecological boundaries . . .

EM emphasizes humans as part of the ecosystem, basing resource management decisions not only on "best science" but on "associated cultural values," "improved communication with the general public," and "forming partnerships" with government, nongovernmental agencies, "and other stakeholders."

DoD Instruction 4715.3 of May 3, 1996, promulgates ten "Ecosystem Management Principles and Guidelines" to be followed by all U.S.-based military installations (DoD 1996). These ecosystem management principles (EMPs) are listed below and explained in Appendix 1.

1. Maintain and improve the sustainability and native biodiversity of ecosystems.
2. Administer with consideration of ecological units and time frames.
3. Support sustainable human activities.
4. Develop a vision of ecosystem health.
5. Develop priorities and reconcile conflicts.
6. Develop coordinated approaches to work toward ecosystem health.
7. Rely on the best science and data available.
8. Use benchmarks to monitor and evaluate outcomes.
9. Use adaptive management.
10. Implement through installation plans and programs.

In fiscal year 1997 alone, one-third of the DoD's $100 million conservation budget supported the development of Integrated Resource Management Plans (IRMPs). These IRMPs are seen as the primary vehicle for promulgating EMPs. DoD's ambitious goal is to complete baseline IRMPs for 425 major military installations spanning approximately 10 million ha of U.S. land by the year 2001 (Boice 1997). One of DoD's "Conservation Measures of Merit" to assess progress in implementing EMPs is the timely completion of these plans (L. P. Boice, pers. comm.). Congress's recent reauthorization and update of the Sikes Act addressing natural resources conservation on DoD installations now mandates development of these plans and periodic reports to Congress on plan implementation progress (Sikes Act Improvement Act of 1997—P.L. 105-95).

In the Results and Discussion section that follows, some of MCBH's endangered species habitat recovery activities over the past 15 years and elements of the base's recently completed Integrated Resource Management Plans (Wilcox et al. 1997, Wilcox 1998) will be reviewed in the context of the concomitant EMPs upon which they are based. To that end, there will be parenthetical references to one or more of the ten EMPs in the sections where they are most pertinent.

RESULTS AND DISCUSSION

ECOSYSTEM-BASED APPROACH TO RESOURCE MANAGEMENT AT MCBH (EMPs 1, 2, 3)

Although terms such as "ecosystem-based management" and the emphasis on humans as part of managed ecosystems are relatively new, MCBH resource management approaches have long reflected the notion that humans do not just generate "anthropogenic effects" *on* ecosystems but are an integral *part of* ecosystems being managed. Application of this broader, human-emphasized perspective is illustrated as follows. First, since MCBHs primary military mission is to maintain facilities and services that support the combat readiness of Marines, base resource managers must view the primary goods and services derived through the air, land, and water resource management zones in and around the peninsula as those which serve this central mission requirement. From this perspective, a primary function of the Nu'upia Ponds Wildlife Management Area is as a valuable security buffer and helicopter overflight corridor between the military installation and the surrounding civilian community (EMP 3).

Secondly, federal mandates also require that base resource managers identify and protect significant cultural and natural resources within their jurisdiction. From this perspective, the dual status of Nu'upia Ponds as an endangered species habitat and an ancient Hawaiian fishpond of national historical significance (Keeper of the National Register 1984) must be recognized. In fact, the valued "natural" waterbird habitat functions of the base's Nu'upia Ponds resulted from a human construct in the first place—a walled fishpond complex whose remnant fishpond features have archaeological and indigenous cultural values contributing to Nu'upia Ponds eligibility for inclusion in the National Register of Historic Places (Drigot and Tuggle 1984). Although no longer actively managed for fish harvesting, the shoreline mudflats bordering the interconnected fishpond rock wall alignments are now used by the Hawaiian Stilt and other protected waterfowl. Historic preservation requirements associated with these features often influence how, when, and where wildlife habitat improvements are made in this area (EMPs 1, 2).

In summary, MCBH is required by federal laws to integrate historic Polynesian and present military functions of the pond landscape in their wildlife habitat recovery schemes. By recognizing that such mandated resource uses are an integral part of the ecosystem, rather than a constraint to overcome, unique opportunities to recover an endangered species as discussed below became apparent.

RESOLVING MANAGEMENT CONFLICTS INTO OPPORTUNITIES (EMPs 1, 3, 5)

From the mid-1960s through the mid-1970s, Hawaiian Stilt counts at Nu'upia Ponds were at much lower levels than today. For example, the average number of stilts counted on 27 censuses between 1965 and 1975 was 54 birds (Rauzon et al. 1997). During this time, Amphibious Assault Vehicles (AAVs) used the northern shoreline of this wetland as their daily transit corridor to the nearest beach maneuver area.

When Hawaiian Stilts attempted to nest in tire tracks left in the mud by these 26-ton tracked vehicles, wildlife biologists were called in to move the birds. In the process of addressing this immediate problem, what was initially seen as a conflict between a military training exercise and an endangered species came to be viewed as a "swords into plowshares" opportunity. State and federal wildlife biologists worked with MCBH environmental and Marine personnel to capitalize on the fact that these birds were attracted to the open mudflat areas cleared of invasive alien vegetation by these vehicles. The immediate conflict was resolved by moving the AAVs' daily transit corridor upland to the north, out of the wetland mudflats. However, on a supervised, annual basis, just before the onset of the breeding season, MCBH began to deliberately deploy these AAVs in plowing-like maneuvers within this mudflat shoreline (Fig. 3). These actions are directed by resource managers in such manner as to avoid culturally sensitive features and break open thick mats of alien invasive plants (primarily pickleweed and some red mangrove) for expanded stilt nesting and feeding opportunities (EMP 5).

Coincident with the past 15 years of performing this annual back and forth AAV plowing ac-

FIGURE 3. Marine amphibious assault vehicles plowing mudflats of Nu'upia Ponds, crushing invasive weeds, and opening water channels to expand and improve Hawaiian Stilt nesting and feeding opportunities. (Photo by D. Drigot).

tion, biannual stilt counts have more than doubled. Direct observations and monitoring studies have confirmed the creation of improved nesting and feeding substrate as significant contributing factors in attracting these birds (Rauzon 1992, Rauzon and Tanino 1995, Rauzon et al. 1997). A predator trapping program and minimization of human disturbances have also played a role. The moat-and-island terrain created by the AAV plowing action reduces the risk of egg predation by mongooses and helps the young, newly hatched stilt gain more ready access to food, water, and shelter. This is important since they are precocial at hatching and must fend for themselves (EMP 1).

As for the immediate human benefit, this action goes beyond compliance with federal resource stewardship mandates by providing the Marines an unexpected opportunity to practice working their vehicles in uncustomary terrain in a normally restricted area (EMP 3).

Thus, what may be construed as inherently destructive military maneuvers have been turned into an environmentally benevolent action. The Marines have become an integral part of the dynamics of this managed ecosystem, both providing and receiving a valuable service. Through this deliberate controlled disturbance once a year, the habitat becomes more available to the birds. In exchange, Marines get a novel training opportunity recognized by favorable media coverage, publications (e.g., Drigot 1996), and national awards earned in interservice military competitions (e.g., 23 Secretary of the Navy Natural Resources and/or Secretary of Defense Environmental Security Awards over 25 years). A sense of pride about environmental stewardship has grown, consistent with the Marine Corps' ethic about doing what is right and being protectors.

The Marines have adopted their own name—"Annual Mud Ops"—for this annual plowing ritual (Compton 1997). In response to base community interest, the base elementary school has even changed its mascot from a stallion to a stilt. When a ritual is thus born, acquires a name, and is adopted by the community, these are signs that it is sustainable and will have lasting affect, despite the constant rotation off the base of the individual Marines involved (Kent and Preister 1997; J. Kent, pers. comm.).

In summary, a potential conflict was turned into an unexpected opportunity to synergistically support valued military and wildlife functions of the pond landscape by applying an EM approach to integrated resource management (EMPs 1, 2, 3, 5).

DEVELOPING A REGIONALLY SHARED, SUSTAINABLE VISION OF AND COORDINATED APPROACHES TOWARD ECOSYSTEM HEALTH (EMPs 4, 6)

Another aspect of how MCBH's early EM approach has improved stilt habitat in a sustainable fashion has been the collaborative manner by which alien invasive red mangrove has been removed from the ponds using volunteer labor, thus cultivating a shared vision of desirable future ecosystem conditions in the region.

Introduced to the islands in the early 1900s for erosion control, red mangrove has spread throughout much of Hawai'i's coastal wetlands (Wester 1981). This invasive species has become a major threat to Hawaiian wetland habitats and to cultural resources as well. At Nu'upia Ponds, if left unchecked, mangrove can overgrow and destroy remnant ancient fishpond walls and valuable mudflat bird nesting and feeding habitat. These plants also clog waterways, alter native aquatic and wetland habitat, and out compete native wetland plants.

Using volunteer labor, in the early 1980s, MCBH began to tackle removal of this invasive alien plant in areas of the ponds not readily accessible by amphibious vehicles or other mechanized equipment. The intention was, with limited labor and funds, to discourage further eastward expansion across the fishpond complex.

In the process of involving diverse groups of volunteers (e.g., Sierra Club, Scouts, Marines, and school and church organizations), modest view planes were cleared into the pond habitat. In so doing, a shared vision of what was possible began to develop as more people were literally drawn into the landscape and established direct connection with the resource (EMP 4). Numerous schools and community groups, both on- and off-base, were successfully encouraged to incorporate pond mangrove-pulling events into their institutions' regular service schedules (Burrows 1997; EMP 3).

Over the years, by publicizing the positive results and coordinating a number of regular, volunteer weed-clearing services, further mangrove encroachment has been curtailed, while a sustained regional commitment to promoting ecosystem health has been fostered (EMPs 2, 3, 6).

Early and regular involvement of these "stakeholders" laid the foundation for sustaining the later benefits of an early 1990s infusion of Congressional Legacy Program funds. These competitively awarded funds helped MCBH to clear 17 acres, or 95% of remaining mangrove vegetation from the ponds, by a combination of contractor-assisted hand and heavy equipment techniques. In a few years, a quantum leap in habitat recovery and cultural landscape restoration was made at MCBH. These gains are being sustained by the continued services of various volunteer groups that have become part of the maintenance routine over the years (EMP 3).

Cultivation of this shared vision and service routines also has been instrumental in creating community awareness of the beneficial effects of a cooperative approach to restoring regional ecosystem health (EMP 6). Thus, cooperation is beginning to expand among resource managers, volunteers, concerned citizens, and groups in multiple ecosystems of the Kāne'ohe Bay region also involved in mangrove control, fishpond restoration, bird habitat enhancement, environmental education, or other ecosystem recovery efforts.

One of these groups, the Kāne'ohe Bay Regional Council, serves a community of interest encompassing the entire Kāne'ohe Bay shoreline adjacent to Mōkapu peninsula. This council is particularly concerned about the adverse effects of mangrove encroachment on Kāne'ohe Bay's shorelines and property values. They are using MCBH's experience and study results to build support for more mangrove removal along the shoreline fronting the bay, outside U.S. Marine Corps jurisdiction but within the jurisdiction of other public and private stakeholders (Kaneohe Bay Task Force 1997, Tully 1997). As awareness thus spreads, it is expected that a more coordinated interagency approach to mangrove control will emerge that will disperse the regional resource stewardship burden more evenly among all eligible stakeholders.

ADAPTING MANAGEMENT PRACTICES (EMPs 7, 8, 9, 10)

Legacy funds for mangrove removal at Nu'upia Ponds also supported systematic evaluation of improved environmental quality and stilt habitat along restored shorelines and adjacent waters (EMPs 7, 8). Careful observations of stilt response showed immediate expansion of bird nesting in the mudflats of the mangrove-cleared areas (Rauzon et al. 1997). Localized improvements in water quality chemistry were documented in areas recently cleared of heavy mangrove infestation (Cox and Jokiel 1997). Cultural features of this historic fishpond complex were more clearly exposed, mapped, and recorded through archaeological monitoring studies (McIntosh and Carlson 1996).

Fish surveys in the ponds documented the presence of at least 16 native fish species (Brock 1994). Fish tagging experiments demonstrated the critical value of the ponds as a nursery area for growing fry of native fish populations who later migrate into surrounding bay or ocean waters where they are caught by sports and commercial fishermen (Cox and Jokiel 1997; EMPs 7, 8).

Parallel research on historical human settlement patterns and former hydrologic regimes of the pond area through archival studies, oral histories, and group discussions led to renewed connections with early century residents and their descendants. Many traditions of resource use and stewardship have been recorded through these indigenous sources (Maly and Rosendahl 1995, Maly et al. 1997; EMP 2).

As public awareness of pond ecosystem health recovery spreads, potential conflicts in future envisioned uses of the Nu'upia Ponds are anticipated. Some interest groups have already requested that the Marines restore former fishpond harvesting techniques for subsistence purposes. However, the large-scale fish harvesting techniques likely needed to realize this vision are not compatible with either military security or endangered waterbird requirements for minimum human disturbance in the area.

MCBH is addressing these and other use pressures within the context of its integrated resource management planning process (Wilcox et al. 1997, Wilcox 1998). Data and insights revealed during this ecosystem-based management planning process have revealed an alternative way of addressing fishpond use pressure through a revival of Native Hawaiian use of these ponds in a way that may be more compatible with the needs of the Marines, the birds, and the interested publics: restoring the easternmost pond to its original saltworks configuration (Wilcox et al. 1997; EMPs 5, 7, 9, 10).

Throughout most of the 1,000 years of the ponds' cultural history, this area of the complex was managed as a saltworks. There is a strong tradition of salt gathering in several locations of the peninsula (Maly and Rosendahl 1995, Maly et al. 1997). Hawaiian Stilt not only can tolerate hypersaline conditions, but restored saltpans will support food sources attractive to stilts (e.g., brine shrimp and flies; Guinther 1985, Rauzon et al. 1997). Restoration of the high salinity extreme in the eastern end of the mixed salinity regime of Nu'upia Ponds will likely improve the heterogeneity of feeding habitats for Hawaiian Stilt there (Guinther 1983, 1985; E. Guinther, pers. comm.).

Restoring the saltworks would involve closing a channel created in the 1920s by the Territorial Game Farm (Cordy 1984). This would solve a current problem of sand migrating into the pond through the channel from the sand dune shoreline of the adjacent beach, enhancing the possibility of exposing Native Hawaiian burials located in this protected archaeological site.

To further develop this emerging vision of a possible restored saltworks, MCBH is looking to local and indigenous sources of knowledge. Thus, for example, oral histories of former Mōkapu residents about early twentieth century salt harvesting traditions and the experiences of other respected Hawaiian elders ("kupuna"), are being reviewed, some of whom still manage saltworks elsewhere in Hawai'i today (Maly and Rosendahl 1995, Maly et al. 1997). MCBH resource managers are also becoming familiar with contemporary Hawaiian cultural resource restoration techniques, having already employed Native Hawaiian stonemasons on a wall replication elsewhere on the peninsula (Kakesako 1997).

Such limited, localized, controlled public use/harvesting of the ponds' resources in an endangered species habitat and historic landscape on a military base may be more manageable and compatible than fish harvesting uses, and more consistent with cultural precedent and recommendations (Maly and Rosendahl 1997; EMPs 5, 9).

Continued Use of Adaptive Management Approach to Installation IRMPs (EMPs 9, 10)

Successful EM requires the recognition that ecosystems are open, changing, and complex. Management practices need to be flexible in accommodating dynamic changes in scientific understandings, management concerns, and public issues. As seen above, they must also often include taking local and indigenous knowledge and ideas into account in addressing resource management problems and opportunities. Effective EM must be a collaborative learning process (Daniels and Walker 1996).

MCBH is following an adaptive management approach to striking a balance among the valued natural and cultural resources services provided by Nu'upia Ponds. This involves a continuous process of identifying and balancing natural, sociocultural, institutional, and economic opportunities and constraints, and framing the process within a consciously defined ecosystem boundary in a regional context. To further ensure that management actions and priorities are continuously effective, the recently developed IRMPs and implementation strategies are subject to regular review and updating (EMPs 9, 10).

CONCLUSION

In the application of EM principles at MCBH, it was discovered that endangered species restoration is possible, even on a busy military installation, so long as it is linked with the community's lifeways and cultural values, both past and present. These findings are similar to those of a recent national survey of over 100 ecosystem management projects in the United States, both public and private (Yaffee et al. 1996). This survey revealed that many pioneering efforts now underway hold promise of restoring ecosystem health through a more holistic approach to resource management. However, these efforts often face resistance if focused on the biophysical aspects of such restoration, with insufficient attention to the viewpoints of many different stakeholders affected by a given restoration scheme. MCBH's experience indicates the potential for sustainable ecosystem recovery is greater using an ecosystem-based management approach focusing on the following elements:

1. Acknowledge and incorporate human influences—past, present, and future—into ecosystem management schemes.
2. Understand that people form cultural attachments over time to an area where ritual activities take place (Kent and Preister 1997). If ways can be found to incorporate people's daily routines or valued rituals (e.g., military training, community service) into ecological restoration projects, then the chances of sustained ecological recovery are increased (J. Kent, pers. comm.).
3. Seek to adapt and refine solutions to emergent resource management challenges in a collaborative manner by regularly reviewing and refining one's vision of possibilities in light of mission requirements, best science, and stakeholder involvement.
4. Realize that such an approach to ecosystem management draws out the natural stewardship values in people. With an unstable funding climate for ecological restoration projects, securing public allegiance and support in this manner is an effective way to sustain the gains made.

ACKNOWLEDGMENTS

Mahalo nui (Much thanks!) to B. Wilcox and J. Kent for their valuable reflections as this manuscript evolved; to S. Conant, M. Morin, M. Scott, and one anonymous reviewer for their suggestions and comments; to state and federal wildlife biologists R. Saito, R. Walker, R. Shallenberger, T. Coleman, T. Burr, V. Byrd, and consultants M. Rauzon and L. Tanino, all of whom played a crucial advisory role over the years on the synergistic interaction possibilities between Amphibious Assault Vehicles and Hawaiian Stilt; and to all the Marines of Amphibian Assault Detachment, Combat Support Company, 3rd Marines, who are the real heroes in this Hawaiian Stilt recovery story. However, the views expressed in this article are those of the author, and do not necessarily reflect the positions of the U.S. Government, the U.S. Department of Defense, and the U.S. Marine Corps.

APPENDIX

ECOSYSTEM MANAGEMENT PRINCIPLES AND GUIDELINES, REPRINTED FROM ENCLOSURE (6) OF DEPARTMENT OF DEFENSE INSTRUCTION 4715.3 OF MAY 3, 1996, ENVIRONMENTAL CONSERVATION PROGRAM, PREPARED BY THE OFFICE OF THE DEPUTY UNDER SECRETARY OF DEFENSE (ENVIRONMENTAL SECURITY), 3400 DEFENSE PENTAGON, WASHINGTON D.C. 20301-3400

A. GOAL OF ECOSYSTEM MANAGEMENT

To ensure that military lands support present and future training and testing requirements while preserving, improving, and enhancing ecosystem integrity. Over the long-term, that approach shall maintain and improve the sustainability and biological diversity of terrestrial and aquatic (including marine) ecosystems while supporting sustainable economies, human use, and the environment required for realistic military training operations.

B. PRINCIPLES AND GUIDELINES

1. *Maintain and Improve the Sustainability and Native Biodiversity of Ecosystems.* Ecosystem management involves conducting installation programs and activities in a manner that identifies, maintains, and restores the "composition, structure, and function of natural communities that comprise ecosystems," to ensure their sustainability and conservation of biodiversity at landscape and other relevant ecological scales to the maximum extent that mission needs allow.
2. *Administer with Consideration of Ecological Units and Time Frames.* Ecosystem management requires consideration of the effects of installation programs and actions at spatial and temporal ecological scales that are relevant to natural processes. A larger geographic view and more appropriate ecological time frames assist in the analysis of cumulative effects on ecosystems that may not be apparent with smaller and shorter scales. Regional ecosystem management efforts are generally more appropriate than either national or installation-specific efforts. Consideration of sustainability under long-term environmental threats, such as climate change, is also important.
3. *Support Sustainable Human Activities.* People and their social, economic, and national security needs are an integral part of ecological systems, and management of ecosystems depends on sensitivity to those issues. Consistent with mission requirements, actions should support multiple use (e.g., outdoor recreation, hunting, fishing, forest timber products, and agricultural outleasing) and sustainable development by meeting the needs of the present without

compromising the ability of future generations to meet their own needs.

4. *Develop a Vision of Ecosystem Health.* All interested parties (federal, state, tribal, and local governments, nongovernmental organizations, private organizations, and the public) should collaborate in developing a shared vision of what constitutes desirable future ecosystem conditions for the region of concern. Existing social and economic conditions should be factored into the vision as well as methods by which all parties may contribute to the achievement of desirable ecosystem goals.
5. *Develop Priorities and Reconcile Conflicts.* Successful approaches should include mechanisms for establishing priorities among the objectives and for conflict resolution during both the selection of the ecosystem management objectives and the methods for meeting those objectives. Identifying "local installation objectives" and "urban development trends" are especially important to determine compatibility with ecosystem objectives. Regional workshops should be convened periodically to ensure that efforts are focused and coordinated.
6. *Develop Coordinated Approaches to Work Toward Ecosystem Health.* Ecosystems rarely coincide with ownership and political boundaries so cooperation across ownerships is an important component of ecosystem management. To develop the collaborative approach necessary for successful ecosystem management installations should:
   a. Involve the military operational community early in the planning process. Work with military trainers and others to find ways to accomplish the military mission in a manner consistent with ecosystem management.
   b. Develop a detailed ecosystem management implementation strategy for installation lands and other programs based on the vision developed in subsection B.4., above, and those principles and guidelines.
   c. Meet regularly with regional stakeholders (e.g., state, tribal, and local governments; nongovernmental entities; private landowners; and the public) to discuss issues and work toward common goals.
   d. Incorporate ecosystem management goals into strategic, financial, and program planning and design budgets to meet the goals and objectives of the ecosystem management implementation strategy.
   e. Seek to prevent undesirable duplication of effort, minimize inconsistencies, and create efficiencies in programs affecting ecosystems.
7. *Rely on the Best Science and Data Available.* Ecosystem management is based on scientific understanding of ecosystem composition, structure, and function. It requires more and better research and data collection, as well as better coordination and use of existing data and technologies. Information should be accessible, consistent, and commensurable. Standards should be established for the collection, taxonomy, distribution, exchange, update, and format of ecological, socioeconomic, cartographic, and managerial data.
8. *Use Benchmarks to Monitor and Evaluate Outcomes.* Accountability measurements are vital to effective ecosystem management. Implementation strategies should include specific and measurable objectives and criteria with which to evaluate activities in the ecosystem. Efficiencies gained through cooperation and streamlining should be included in those objectives.
9. *Use Adaptive Management.* Ecosystems are recognized as open, changing, and complex systems. Management practices should be flexible to accommodate the evolution of scientific understanding of ecosystems. Based on periodic reviews of implementation, adjustments to the standards and guidelines applicable to management activities affecting the ecosystem should be made.
10. *Implement Through Installation Plans and Programs.* An ecosystem's desirable range of future conditions should be achieved through linkages with other stakeholders. "Specific DoD activities" should be identified, as appropriate, in INRMPs and ICRMPs and in other planning and budgeting documents.