

# ENDANGERED *Species* BULLETIN

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*When Charles Darwin visited the Galapagos Islands, he was struck by the diversity of life found in these unique habitats. It is now clear that factors such as geographic isolation that lead to the origin of new island species can make these creatures and their ecosystems vulnerable to change from outside influences. Many endemic species, such as those found in the Pacific island nation of Palau (left), are imperiled by habitat loss and the introduction of non-native animals and plants, which can overwhelm species that never needed to develop defenses. This edition of the Endangered Species Bulletin features examples of biodiversity in several of our own nation's island ecosystems, some of the threats they face, and potential remedies.*



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#### On the Cover

The Seventy Island Nature Preserve in the Republic of Belau (Palau) contains a wealth of plant and animal species. Even though the habitat in this preserve is protected, however, the endemic palms are threatened by introduced cockatoos.

*Photo by Joan Canfield*

#### Opposite page

The Galapagos Islands are home to the world's only sea-going iguana species.

*Corel Corp photo*



The Endangered Species Bulletin welcomes manuscripts on a wide range of topics related to endangered species. We are particularly interested in news about recovery, habitat conservation plans, and cooperative ventures. Please contact the Editor before preparing a manuscript. We cannot guarantee publication.

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# “Radiating” Plants

by Robert Robichaux,  
Joan Canfield, Frederick  
Warshauer, Lyman Perry,  
Marie Bruegmann,  
and Gerald Carr



Top view of silversword rosette with “radiating” leaves

Photo by Robert Robichaux

**Adaptive radiation of Hawaiian species has been aided by the isolation of the archipelago and by its distinctive geological origin from a “hot spot” in the Earth’s mantle beneath the Pacific tectonic plate. Volcanic activity has created a succession of high islands at the stationary “hot spot.” Once formed, the islands have drifted northwestward on the plate’s surface at a rate of about 3-3.5 inches (75-90 mm) per year. Through erosion and subsidence (or sinking), they have been reduced from large emergent volcanoes to low islands and atolls. The youngest island in the archipelago (Hawai’i) emerged above sea level only about one-half million years ago and is still growing today through active lava flows. Kaua’i emerged over 5 million years ago. The low islands and atolls northwest of Kaua’i,**

The Hawaiian Islands are renowned as a “living laboratory” of evolution due to their rich diversity of native plants and animals, most of which are endemic to the archipelago. Of special interest are the striking examples of adaptive radiation that pervade Hawaii’s biotic landscape. In adaptive radiation, a single ancestral species evolves into a wide array of descendant species that differ greatly in habitat, form, or behavior. Although other oceanic islands feature examples of adaptive radiation, nowhere else has this process yielded as dazzling an array of life forms as in Hawaii, where conditions seem to favor unusually high rates of speciation and evolutionary innovation.

A premier example of adaptive radiation in plants is the Hawaiian silversword alliance, an endemic lineage in the sunflower family (Asteraceae). The silversword alliance includes 30 species in 3 endemic genera (*Argyroxiphium*, *Dubautia*, and *Wilkesia*). These species grow in habitats as varied as exposed lava, dry shrublands, wet forests, and bogs. The range in annual rainfall among the habitats, from less than 15 inches (380 millimeters) to more than 450 inches (11,430 mm), is truly exceptional. In elevation, the habitats of the species extend from near sea level to over 12,500 feet (3,800 meters).

Species in the silversword alliance show amazing variation in form, from small cushion plants and rosette shrubs to vines and trees. They also vary greatly in reproductive mode. Most species in the silversword alliance flower repeatedly throughout their lives, but several species flower only once before dying. The Haleakala silversword (*Argyroxiphium sandwicense* ssp. *macrocephalum*) may grow for 40 or more years before it is ready to flower. Then it produces a massive 5-foot (1.5-m) tall flowering

stalk with up to 600 showy heads, each containing up to 600 individual flowers. Following this enormous burst of reproduction, the entire plant withers and dies.

Despite their spectacular diversity, species in the silversword alliance are very closely related. Recent analyses of nuclear DNA sequences by Bruce Baldwin of the University of California at Berkeley provide compelling evidence that the 30 species evolved from a single ancestor that arrived in Hawaii from North America, probably about 5 million years ago. Possibly the seeds of this ancestor got caught in the feathers of a wandering bird that later landed in Hawaii. Nothing in the outward appearance of the modern continental relatives of this ancestor hints at the extraordinary adaptive radiation that has occurred in the Hawaiian Islands.

The Hawaiian flora is replete with examples of adaptive radiation, including plants in the poinsettia family (Euphorbiaceae) that evolved into trees (*Chamaesyce*) and plants in the lobelia family (Campanulaceae) that evolved into 40-foot (12-m) tall palm-like trees (*Cyanea* and related genera). In some instances, the diversification of the plants appears intimately linked to diversification in animal groups, especially insects. For example, George Roderick of the University of Hawaii has shown that planthoppers in the genus *Nesosydne* have co-speciated with members of the silversword alliance. For insects that feed or breed on the plants, adaptive radiation in one group may promote adaptive radiation in the other.

## Alien Threats

Understanding adaptive radiation in Hawaii offers a unique window into the evolution of life’s diversity. But peering through this window is becoming ever

more difficult, mainly because of the impacts of alien (or non-native) organisms. Competition with alien plants and predation by alien animals pose severe threats to many of Hawaii's native plants and thus to the many native animals that depend on them. Sadly, Hawaii's fame as a "living laboratory" of evolution is now matched by its unenviable reputation as the "endangered species capital of the world." Of the 669 threatened and endangered plant species in the U.S. as of November 30, 1998, 282 (or 42 percent) are endemic to Hawaii. With fewer than 50 individuals left in the wild, over 100 of these species teeter on the edge of extinction.

The severe impacts of alien species are clearly evident in the Hawaiian plant groups that best illustrate adaptive radiation. In the silversword alliance, for example, 6 of the 30 species are listed as endangered, with alien plant and animal species posing a serious risk to all of them. In some cases, as with the vine koholapehu (*Dubautia latifolia*),

competition with alien plants such as prickly Florida blackberry (*Rubus argutus*) and banana poka (*Passiflora mollissima*) constitutes a grave threat. In other cases, predation by alien ungulates such as sheep (*Ovis* spp.), goats (*Capra hircus*), and pigs (*Sus scrofa*) has caused severe population crashes. The Mauna Loa silversword (*Argyroxiphium kauense*) historically occupied a broad band across the south, east, and north flanks of Mauna Loa volcano on the Island of Hawai'i. But following the introduction and spread of mouflon sheep (*Ovis musimon*), pigs, and other alien ungulates on Mauna Loa, the silversword population declined precipitously. Although a recovery program for the Mauna Loa silversword is working to overcome the direct threats from alien ungulates, the plants now face additional indirect threats from alien insects such as yellowjacket wasps (*Vespula pensylvanica*) that have the potential to decimate populations of native pollinators such as yellow-faced bees (*Hylaeus* spp.). Loss of native pollinators may

significantly threaten the long-term survival of the silversword. To succeed, the recovery program will need to overcome these and other indirect alien threats.

Hawaii's biotic landscape is filled with dynamic, actively evolving lineages of plants and animals. Our long-term goal should be to provide opportunities for the continued adaptive radiation of the myriad plant and animal lineages whose evolutionary potential has barely been tapped. Implementing such a lineage-based approach together with an ecosystem-based approach may offer the best prospect for conserving and restoring the extraordinary "living laboratory" of evolution that is Hawaii.

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*Dubautia waialealae*  
Photo by Gerald D. Carr

**which were once high islands, emerged still earlier. With new islands arising at the "hot spot" throughout the archipelago's long history, native plants and animals have experienced a wealth of opportunities for interisland dispersal, colonization, and diversification.**

**The endemic silversword alliance illustrates the many conservation challenges confronting Hawaii's native flora. Seven (23 percent) of the 30 species are near or over the brink of extinction (six are endangered and another is presumed extinct). These imperiled species represent the wide array of habitats, forms, and reproductive modes evident in the alliance, suggesting that the threats confronting the native flora, especially those posed by alien species, cut a wide swath. Few if any native species are immune to such threats, regardless of the habitats in which they grow or the life-history traits they exhibit. Coordinated efforts are targeting the threats in order to protect Hawaii's unique flora (see article in this edition of the *Bulletin* by Loope and Bartlett).**

# The Elfin Forests of Kaua'i

by Barbara Maxfield



Tucked away in the swirling mists high above its famous beaches and swaying palm trees are small patches of a unique and fragile Hawaiian biological community that few people even know exist: the montane bog. Here, 'ohi'a (*Metrosideros polymorpha*) trees that reach 50 feet (15 meters) into the sky in Hawaiian rainforests often grow less than a foot tall (0.3 m), and a step in the wrong direction can plunge you into muck up to 10 feet (3 m) deep.

Although montane bogs can be found on five of the main Hawaiian Islands, some of the best examples are concentrated on the island of Kaua'i. Toward the summit of Mount Wai'ale'ale, often called the rainiest spot on Earth, where almost 40 feet (12 m) of rain falls every year, a series of bogs within the Alaka'i Swamp provides habitat for 40 flowering plant species. Thirty-five of these species are endemic to the Hawaiian Islands, and 16 are found only in the boggy areas of Kaua'i.

Mount Wai'ale'ale has long been held sacred as the source of the waters of life

for the island of Kaua'i. Hawaiian legends tell of yearly treks by the ali'i nui (high chiefs), kahuna (priests), and their attendants from the lowlands to the most remote heiau or ceremonial site at the summit of Wai'ale'ale. There, they would pay tribute to their gods, thank them for the life-giving waters provided during the past year, and ask that the waters continue in the coming year.

Along the way, they would collect plants and bird feathers to place as offerings to their ancient gods, and to use in the ceremonial robes and headpieces of the ali'i. Just as these ancient Hawaiians revered the Alaka'i for its plants, insects, and birds, the scientists of today make the long journey up the mountain to study the area and seek ways to protect it.

## Formation of the Bogs

Famous for its steep surrounding cliffs and abundant waterfalls, the Alaka'i Swamp itself is actually rather flat. Lava that was once part of Mount Wai'ale'ale's caldera eroded to create a

concrete-like layer of soil that holds the rainfall. As plants dropped their leaves, a thick layer of wet, mucky soil developed, creating bogs that act as immense sponges to absorb the heavy rains. Over millions of years, plants evolved unique adaptations to tolerate the very wet and acidic conditions of the Alaka'i.

Grasses, sedges, clubmosses, ferns, and 'ohi'a dominate these bogs, but unique species of flowering violets, orchids, primroses, geraniums, lilies, and daisies also are found there. In some cases, only remnant populations of these plants are scattered in Wai'ale'ale's bogs, some with fewer than 20 individuals. Two plant species, 'ale (*Plantago princeps*) and the orchid *Plantanthera holochila*, are listed as endangered species, and seven others are being monitored as candidates for listing or as species of concern.

## Threats to the Fragile Habitat

After millions of years of slow and natural formation, the bogs have seen rapid changes in recent years. Despite

the remoteness and harsh conditions of the Alaka'i, a variety of alien species, including humans, now threaten its fragile ecosystems.

By far the most threatening invader is the feral pig (*Sus scrofa*). In the bogs, they uproot vegetative cover searching for invertebrates and plant material, trample plants and seedlings, and disperse alien weed species. Feral pigs selectively eat certain native plants, sometimes extirpating rare species and frequently changing the composition of the bog.

The bogs of the Alaka'i have had relatively few invasions, and most are concentrated in highly disturbed areas. A small reed, *Juncus planifolius*, is the most common invader; others are beardgrass (*Schizachyrium condensatum*) and prickly Florida blackberry (*Rubus argutus*).

Humans also have played a role in disturbing the delicate bog ecosystems. For decades, hikers have trampled native plants growing along the Alaka'i Swamp Trail. Once the vegetative "crust" of the bog is broken, damage spreads quickly, and large, muddy wallows develop. Weed seeds also can be introduced and spread by hikers' boots.

### Protecting the Elfin Forests

The first major step taken to protect these unique bog ecosystems was a cooperative effort led by the State of Hawaii's Department of Land and Natural Resources and carried out by volunteers. A boardwalk over the old Alaka'i Swamp Trail is almost complete, enabling visitors to experience the forest with minor impacts.

In 1996, the Fish and Wildlife Service worked with the State and Wellington Fencing Company to exclude feral pigs from approximately 100 acres (40 hectares) of the montane bog. Nine rare plant species were protected by the fencing, including at least two, *Astelia waialealae* and *Geranium kauaiense*, that are candidates for listing under the Endangered Species Act.

Although building fences can be controversial in Hawaii, we took extra care on this project not to impact hunters, whose efforts are the most effective means currently available to control feral pigs and goats (*Capra hircus*) on Kaua'i. Hunters joined with us in determining the appropriate location of fencelines and helped us design gates into fencelines to ensure appropriate human access, including a path to a culturally important heiau (a pre-Christian place of worship).

Stuart Wellington, owner of the Wellington Fence Company, is a hunter himself and provided valuable expertise as well as an excellent means of communication with the local hunters. He takes pride in the fact that his company has helped protect these unique bogs and their rare plants for future generations.

We also worked with the National Tropical Botanical Garden to fund a videotape that has run repeatedly on public television channels on Kaua'i. It also has been used in Hawaiian classrooms to tell the story of these elfin forests and their importance to Kaua'i.

While it is a little early to see extensive improvements in these centuries-old communities, biologists are encouraged that the first bog fenced for protection is showing regrowth. In May 1998, they saw for the first time in years the flower of *Astelia waialealae*, a species known only from three bogs within the Alaka'i Swamp and numbering only 35 individual plants. In the past, feral pigs had repeatedly eaten it almost to the ground.

Kaua'i's elfin forests indeed have a magical spirit about them, for one cannot visit without feeling awe for their ability to adapt and thrive in such harsh conditions. It is now our job to ensure that they survive and flourish in this, the wettest place on Earth.

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*Barbara A. Maxfield is a Public Information Specialist with the FWS Pacific Islands Ecosystem Office in Honolulu, Hawaii.*

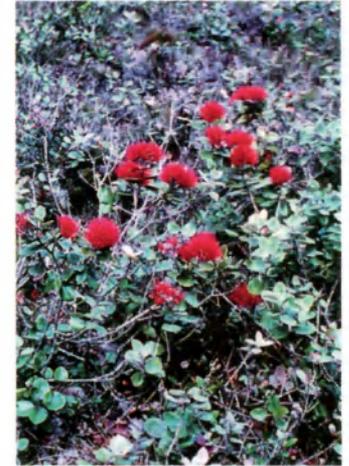
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**(Opposite page) Mount Wai'ale'ale receives an average annual rainfall of about 460 inches.**

*Photo by Marie Brueggmann/USFWS*

**(Below) Normally 50-foot tall trees, these bog 'ohi'a (*Metrosideros polymorpha*) are less than 2 feet tall yet have full-sized blossoms.**

*Photo by Marie Brueggmann/USFWS*



# Maui Invasive Species Committee

by Lloyd Loope  
and Randy Bartlett



Photo by Betsy H. Gagne

**Miconia (above) is an especially aggressive invader because of its fast growth, dense canopy, prolific reproduction, and ease of dispersal. In Hawaii's climate, miconia quickly towers over surrounding plants, its giant leaves creating such deep shade that few native seedlings and shrubs can persist. One tree can produce 15,000 to 12 million seeds several times each year. Birds, especially the many species of alien birds in Hawaii's lowlands, eat the juicy miconia fruits and carry the seeds into new areas. Likewise, hikers and feral pigs unwittingly track the minute seeds into forests not yet invaded by miconia. Search by helicopter is an effective way to locate mature miconia in remote rainforests.**

**Alien treefrogs are another of Hawaii's new invasive threats. First reported in**

Biological invasions are causing severe problems worldwide, but oceanic island ecosystems are exceptionally vulnerable to invading weeds and animals. In his forward to Robert Devine's new book, *Alien Invasion*, Secretary of the Interior Bruce Babbitt contends that we have the means to cope with the invasion of alien (non-native) species if we act quickly and in concert with others. Devine's discussion on "Choosing Our Future, Saving Our Past" showcases networking efforts against alien species on the Hawaiian island of Maui. Indeed, grassroots efforts on Maui are resulting in effective cooperation among a wide variety of interests in dealing with alien threats. Whether this approach will succeed in stemming the tide of alien species remains to be seen, but participants in a local partnership called the Maui Invasive Species Committee are excited over the prospects.

The idea of working together to address alien invasions on Maui was stimulated by the threat to conservation lands from *Miconia calvescens*, *Tibouchina herbacea* (glorybush), and *Clidemia hirta* (Koster's curse)—three aggressively invasive plants in the family Melastomataceae. The Melastome Action Committee (MAC) was formed in August 1991 through the initiative of Randy Bartlett, Pu'u Kukui Watershed Supervisor for the Maui Pineapple Company, and Ernest Robello, Project Director of the Tri-Isle (Maui County) Resource Conservation and Development Office of the U.S. Department of Agriculture. The following State, private, and Federal entities have met regularly as MAC members since 1991: Hawaii Department

of Land and Natural Resources (DLNR), Hawaii Department of Agriculture (HDOA), Maui Economic Development Board, The Nature Conservancy of Hawaii, the National Park Service, the U.S. Forest Service, the Biological Resources Division of the U.S. Geological Survey (USGS/BRD), and the Pacific Cooperative Studies Unit of the University of Hawaii (PCSU/UH, now with USGS/BRD). More recently, the U.S. Fish and Wildlife Service joined MAC. The group's activities include public education, providing information to the Hawaiian State legislature and Maui County government, and planning chemical, mechanical and biological control programs.

## **Miconia: The "Green Cancer" of Tahiti**

The invasive tree miconia (*Miconia calvescens*) has been MAC's primary target to date. This species, native to neotropical forests at 1,000-6,000 feet (300-2,000 meters) in elevation, has proven to be an unusually aggressive invader of moist tropical island habitats. Introduced to Tahiti from South America in 1937, dense thickets of miconia had entirely replaced the native forest over most of the island by the 1980's, with a dramatic reduction in biological diversity. After the late ecologist F.R. Fosberg saw miconia in Tahiti in 1971, he reported that "it is the one plant that could really destroy the native Hawaiian forest." Yet because of its attractive purple and green foliage, it had already been brought to Hawaii as an ornamental in the 1960's, and no sustained efforts were made to control it until it became well established on the island of Hawai'i.

After conservation agencies discovered miconia on Maui in 1990, they

raised an alarm. This species appeared to pose an especially severe threat to the high-elevation rainforest habitat of many endemic and endangered forest birds and plants. Thanks to a public education campaign, miconia has become something of a household word on Maui and progress is being made against it. A full-time 5-man crew funded by Maui County and supervised by the DLNR is combating this weed's primary infestation site near Hana, and over 850 acres (345 hectares) have been treated. The Nature Conservancy is taking the lead in dealing with outlying populations. With assistance from scientists in Brazil, USGS/BRD and PCSU/UH biologists have found fungi in miconia's home range that may prove to be useful biocontrol agents, and the HDOA is conducting tests. So far, one fungus has been released for biocontrol and it is now established on the islands of Maui and Hawai'i.

Work against miconia is progressing well, though the battle is far from won.

However, other invasive species continue to appear with alarming frequency. In December of 1997, members of MAC decided to form another group to address a broader range of invasive pest species problems in Maui County. This group, the Maui Invasive Species Committee (MISC), is a voluntary partnership of private, government, and nonprofit organizations committed to preventing new pest species—plant and animal—from becoming established in Maui County and to stop newly established pests from spreading wherever possible. The MISC recognizes that, rather than focusing exclusively on threats to biodiversity, it must address a wider range of threats (to agriculture, health, quality of life) to elicit a broader base of support. It seeks to establish relations with, and encourages the participation of, the Maui Association of Landscape Professionals, Maui Chamber of Commerce, Maui Economic Development Board, Maui Farm Bureau, Maui Hotel Association, Maui Visitors Bureau, and similar groups.

**The barren forest floor under *Miconia* stands may have consequences for watersheds and slope stability beyond obliteration of native biodiversity. This landslide in Tahiti appears to have been triggered by roadbuilding through a "dog hair" thicket of the non-native plant.**

*Photo by Paul Holthus/The Nature Conservancy*



The greatest challenge is to obtain funding and personnel to carry out alien species control work in an era of shrinking governments. Is success possible? The MISC developed a plan for priority species to combat, resources needed, and possible funding sources at a workshop in September 1998. All participants agreed that education is a crucial ingredient of the anti-alien species strategy and that direct public involvement in selected eradication efforts is an important tool. The group's future successes and failures may guide efforts statewide and even influence the approaches taken elsewhere in the world to combat the threats to native ecosystems posed by alien invasions.

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**1997, the Puerto Rican "coqui" (*Eleutherodactylus coqui*) may pose an especially severe threat to native insects (and indirectly to birds) in Hawaiian rainforests. In its native habitat, coqui densities exceed 20,000 animals per hectare, consuming an average of 114,000 food items per night per hectare! Three Caribbean tree-frog species are appearing in Hawaiian greenhouses and nurseries on imported plants. The frogs are spreading from nurseries and are being transported by residential and resort landscaping on plants from those nurseries. The tree-frogs' painfully piercing calls even pose a potential nuisance to human residents and resort guests. The MISC is investigating the feasibility of tree-frog control in Hawaii.**

# Alien Snake Threatens Pacific Islands

by Thomas H. Fritts  
and Gordon H. Rodda



**Micronesian kingfisher**

Photo by Jessie Cohen/National Zoological Park, Smithsonian Institution

**The reproduction of endangered Mariana crows (*Corvus kubaryi*) is intensively monitored, nests are protected, and (when necessary) eggs or young are moved to the safety of lab conditions until they are less vulnerable to the threats in natural habitats. Barriers on tree trunks and judicious pruning of adjacent trees are used in attempts to exclude snakes from nest trees. Two birds unique to Guam—the Micronesian kingfisher (*Halcyon cinnamomina cinnamomina*) and Guam rail (*Gallirallus owstoni*)—are maintained at captive propagation facilities on Guam and in mainland zoos. Studies of these and other species, in captivity and on nearby islands, are underway to bolster our biological understanding of their behavior, reproduction, habitat use, and population biology.**

Until the 1950's, the island of Guam, like many oceanic islands, lacked predatory snakes, but the abnormally high ship and air traffic immediately after World War II resulted in the accidental introduction of the brown treesnake (*Boiga irregularis*) from the Admiralty Islands in the South Pacific. The nocturnal, arboreal snake quickly spread throughout Guam, feeding on the island's lizards, birds, and mammals. As the snake grew in numbers, it reduced the populations of several native species and ultimately causing unprecedented changes in the ecology of the island.

By the 1980's, when the snake was identified as the cause of the declines in the native fauna, 10 of 13 Guam's native forest birds had disappeared, along with several species of seabirds and lizards. Other species were reduced to precariously low numbers. The mildly venomous snake also created other problems: causing numerous power outages when contacting high voltage lines; consuming poultry, pets, and other domesticated animals; entering homes and biting children; and invading cargo leaving Guam for other destinations.

The U.S. Fish and Wildlife Service and Guam's Division of Aquatic and Wildlife Resources have made an intensive effort to protect and recover endangered bird and bat species on Guam using a wide array of conservation techniques and strategies. These efforts have been supplemented by researchers and cooperators from other Federal agencies (U.S. Geological Survey, U.S. Department of Agriculture's Wildlife Services, U.S. Departments of the Navy and Air Force) and a host of cooperators from universities, zoos,

conservation organizations, and other island governments. The severity of the conservation crisis led to the establishment of the Guam National Wildlife Refuge to preserve habitat and serve as a focal point for research and recovery.

Only recently have we gained enough knowledge about the many biological problems caused by the snake to begin controlling snake populations by protecting habitats rather than individual bird nesting sites. One experiment involving the removal and exclusion of snakes from 2.5 acre (1-hectare) forested plots in northern Guam has demonstrated the potential role of snake barriers in promoting the restoration of important habitat areas for wildlife recovery. However, much work is needed to solve problems of costs, durability, and application in order to protect the broadest spectrum of native fauna. Recently, such snake exclusion technology was used to facilitate the repatriation of 15 captive-bred Guam rails to a 22-ha area of forest habitat on Guam National Wildlife Refuge.

The predation pressure exerted by high snake populations resulted in the disappearance of most of Guam's native birds within four decades of the snake's arrival. At the peak irruption, snakes outnumbered birds about 4 to 1. Even the most common birds were vulnerable to the numerical superiority and agility of the snakes, which foraged at night when birds were sleeping and defenseless in trees. As many as five native lizard species are gone or exceedingly rare on Guam due to snake predation and the ecological changes that the snake produced.

Several factors contribute to the concern that snakes could be trans-

ported accidentally from Guam to other areas: the abundance of snakes on Guam, even in areas near humans and commercial areas; the tendency of snakes to hide in all sorts of artificial objects, including vehicles, cargo containers, and buildings; and the large volume of ship and air traffic from Guam to other parts of the world. The brown treesnake has been discovered in and near transportation facilities on three other islands in the Marianas Archipelago, elsewhere in the Federated States of Micronesia, the Republic of the Marshall Islands, Okinawa, Diego Garcia, the State of Hawaii, and, in one case, Corpus Christi, Texas. The snake already has successfully colonized the island of Saipan in the Northern Marianas, and an irruption of snakes on that island could further threaten both its ecology and economy, as well as contribute to the spread of the snake to other islands.

Trapping of snakes is an intensive but effective tool for controlling snake numbers in localized areas, and most control efforts at present (coordinated by the U.S. Department of Agriculture's Wildlife Services Program) are in and around air and seaport facilities that are potential dispersal sources. Guam's Department of Agriculture also manages a large trapping effort in areas contiguous with U.S.D.A. control areas, but the area represents a fraction of the island. Reduction of snake populations by trapping over larger areas of Guam would not be practical. The difficulties of capturing snakes while working at night in Guam's dense vegetation and rough terrain would severely handicap any bounty or commercial hunting program. U.S.D.A. personnel conduct searches with dogs trained to use their keen sense of smell to find snakes in cargo leaving Guam. Detector dogs are used by quarantine personnel in Hawaii and the Northern Marianas Islands, but the cost of dog handler teams is high for the number of snakes detected.

Snake-proof barriers are a recent innovation that ultimately may be used

to protect transportation facilities, electrical installations, and critical natural habitats, and to reduce the numbers that must be captured by hand or trapping. But there are limits to the usefulness of this approach in situations where cargo is brought in daily from other areas, where snakes are abundant, and where large areas of natural habitat are needed to protect core wildlife populations. Research also is underway to develop toxicants, attractants for baiting snakes, innovative traps, repellents, and even biological methods of control, but all of these depend upon having a complete understanding of the snake's biology, habits, movements, and numbers.

An expanded effort involving both innovative research and control programs is essential to reduce damages and curb the spread of this pest to much larger areas of the Pacific and elsewhere in the world.

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*Thomas H. Fritts and Gordon H. Rodda are with the U.S.G.S. Midcontinent Ecological Science Center in Fort Collins, Colorado. For more information, consult the following internet address: <http://www.nbii.gov/browntreesnake/>*

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***The average density of snakes in forested and most suburban areas of Guam is much higher than that of comparable snakes in other parts of the world. At the peak of the invasion, and prior to the collapse of Guam's bird and mammal fauna, snake densities may have exceeded 100 per hectare (40 per acre). Even today, densities in forested areas average 20-50 snakes per hectare (the equivalent of 8-20 snakes per acre). These high numbers of snakes fed on a broad array of Guam's vertebrate fauna (birds, shrews, bats, and lizards). Snake populations on Guam have subsided by as much as 50 percent since 1985 and, contrary to their expectations, visitors to Guam are unlikely to see many snakes. However, enough snakes remain on Guam to suppress wildlife populations and inhibit their recovery.***

*Photo by Thomas H. Fritts*



by Connie Rutherford

# Santa Rosa Plants Gain New Lease on Life



*Gilia tenuiflora hoffmanni*

Photo by Tim Thomas

Change has come to Santa Rosa Island, the largest of the islands off the coast of southern California included in Channel Islands National Park. Last summer, after 90 years of continuous occupation by cattle, the island and its unique plant life gained a reprieve from non-native animals. It came when the last of the bovines were herded onto a special barge to make the 30-mile (48-kilometer) trip back to the mainland.

The agreement to remove the cattle was many years in the making, pulling environmentalists, ranchers, concerned members of the public, the courts, and agency experts alike into the debate on the eventual future of the island. After several lawsuits were filed over the management of the island, all of the parties involved—including the Fish and Wildlife Service (FWS), National Park Service, National Parks and Conservation Association, and former owners of Santa Rosa Island—negotiated a settlement. Under the settlement agreement, the cattle would be removed immediately in exchange for non-native deer and elk being allowed to remain in reduced numbers. At stake are the fate of six of Santa Rosa's plant species, five of which occur nowhere else.

We became concerned about the plants in the 1990's, when surveys conducted by the park, the FWS, and what it now the Biological Resources Division of the U.S. Geological Survey were unable to locate populations that had been noted by botanists such as E.E. Greene and William Lyons at the end of the 19th century, and a few decades later by Ralph Hoffman, who met his untimely death while scaling the cliffs on San Miguel Island looking for

plants. After an exhaustive survey, the FWS proposed Endangered Species Act protection for 16 plants from the northern Channel Islands in 1994. Habitat for the plants had been altered due to grazing, browsing, and rooting by mammals alien to the Channel Islands (pigs, goats, sheep, donkeys, cattle, deer, elk, horses, and bison). In some cases, the alien mammals had been removed but the habitats had not fully recovered from past disturbance, including loss of topsoil, erosion, and an invasion by a host of alien plant species.

Santa Rosa Island was a private inholding within the boundaries of Channel Islands National Park until it was purchased from a willing seller in 1986. Congressional legislation allowed the former landowner to continue ranching and hunting operations for up to 25 years at the discretion of the park management. However, increasing evidence of harmful impacts to natural and cultural resources by the non-native cattle, elk, and deer, as well as mounting public concern and a mandate from the California State Water Quality Control Board to improve water quality, convinced the park to develop a comprehensive management plan for Santa Rosa Island.

Because of the number of plant species considered for listing, the variety of threats they faced, and the desire to treat the island as an ecosystem, the agencies involved agreed to develop a Conservation Strategy for conservation and recovery of the species and their habitats. This Conservation Strategy then became a template for the park's management plan for Santa Rosa Island. It is also being dovetailed into the draft recovery plan for the 13 island plants that were listed as endangered in 1997.

Central to the Conservation Strategy was the development of recovery standards for each of the plant communities within which the listed species occurred, a time frame for achieving those standards, and a blueprint for implementing changes in management. The implementation of the resulting management plan has facilitated the removal of all cattle. Elk and deer will also be phased out over a longer time frame, and the plants that are most vulnerable will be protected in the meantime by fencing.

Although the departure of the cattle was a giant step forward in plant conservation on Santa Rosa Island, it is not a panacea for habitat restoration. Years of extensive grazing were the vehicle for introduction of many weeds, and the residual impacts have reduced the island's natural ability to prevent their spread. Fortunately, the park has acquired additional funding for a weed management program. Park managers also are continuing a long-term vegetation monitoring program to track changes in the structure and composition of the island's plant communities now that cattle no longer roam the island.

Changes are already evident in a number of the island's riparian zones. Willow seedlings have emerged along Old Ranch Creek this year, even though there are no mature willows in the vicinity. Once the riparian vegetation has returned, perhaps the songbirds that have been absent from the island over the last century will also return.

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*Connie Rutherford is a Botanist with the FWS Ventura, California, Field Office.*

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***Grazing, browsing, and rooting by a variety of non-native mammals did serious damage to the environment of Santa Rosa Island. With the removal of these alien animals, the long-term process of recovery can begin.***

*Photo by Connie Rutherford*



by Joelle Buffa  
and Rick Morat

# Restoring a Balance Among Seabirds



**Cassin's auklet**  
Photo by Joelle Buffa

**F**arallon National Wildlife Refuge, a satellite of the more expansive San Francisco Bay National Wildlife Refuge Complex, is a group of rocky islands located about 28 miles (45 kilometers) west of San Francisco. The 211 acres (85 hectares) in the islands contain the largest seabird nesting colony south of Alaska, with approximately 200,000 individuals of 13 different species breeding on the islands each year. The refuge supports the largest breeding population of ash storm-petrels (*Oceanodroma homochroa*), comprising 50 to 70 percent of the world population, and the world's largest breeding population of another bird, the western gull (*Larus occidentalis*).

So, what are managers to do when ecological relationships become strained among a few seabird species, namely western gulls, ash storm-petrels, and Cassin's auklets (*Ptychoramphus aleuticus*)? Long-term monitoring recently revealed an alarming trend: ash storm-petrel breeding populations declined 40 percent from 1972 to 1992 and Cassin's auklets declined over 60 percent between 1971 and 1989. Evidence pointed to western gulls as the culprits. The number of gull-killed petrels that island biologists were finding each year (about 2.5 percent of the population per year) approximated the observed population decline of ash storm-petrels on the 120-acre (48 ha) Southeast Farallon Island (SEFI). Dead Cassin's auklets that have been regurgitated by western gulls are commonly found along island paths each morning. Western gulls apparently prey on the burrow-nesting seabirds, which are about the size of a robin, as the auklets

return to incubate eggs and feed their chicks at dusk.

A Population Viability Analysis determined that the slow-reproducing, but long-lived, petrels couldn't survive this level of predation, and concluded that the species should be considered vulnerable. While not listed under the Endangered Species Act, the petrel is considered a species of concern. Both the refuge and the Point Reyes Bird Observatory, the refuge's cooperator in monitoring seabird populations and managing SEFI, agreed that something was needed to reduce gull predation on petrels and auklets. Biologists began exploring solutions and funding sources in early 1997.

First, what was it about western gulls that made them a problem? Although western gulls have always bred on SEFI, the distribution of nesting colonies has changed dramatically over the years. Previously, western gulls nested only on certain, mostly rocky, portions of SEFI, areas not favored by burrow-nesting auklets and crevice-nesting petrels. Gradually, however, the western gulls have expanded their nesting habitat and now nest all over SEFI, including in high quality auklet and petrel habitat, which is scarce on the island. Gull populations have benefited from feeding on mainland landfills some 25 miles (40 km) away, while changes in oceanic productivity have been unfavorable for seabird species such as auklets.

Second, what were the management options for reducing gull predation? Three potential solutions were culling, egg addling, and construction of physical barriers. After weighing the pros and cons, the Fish and Wildlife Service (FWS) decided to try physical barriers first

and researched design options from successful projects in other parts of the United States and Canada. Installing a system of overhead cables seemed promising, as gulls avoid landing and flying through parallel overhead wires, just as cattle tend to avoid walking over parallel rails.

In October 1997, refuge staff constructed two experimental gull exclosures to discourage western gulls from nesting on a portion of the marine terrace on SEFI. Each exclosure consists of 11 parallel overhead cables strung between paired poles, with cables elevated about 4 to 6 feet (1.2 to 1.8 meters) above the ground. In one exclosure, the cables are about 10 feet (3 m) apart (plot size = 30 meters square), and in the other, the cables are about 15 feet (4.5 m) apart (plot size = 50 meters square). The cable is made of a lightweight, pliable plastic material in order to minimize the risk of injury to flying birds. The project was funded with \$6,000 from the FWS Coastal Ecosystems Program.

In April 1998, nesting boxes also were installed within the exclosure plots to entice ashy storm-petrels to recolonize the newly predator-free habitat. To promote recolonization, biologists played taped calls of petrels all night long between April and August on a specially designed solar-powered tape/playback recorder purchased as part of the project. This technique of attracting seabirds is known in seabird biology terms as social attraction.

So how are the western gulls reacting to these "gull cattleguards"? Nesting by western gulls was reduced 32 percent under the larger exclosure from 1997 to 1998, while the number of gulls nesting in other monitored plots on the island remained constant during the same period. The smaller exclosure was not effective in reducing the numbers of nesting gulls.

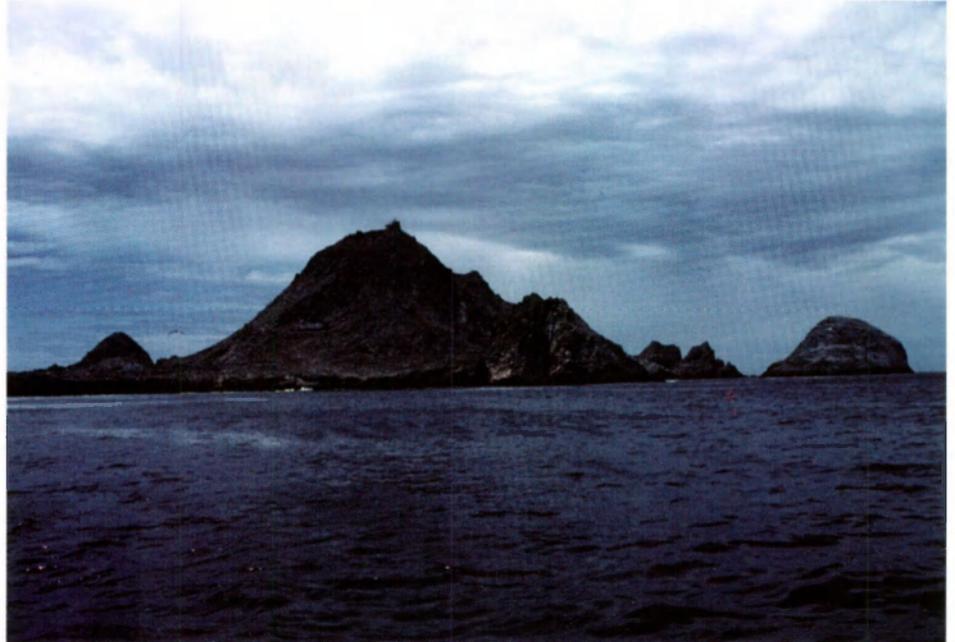
Encouraged by the project's partial success, the refuge and the FWS Coastal Ecosystems Program, which supports this and many other projects, plan to modify the exclosures before the 1999 breeding

season to make them even more intimidating to gulls. We will experiment by attaching "bird baffler," a reflective tape, to one of the exclosures and adding more cables to the other.

This is not the first time the Coastal Program has partnered up with the San Francisco Bay National Wildlife Refuge

**Farallon NWR**

Photo by Joelle Buffa



Complex, and it certainly won't be the last. On average, about one-half of the Coastal Program's projects have indirectly supported the Refuge Program and, in a few cases such as this, they have directly supported Refuge activities. Through such cooperative projects, we hope to reverse the declining trends of ashy storm-petrels and Cassin's auklets and keep them off of the endangered species list.

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*Joelle Buffa is a Supervisory Wildlife Biologist for the San Francisco Bay National Wildlife Refuge Complex and Manager of Farallon National Wildlife Refuge. Rick Morat is a Biologist with the Sacramento Fish and Wildlife Office and manages the Coastal Ecosystem Program/San Francisco Bay Program.*

**Biologists with the Point Reyes Bird Observatory have been conducting monitoring and research on the Farallon National Wildlife Refuge through a cooperative agreement with the FWS for over 25 years (roughly the life-span of an ashy storm-petrel), and they will monitor the success of the gull control project. The U.S. Department of Agriculture's Wildlife Services (formerly Animal Damage Control) provided technical advice on gull control methods and assisted with project design.**

by Lois Winter

# Lending a Hand to Maine's Island Birds



**Atlantic puffin**  
Corel Corp. photo

For most of the year, Maine's 3,500 coastal islands are lonely, rockbound sentinels. But for a few months each summer, hundreds of the islands are transformed into marvelously raucous and lively homes for a unique assemblage of nesting seabirds, wading birds, and threatened and endangered species.

The Maine islands are a meeting ground of north and south, providing the only breeding sites in the United States for Atlantic puffins (*Fratercula arctica*) and razorbill auks (*Alca torda*). With the possible exception of a few islands south of the State, the Maine islands also provide black guillemots (*Cepphus grylle*), Leach's storm petrels (*Oceanodroma leucorhoa*), and common eiders (*Somateria mollissima*) their southernmost breeding territories in North America. At the same time, Maine islands are the northernmost breeding sites for laughing gulls (*Larus atricilla*), snowy egrets (*Egretta thula*), little blue herons (*Egretta caerulea*) and tricolored herons (*Egretta tricolor*). Some islands also support rare nesting birds, such as the endangered roseate tern (*Sterna dougallii dougallii*) and the threatened bald eagle (*Haliaeetus leucocephalus*), and endangered peregrine falcons (*Falco peregrinus*) find food for their young on the islands. Many islands and associated mudflats are used for feeding and resting by large numbers of migrating waterfowl, including recovering populations of Atlantic brant (*Branta bernicla*) and declining populations of black ducks (*Anas rubripes*). Other birds whose populations appear to be decreasing internationally, including some neotropical migrants and internationally important populations of migrating shorebirds, also depend on the

Maine islands for undisturbed nesting, feeding, and roosting habitat.

As Stew Fefer, a seabird expert and Project Leader at the Fish and Wildlife Service's (FWS) Gulf of Maine Coastal Ecosystems Program, has noted, "These birds seek out Maine's coastal islands because they are generally free of human disturbance and mainland predators, but are situated close to rich feeding grounds." However, as development spreads along the eastern seaboard, such islands are attracting increased attention from potential users. Disturbances associated with second home developments and subdivisions, timber harvesting, recreational use, and aquaculture are increasing and sometimes threaten important island habitats.

To address growing concerns about habitat loss, the Gulf of Maine Coastal Ecosystems Program and Petit Manan National Wildlife Refuge initiated the Maine Coastal Islands Project in the early 1990's to identify and protect significant habitat on the islands. The FWS invited key partners, including two State agencies and conservation organizations, to participate. The Gulf of Maine Coastal Ecosystems Program initiated the project by collecting and analyzing existing biological data to identify all islands used by nesting seabirds, wading birds, and endangered species.

Using specific biologically-based criteria, the project partners pared the list down to 294 nationally significant nesting islands, which represent less than 4 percent of the total acreage of Maine islands. Next, they determined the current ownership of each island. The partners learned that Federal and State agencies, private organizations, and individuals are providing permanent

protection for nesting birds on approximately half of the nationally significant islands. The Maine Coastal Islands Project decided to focus its work on protecting habitat on the remaining islands by working directly with private landowners to promote voluntary conservation measures.

"Partners in the Maine Coastal Islands Project all recognize that permanently protecting these nesting islands is the key; who holds the deed and who manages the property for the birds is far less critical," explained Fefer. "Therefore, we work opportunistically, capitalizing on the strengths of different partners as needed. Our coordinated approach allows us to realize our common goals when no one organization would be likely to accomplish its goals independently." Land protection strategies include private stewardship, conservation easements, technical assistance, resource management recommendations and actions, and acquisition by conservation organizations (on a willing-seller/willing-buyer basis only).

Since 1994, 30 important nesting islands have been acquired by conservation organizations. Petit Manan National Wildlife Refuge has expanded its holdings from 11 islands to 32. The Maine Department of Inland Fisheries and Wildlife, with support from National Coastal Wetland Conservation Grants, has acquired three important islands. Local land trusts and conservation groups have acquired six islands, frequently with management agreements and easements directed to a State or Federal wildlife agency.

However, to protect the birds, more is needed than conservation ownership. The FWS actively participates in the Gulf of Maine Seabird Working Group, a coalition of biologists from Federal, State, and non-profit organizations committed to restoring avian diversity in the region. The Gulf of Maine Coastal Ecosystems Program, in coordination with Petit Manan National Wildlife Refuge and other partners, obtained a challenge grant from the National Fish

and Wildlife Foundation to ensure stable funding for nesting bird restoration initiatives in Maine. Projects conducted in recent years on six FWS islands and three islands owned by conservation partners are playing a critical role in restoring a diverse assemblage of seabirds to the Maine coast.



Because public support for nesting island protection is critical, the Gulf of Maine Coastal Ecosystems Program, Petit Manan National Wildlife Refuge, and conservation partners worked with 33 co-sponsoring organizations to plan and present four information forums throughout coastal Maine in the spring of 1995. The favorable response from attendees encouraged the FWS to move forward with an Environmental Impact Statement (EIS) that would permit the agency to remain an active participant in acquiring important nesting islands in Maine. A draft EIS, prepared in consultation with many interested parties, will be completed soon. After the document receives public review, the FWS will produce a final planning document to guide our continuing efforts to protect Maine's nesting waterbirds.

*Lois Winter is a Wildlife Biologist and Outreach Specialist with the FWS Gulf of Maine Program.*

***Little Thumpcap Island, one of 30 coastal Maine nesting islands, has been protected since 1995 through the joint efforts of the Fish and Wildlife Service and other conservation partners.***

*Gulf of Maine Program/USFWS photo*

# “Islands” of Habitat in an Agricultural “Sea”

by Michelle S. Mazzola,  
William O. Vogel,  
and Chris Warren



**The pygmy rabbit requires deep, loamy soil for its burrows and for the growth of the tall sagebrush plants that provide cover from avian predators. These are the same soils that have often been converted to farmland. Douglas County is the only county in Washington with pygmy rabbits. It contains several sites that have been disjunct from the remaining rabbit populations in other States (several hundred miles away) for thousands of years.**

Photo by C. Garber/WDFW.

“When my great grandfather moved to Douglas County in 1898 to start farming, prairie bunch grass was stirrup high on the horses and sage grouse were abundant,” says John McLean, Chair of the Foster Creek Conservation District in north-central Washington.

Today, sage grouse (*Centrocercus urophasianus*) have been eliminated in most areas of the State, but Douglas County contains a virtual island of habitat for 800 of the remaining 1,000 birds in Washington. In addition, four species federally listed as threatened or endangered—bull trout (*Salvelinus confluentus*), spring chinook salmon (*Oncorhynchus tshawytscha*), steelhead trout (*Oncorhynchus mykiss*), and bald eagles (*Haliaeetus leucocephalus*)—reside here along with three animals on the State of Washington’s own list of threatened and endangered species—sage grouse, sharp-tailed grouse (*Tympanuchus phasianellus*), and pygmy rabbit (*Brachylagus idahoensis*). “The farmers and ranchers here really appreciate our wildlife resource, and we want to see it remain for future generations to enjoy,” says McLean.

Douglas County has an approximately 1 million-acre (405,000-hectare) land base that is 88 percent privately owned. Agriculture, the dominant land use here, began to grow in the 1870’s. About one-half of the agricultural acreage in the county is used for cattle grazing, with ranches reaching a size of 20,000 acres (8,100 ha). Most of the other agricultural acreage in the county is used for wheat cultivation, with some farms as large as 5,000 acres (2,025 ha). Irrigated orchard farming along the Columbia River is another part of the local agriculture picture. These uses

provide multiple benefits to the region, ranging from economic stability to habitat for endangered fish and wildlife.

Two major basins drain Douglas County, both of which feed the Columbia River. The river borders the county for 65 miles (105 kilometers), providing substantial wild salmonid habitat. In addition, hundreds of small basins and ponds of glacial origin are also present. Birds by the thousands drop into Douglas County during their spring migration, and many stay to brood and rear their young in these glacial ponds. The low human population density of only one person per 85 acres (137 ha)\* helps to make Douglas County a prime nesting and resting place for traveling birds.

The soils here are a unique mixture of glacial till deposits and, in most cases, are not more than 40 inches (100 centimeters) deep. The glaciers also left behind many large basalt boulders. Each of these boulders is avoided during farming operations, leaving a band of native shrub-steppe land surrounding it. These bands provide miniature islands of upland game habitat, especially for the sage and sharp-tailed grouse.

The county contains four principal classes of wildlife habitat. These include shrub steppe (sagebrush/grass), wooded stream courses and draws (riparian),

\* The population from one city (greater East Wenatchee) has been removed from this equation.

wetlands (ponds, small kettle lakes, and marshes), and cultivated lands. Each of these habitat types presents different sets of management options and opportunities to enhance the quality of fish and wildlife habitat.

About 33 percent of the cultivated lands (186,000 acres, or 75,275 ha) were enrolled recently in the Conservation Reserve Program (CRP). According to Mike Schroeder, Upland Bird Research Biologist with the Washington Department of Fish and Wildlife, "The CRP program during the past 10 years has provided tremendous benefits to sage grouse. This is especially true in Douglas County, where CRP is mixed with winter wheat, healthy rangelands, and riparian areas with deciduous shrubs."

The farming community here is comprised of second and third generation family-farmers. With only 9 to 11 inches (23 to 28 cm) of annual rainfall, farming is indeed challenging, requiring farmers to be innovative and open to new opportunities. At the same time, concern for the perpetuation of native wildlife species has grown. It led the Foster Creek Conservation District to establish an umbrella Habitat Conservation Plan (HCP) to provide long-term certainty to these farmers that they can both continue farming and provide protection for these valued wildlife species. The Foster Creek Conservation District is a legal subdivision of the Washington State government and is mandated to develop and administer voluntary, non-regulatory programs to conserve natural resources. The District is governed by an elected, volunteer board of local farmers and business people who establish local priorities and set policies.

During a day-long "environmental tour" in June 1997 that was attended by environmental groups, land management agency representatives, and the farming community, a dialog on endangered species issues was held in an attempt to reach a resolution on how to ensure a future for family farmers. One of the questions posed to the Fish and



Wildlife Service by a local rancher during this tour was, "I understand that several of our wildlife species here are endangered. What does this mean to the private landowner? Could you really shut my ranching operation down to protect the species?" Our reply was, "Possibly, but there is a better way. Why don't you consider developing a Habitat Conservation Plan?" One year and a lot of education later, the District held a second tour with 90 people, representing almost every stakeholder group, to discuss the development of a Douglas County HCP

At present, the participants are seeking financial support to launch the first multi-stakeholder, aquatic and terrestrial species HCP ever for private agricultural lands.

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*Michelle S. Mazzola is District Manager of the Foster Creek Conservation District based in Waterville, Washington. Bill Vogel is an FWS biologist with the HCP team in the Western Washington Fish and Wildlife Office, Lacey, Washington. Chris Warren is an FWS biologist in Spokane.*

***More than 70 stakeholders from the environmental, agency, and farming communities participated in an "Endangered Species and Sustainable Agriculture" tour hosted by the Foster Creek Conservation District in June.***

*Photo by Gordon Congdon*

# Biodiversity in Puerto Rico

by Susan Silander



**Studies conducted by the University of Puerto Rico, in cooperation with the FWS, have collected important data on the biology of the beautiful goetzea (*Goetzea elegans*) and many other rare plants. Propagation of this showy tree is being conducted successfully at nurseries under the management of the Puerto Rico Department of Natural and Environmental Resources.**

Photo © Eugenio Santiago

The island of Puerto Rico is part of the archipelago of over 1,000 islands known as the West Indies, a chain that separates the Caribbean Sea on the south from the Atlantic Ocean to the north. Approximately 110 miles (160 kilometers) long and 35 miles (55 km) wide, Puerto Rico has more than 300 miles (483 km) of coastline. The Commonwealth of Puerto Rico also contains two other inhabited islands and a number of small, uninhabited islands. The wide variety of habitats found in these islands has produced a rich diversity of plant and animal life, including species found nowhere else.

The main island of Puerto Rico is volcanic in origin, and its topography is rugged. Puerto Rico can be divided into several major physiographic regions: the central mountains ("Cordillera Central"), the Luquillo Mountains ("Sierra de Luquillo"), the limestone region ("Calizas" or "Mogotes"), and the coastal plains ("Llanos Costeros"). Elevations reach 4,390 feet (1,338 meters) at Cerro Punta in the central mountains, from which more than 100 rivers and streams flow to the sea. Rainfall on the island, despite its small size, is not evenly distributed. Because of differences in topography and the effect of the easterly trade winds, rainfall can range from more than 100 inches (250 centimeters) at the summits of the central mountains to as little as 30 inches (75 cm) in the southwestern region. Rainfall patterns and geologic formations have resulted in a wide variety of soils and vegetation types. The island's vegetation has been classified according to the Life Zone system (Ewel and Whitmore 1973) as subtropical dry forest, subtropical moist forest, subtropical wet forest, subtropical rain forest, lower montane wet forest, and lower montane rain forest.

The karst region of northwestern Puerto Rico has been described as one of the best of its kind in the Caribbean. This area of porous limestone abounds with caves, sinkholes, and underground rivers. An excellent example of subtropical dry forest can still be found on the island's southwestern coast, largely within the Guanica Commonwealth Forest. This forest type is rapidly being destroyed elsewhere in the region. The Caribbean National Forest, where dwarf or cloud forests grow on the peaks of the Luquillo Mountains, is the only tropical forest in the U.S. national forest system, and is currently home for the only known wild flock of the endangered Puerto Rican parrot (*Amazona vittata*). Mona Island, an uninhabited island between Puerto Rico and the Dominican Republic, is bounded by cliffs that rise 200 feet (60 m) from the sea to a plateau covered with subtropical dry forest. Formerly the home of Taino Indians, pirates, guano miners, and treasure hunters, it harbors species found on no other island.

As with many other Caribbean islands, Puerto Rico has been, and continues to be, heavily affected by the influence of humans. Agriculture reduced some forests in the 16th and 17th centuries, but in the 18th century massive deforestation took place to clear land for crops such as sugar cane, coffee, and tobacco. Coffee, at that time planted in the shade, was grown primarily in the central mountains. In the early 19th century, sugar cane became the island's principal crop and its cultivation destroyed most of the forests on the coastal plain. Later, as the sugar industry declined and the population shifted away from rural areas, much former agricultural land was developed for urban and industrial uses. One by-product of this change was the regrowth

of secondary forests in areas such as the central mountains. Nevertheless, urban, industrial, and tourist development, along with changes in agricultural techniques such as the planting of sun-dependent coffee, threaten many of the rich natural resources that still remain.

Approximately 5 percent of the island is protected either as public forests or reserves managed by the U.S. Forest Service (Caribbean National Forest) and the Puerto Rico Department of Natural and Environmental Resources (with its system of 15 public forests), as refuges managed by the U.S. Fish and Wildlife Service (FWS), and as land protected by non-governmental organizations. These forests contain an excellent representation of the diverse ecosystems once found widely on the island.

The native avifauna includes 239 species, of which 14 are endemic to Puerto Rico. (Another two are also found in the U.S. Virgin Islands.) Six of these endemic species are federally-listed as endangered (Raffele 1989, Raffele et al. 1998). Of the 63 species of land reptiles and amphibians occurring in Puerto Rico, 42 occur nowhere else, and 14 of the rest are restricted to Puerto Rico and the U.S. Virgin Islands (Rivero 1998). Fourteen of the 63 reptiles and amphibians are listed as either threatened or endangered.

The native flora of Puerto Rico consists of about 3,000 species, of which about 8 percent are endemic. When considering only trees, Puerto Rico and the Virgin Islands harbor about 550 native species, of which 142 (or 26 percent) are endemic (Liogier and Martorell 1982). As of September 30, 1998, the FWS listed 669 plant taxa worldwide as either threatened or endangered, of which 48 (or 7.2 percent) are from Puerto Rico, even though this island contains only 0.09 percent of the total land area of the United States. Most of these listed plants are found either in the northern karst region or on the dry southern coast, two areas under pressure for development.

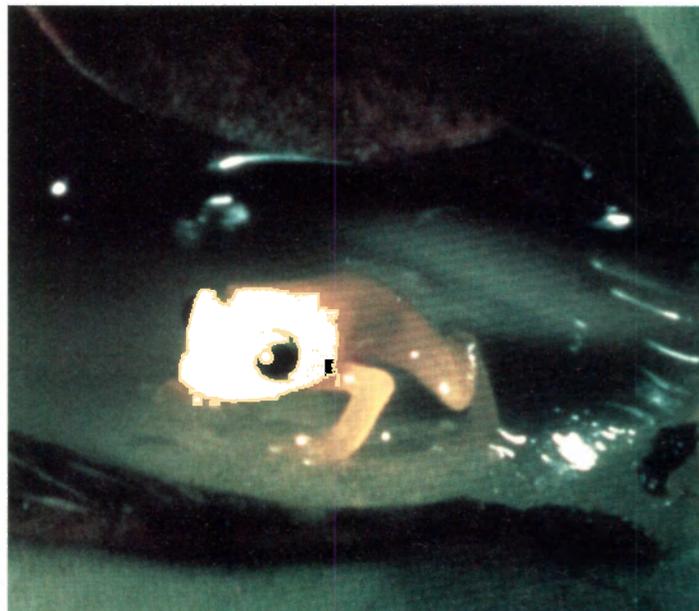
The FWS staff in Puerto Rico works with Commonwealth agencies such as the Puerto Rico Department of Natural and Environmental Resources, universities, and non-governmental organizations for the protection and recovery of threatened and endangered species. Because of Puerto Rico's geographical and cultural ties to the Caribbean, partnerships with neighboring island countries are essential. Through our cooperative efforts, we are making strides towards recovery that our agency could not achieve on its own.

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*Susan Silander is a Botanist with the FWS Caribbean Office in Puerto Rico.*

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*The golden coqui or coqui dorado (Eleutherodactylus jasperi) is one of 16 species of coqui or tree frogs, a group well known to Puerto Ricans and tourists as well. The unique golden coqui is known only from the mountains of Cayey but has not been seen or heard since 1985.*

*Photo by J. Colón*

**The primary threats facing the island's native flora and fauna are habitat destruction and modification, illegal hunting or capture, and the introduction of exotic species. At present, 78 species of plants and animals are federally-listed as threatened or endangered. This includes 3 species of amphibians, 11 reptiles, 11 birds, 5 mammals, and 48 plants. Of these 78 species, 56 are known only from Puerto Rico. The Puerto Rico Department of Natural and Environmental Resources has listed 90 plants and animals as threatened or endangered, and it maintains a list of over 500 plant species whose status is considered critical.**

by Dawn Jennings

# South Florida Multi-Species Recovery Plan

In 1993, five Federal departments and the Environmental Protection Agency signed a five-year Interagency Agreement on South Florida Ecosystem Restoration. This agreement formally established an Interagency Task Force responsible for developing consistent policies, strategies, plans, programs, and priorities for addressing the concerns of the South Florida Ecosystem. The purpose of the South Florida Ecosystem Restoration Initiative is to restore and maintain the natural functions of freshwater, estuarine, and marine environments where human activities occur in a manner that supports healthy natural conditions.

Two of the major objectives of the Restoration Initiative are 1) to restore and maintain the biodiversity of native plants and animals in the upland, wetland, estuarine, and marine communities of the South Florida Ecosystem, and 2) to recover species that are threatened or endangered. In 1995, the U.S. Fish and Wildlife Service (FWS) was directed to prepare a comprehensive, ecosystem-wide recovery strategy to help fulfill these objectives. This strategy is known as the Multi-Species Recovery Plan for the Threatened and Endangered Species of South Florida.

The Multi-Species Recovery Plan identifies the recovery and restoration needs of imperilled species and their habitats in the South Florida Ecosystem—an area encompassing 67,346 square kilometers covering the 19 southernmost counties in Florida—using an ecosystem-wide approach. This is one of the first recovery strategies specifically designed to meet the needs of multiple species that do not occupy similar habitats. It is also one of the first

designed to approach recovery by addressing the needs of entire watersheds: the Kissimmee/ Okeechobee/ Everglades watershed, the Caloosahatchee River/Big Cypress watershed, and the Peace/Myakka River watershed. To make certain the greatest diversity of species found in South Florida benefit from the management actions of the FWS and our partners, the Multi-Species Recovery Plan will also cover candidates for Federal listing, State-listed species, migratory birds, and other species of concern. This recovery strategy is intended to serve as a blueprint to be used by the Federal agencies, State agencies, Tribes and other partners who are committed to the restoration of the South Florida Ecosystem. It is also designed to meet the information needs of the agencies involved in the South Florida Ecosystem Restoration Initiative as they prepare NEPA compliance documents, go through regulatory permitting processes, or engage in endangered species consultations with the FWS.

To make the recovery plan more manageable, it is divided into two volumes. Volume I, "The Species," contains information on the biology, ecology, distribution, status, trends, management, and recovery actions needed for the 68 federally-listed species that occur in South Florida. The species accounts provide the most current biological information available and include updates and revisions to existing recovery plans for individual species. Volume II, "The Ecosystem," provides an overview of the South Florida Ecosystem and discusses the biological composition, status, trends, management and restoration needs of 23 major ecological



communities in this region. It describes a holistic approach to recovery by including recommendations on how to manage, reconstruct, or restore these ecological communities.

Public comments on the Technical/ Agency draft of the entire recovery plan are now being evaluated. The FWS expects to complete the final recovery plan in early 1999. Because the paper copies are so voluminous (~1300 and 900 pages for Volumes I and II respectively), the FWS Publications Unit in Shepherdstown, West Virginia, (304)876-7203, is serving as the distribution clearinghouse. To reduce expenses, however, we are encouraging that requests be for the CD-ROM version. The recovery plan is also available on the South Florida Ecological Service's Field Office website at <http://www.fws.gov/r4eao/esvb.htm>.

*Dawn Jennings is a Fish and Wildlife Biologist in the FWS South Florida Field Office in Vero Beach.*

# Fixing All the Parts

by Susan D. Jewell



**(Opposite page) Florida panther**

Photo by John & Karen Hollingsworth

**(Left) Such endangered species as wood storks and fragrant prickly-apple (cactus) can be seen virtually side by side where a sawgrass marsh meets a ridge of coastal scrub (on horizon).**

Photo by Susan D. Jewell

Biologists have learned that trying to save the planet species-by-species is not working. In too many cases, restoring habitat for one endangered species has encroached on the habitat of another. This is particularly true in South Florida, where at least 50 percent of the original Everglades habitat is gone and a smaller pie must be split into the same number of pieces. All over South Florida, the story is the same—wild animals are squeezed onto lands too diminished to support them. A century of diking and draining the southern Florida peninsula has permanently altered the landscape. Six million people now share South Florida with the wildlife, and with more arriving in record numbers, the pressure from developers is intense.

South Florida harbors habitat types, such as tropical hardwood hammocks, that are found nowhere else in the continental United States. Exotic or non-native species, particularly plants, are

more abundant here than in almost any other part of the country. Thus, the southern peninsula is faced with a “quintuple whammy”—long-term landscape alterations, intense and growing human population pressures, an unparalleled mixture of Caribbean and temperate flora and fauna, invasions by exotic plant species, and oceans on three sides that limit expansion.

In South Florida, the uplands were the first areas to be developed and farmed when the European settlers arrived. These areas had been a stronghold for the Florida panther (*Puma (Felis) concolor coryi*), currently one of the most endangered mammals in the U.S. As their former habitat dwindled, panthers retreated to marginal swampy habitat and to newly drained areas of the Everglades marsh. Now, South Florida scientists want to restore the Everglades as closely as possible to its former functions. That would mean taking some of the newly drained areas

and reflooding them, leaving the panthers with even fewer suitable areas. On the other hand, the restored habitat should encourage wood storks (*Mycteria americana*), snail kites (*Rostrhamus sociabilis plumbeus*), and other endangered or listed species. Will this habitat restoration be at the expense of a species like the panther or is there another way?

The Multi-Species Recovery Plan is a way of looking at the whole region's potential for getting all the parts to function as a healthy ecosystem. The most immediate use for this plan will be as part of the continued planning for the Army Corps of Engineers' Central and South Florida Restudy Project, a major effort to review the human-caused alterations to the region's hydrology and to use that information for implementing the restoration of the South Florida ecosystems. The Restudy will allow scientists to anticipate the effects (through computer modeling) of certain restoration actions on listed species and adjust their strategies to benefit those species as parts of the total system. This is the first time in Florida that such a multi-agency effort has been used on such a broad environmental scale.

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*Susan Jewell is a Biologist in the FWS office of Endangered Species in Arlington, Virginia. She was formerly the Senior Biologist at Loxahatchee NWR in the Everglades.*

by Steve Glomb

# Coastal Barriers and Endangered Species



**Swept by wind and waves, barrier islands provide a dynamic home to a number of threatened and endangered species.**

*FWS photo*

**The funding restrictions under the Coastal Barrier Resources Act cover many barrier peninsulas, sand spits, and fringing mangroves in addition to true barrier islands. These other landscape features shield the mainland from the brunt of winds, waves, and storms, just like the barrier islands. Many of these features are just one major storm, and the creation of a new inlet, away from becoming barrier islands.**

Over millenia, geologic cycles and changing weather patterns have shaped and reshaped the ecology of barrier islands. The islands themselves have grown and shrunk, migrated landward, and been separated by inlets that formed and filled in many times over the years, thanks to longshore sand transport, tidal cycles, and storm surges. Only a limited number of hardy plants have evolved to survive the harsh conditions of salt spray, heavy winds, and shifting sands. These plants have, in turn, influenced which animals can call coastal barriers their home. Threatened or endangered species such as sea turtles, piping plovers (*Charadrius melodus*), bald eagles (*Haliaeetus leucocephalus*), beach mice, and the seabeach amaranth (*Amaranthus pumilus*) are examples of the diversity of life found on coastal barrier islands.

People are drawn to barrier islands as well, some to live year-round, others just for visits. Census projections show that the Nation's densely populated coastal counties will become increasingly populated over the next decade. Many barrier islands have already seen their dune grass and maritime forest habitats replaced by cottages, condominiums, and other commercial developments, leading to declines in the populations of barrier island wildlife. In a 1996 follow-up to a report by the U.S. Geological Survey on endangered ecosystems, an independent conservation group, Defenders of Wildlife, listed coastal ecosystems as one of the 10 most endangered ecosystem types in the country, and pointed to dune habitats and coastal barriers as examples of the vital habitats that continue to be lost.

Over 15 years ago, Congress attempted to merge coastal habitat conservation with fiscal conservatism when it passed the Coastal Barrier Resources Act of 1982. This law limited Federal subsidies (e.g., loans and storm insurance) for development within undeveloped coastal barriers included in a Coastal Barrier Resources System. By restricting additional Federal expenditures and financial assistance that would otherwise encourage the development of coastal barriers, Congress sought to reduce wasteful government spending and protect the natural resources associated with coastal barriers without increasing Federal regulations. Privately financed development is not prohibited within the System, although many potential developers have opted not to proceed with their plans in the absence of Federal aid and subsidies.

Support for the Coastal Barrier Resources System and its goals is widespread. The 1982 coastal barrier legislation and 1990 amendments to broaden its coverage both passed with overwhelming bipartisan support. The System now covers approximately 1,200 miles (1,930 kilometers) of shoreline and 1.3 million acres (0.5 million hectares), mostly along the Atlantic Ocean and the Gulf of Mexico. Aerial photography of these areas shows the success of the Act. Where Federal subsidies are provided, development thrives. Where they are not, the habitat often remains intact, ensuring that endangered species continue to have a place on the coast to call home.

*Steve Glomb is an FWS Biologist in the Division of Habitat Conservation in Arlington, Virginia.*

During August and September 1998, the Fish and Wildlife Service (FWS) published the following proposed and final Endangered Species Act (ESA) listing actions in the *Federal Register*:

## Listing Proposals

**American Peregrine Falcon (*Falco peregrinus anatum*)** On August 26, the FWS proposed to recognize the comeback of the American peregrine falcon by removing it from the list of threatened and endangered species. (See *Bulletin* Vol. XXIII, No. 5.)

**Koala (*Phascolarctos cinereus*)** Although often thought of as a bear, the koala of Australia is really a marsupial, and is more closely related to kangaroos and possums than to true bears and other placental mammals. Its young is carried in a pouch for about 6 months. As an arboreal species, the koala occurs mainly in the eucalyptus forests and woodlands. Evidence that more than half of the koala's forest habitat has been lost, along with threats from disease and reduced genetic viability resulting from habitat fragmentation, led the FWS to propose listing this species on September 22 as threatened.

## Final Listing Rules

**Southern California Plants** In 1995, the FWS proposed listing seven plant taxa from the mountains of southern California as endangered or threatened. Six of these plants were listed on September 14, 1998:

- San Bernardino bluegrass (*Poa atropurpurea*), a member of the family Poaceae, as endangered,
- California taraxacum (*Taraxacum californicus*), a perennial herb in the sunflower family (Asteraceae), as endangered,
- Bear Valley sandwort (*Arenaria ursina*), a perennial herb in the pink family (Caryophyllaceae), as threatened,
- ash-gray Indian paintbrush (*Castilleja cinerea*), a semi-parasitic perennial wildflower in the figwort family (Scrophulariaceae), as threatened,
- southern mountain wild buckwheat (*Eriogonum kennedyi* var. *austromontanum*), a perennial in the family Polygonaceae, as threatened, and
- Hidden Lake bluecurls (*Trichostema austromontanum* ssp. *compactum*), an annual in the mint family (Lamiaceae), as threatened.

The proposal to list the seventh plant in this group, Johnston's rock-cress (*Arabis johnstonii*), was withdrawn due to new information that this species is not

as vulnerable as it formerly appeared.

**Sierra Nevada Plants** In 1994, the FWS proposed to list 10 plant taxa native to the foothills of the Sierra Nevada in California. On September 14, 1998, four of these plants were listed as threatened:

- Chinese Camp brodiaea (*Brodiaea pallida*), a perennial in the lily family (Liliaceae),
- Springville clarkia (*Clarkia springvillensis*), an annual herb in the primrose family (Onagraceae),
- Red Hills vervain (*Verbena californica*), a perennial herb in the family Verbenaceae, and
- Mariposa pussypaws (*Calyptridium pulchellum*), an annual herb in the purslane family (Portulacaceae).

ESA protection was found unnecessary for the other six proposed plants. Additional data received after the listing proposal was published indicated that the Mariposa lupine (*Lupinus citrinus* var. *deflexus*), Kelso Creek monkeyflower (*Mimulus sbevoeckii*), Rawhide Hill onion (*Allium tuolumnense*), carpenteria (*Carpenteria californica*), Greenhorn adobe lily (*Fritillaria striata*), and Piute Mountains navarretia (*Navarretia setiloba*) are not in imminent danger of becoming extinct or endangered.

**Central California Plants** Five plants found primarily in Monterey County were listed under the ESA on August 12, 1998. Four are considered endangered:

- coastal dunes milk-vetch (*Astragalus tener* var. *titi*), an annual herb in the pea family (Fabaceae),
- Yadon's piperia (*Piperia yadonii*), a perennial herb in the orchid family (Orchidaceae),
- Hickman's potentilla (*Potentilla hickmanii*), a perennial herb in the rose family (Rosaceae), and
- Monterey clover (*Trifolium trichocalyx*), a prostrate annual herb in the pea family

The fifth plant, the Gowen cypress (*Cupressus goveniana* ssp. *goveniana*), a small tree or shrub in the family Cupressaceae, was listed as threatened.

The 1995 proposal to list these plants also contained a proposed listing for the black legless lizard (*Anniella pulchra nigra*); however, this part of the proposal was withdrawn on August 12, 1998, after the threats to the lizard's survival decreased.

**Winkler Cactus (*Pediocactus winkleri*)** A small, globe-shaped species with pink flowers and short spines, the Winkler cactus is known from only four popula-

tions on the Colorado Plateau in south-central Utah. Due to over-collecting and habitat damage resulting from grazing, mining, and off-road vehicle use, the FWS listed it on August 20, 1998, as threatened.

**San Bernardino Kangaroo Rat (*Dipodomys merriami parvus*)** The habitat of this small mammal, which was once common in San Bernardino and San Jacinto counties, has been reduced by about 95 percent by sand and gravel mining, flood control projects, urban development, and off-road vehicle use. On January 27, 1998, the FWS listed the San Bernardino kangaroo-rat as endangered on an emergency basis, and this temporary action was made permanent by a listing rule published September 24, 1998.

**Illinois Cave Isopod (*Gammarus acherondyte*)** As its name indicates, the Illinois cave isopod is a small invertebrate found in underground streams. Its aquatic habitat has been degraded by groundwater contamination resulting from agricultural pesticides and fertilizers, run-off from livestock feedlots, and residential septic systems. Recent surveys found the species at only three of its original six sites in Monroe and St. Clair counties. On September 3, the FWS listed the Illinois cave isopod as endangered.

**Jarbidge River Bull Trout (*Salvelinus confluentus*)** The bull trout population found in the Jarbidge River of southern Idaho and northern Nevada was given temporary emergency ESA protection on August 1, 1998. Earlier, on June 10, the FWS proposed to list this population as threatened due to various forms of habitat disturbance. The subsequent August 1 emergency action was believed necessary after the start of river channel alterations (associated with unauthorized road construction on the West Fork of the Jarbidge River) that imminently threatened the population's survival. The FWS plans to make a final decision on permanent ESA protection before the 240-day emergency rule expires.

**Parish's Alkali Grass (*Puccinellia parishii*)** This small annual occurs near certain desert springs, seeps, and seasonally wet areas in California, Arizona, New Mexico, and Colorado. It was proposed in 1994 for listing as endangered, but discoveries of additional populations and new information about its tolerance of some forms of human disturbance led the FWS to withdraw the listing proposal on September 25, 1998.

by Barbara Maxfield

# Hakalau Forest NWR



Male akepa (*Loxops c. coccinea*) in 'ohi'a tree

Photo by Jack Jeffrey



'Akiapola'au

Illustration by H. D. Pratt

Like an island within an island, Hakalau Forest National Wildlife Refuge lies within ranching lands spread across the windward slope of Mauna Kea on the island of Hawai'i (the "Big Island"). Its nearly 33,000 acres (13,350 hectares) of tropical rainforest and recovering pasture lands are set aside primarily to benefit five species of endangered Hawaiian forest birds. Through the forest's treetops flit small, colorful birds with magical songs and names . . . akiapola'au, 'akepa, 'i'iwi, 'elepaio, and 'oma'o,\* among others.

But managing the birds themselves is not what this refuge is about. According to refuge manager Richard Wass, "we're giving the birds a nice place to live, and if we succeed in our job, they'll take care of themselves."

As in most of Hawai'i's National Wildlife Refuges, habitat management began at Hakalau Forest with a battle against aliens. Feral ungulates, cattle (*Bos taurus*) and pigs (*Sus scrofa*), significantly damaged Hakalau Forest by consuming native plants, promoting the spread of non-native plant species, and causing erosion.

Trying to eliminate cattle and pigs from such a large area is an overwhelming task. The refuge staff has approached it by dividing the property into 18 feral ungulate management units. Members of the staff began fencing these units in 1988, and so far they have enclosed 8 units or 14,150 acres (5,725 ha), using almost 44 miles (71 kilometers) of fencing. Erecting fences on a

mountainside with steep gullies and rifts is not an easy task, and costs to date have averaged more than \$28,000 per mile (\$17,400 per km).

Within these fenced areas, feral cattle and pigs are removed primarily through hunting by the public, refuge staff, or contracted hunters. Although staff hunting has removed the most animals, public hunting has also played an important role in reducing numbers of these non-native animals. Since the feral ungulate management program began at Hakalau Forest in 1988, more than 1,100 pigs and 260 wild cattle have been removed. Of the eight fenced units, six are now cattle free, and the other two have only one or two cows remaining in each. Three units are pig free and two others have only a few pigs remaining.

But animal aliens are not the only enemy in Hakalau Forest; invasive weeds also threaten native forests and deter reforestation efforts in open pastures. One of the most noticeable features when driving to the refuge is the remarkable difference between the pasture lands outside the refuge boundary and those inside. In the mid-1980's, gorse (*Ulex europaeus*), a nasty, thorny relative of Scotch broom, infested about 500 acres (200 ha) of the refuge at its upper reaches, either in scattered clumps or impenetrable thickets. Today, after intensive work by refuge staff and contractors, this exotic pest covers less than 1 acre (0.4 ha) within the area. But the recently acquired 500-acre Pua Akala Unit includes about 300 acres (120 ha) of gorse, so the battle continues.

Other major alien plants to be controlled include prickly Florida blackberry (*Rubus argutus*); banana poka (*Passiflora mollissima*), an

\* *Hemignathus munroi*, *Loxops coccineus*, *Vestiaria coccinea*, *Chasiempis sandwichensis sandwichensis*, and *Myadestes obscurus*, respectively

## SPOTLIGHT ON REFUGES

invasive, viney passion fruit from South America that can smother native forests; cane tibouchina (*Tibouchina herbacea*), which has almost been eliminated at Hakalau Forest through hand pulling; and English holly (*Ilex aquifolium*). Staff and volunteers are attacking these invaders and have developed effective treatments for most of them.

The other half of habitat management at Hakalau Forest is reestablishing native species. The refuge staff is at the forefront in developing techniques to restore a mixed native forest in areas degraded by grazing and alien grasses. Since 1987, refuge staff and volunteers have planted more than 171,000 koa (*Acacia koa*) seedlings, some of which were grown to the seedling stage by the State of Hawai'i's Division of Forestry and Wildlife from seeds gathered under mature koa trees on the refuge. Many of these trees are now more than 20 feet (6 meters) tall.

In 1997, the planting emphasis shifted from koa to other native trees that make up the rainforest community at Hakalau Forest. A greenhouse was constructed on the refuge in 1995, and a horticulturist was hired the following year to begin propagating plants. Since 1997, almost 4,800 'ohi'a seedlings from the greenhouse were outplanted. Hundreds of other native species raised in the greenhouse and planted on refuge lands include mamane (*Sophora chrysphylla*), olapa (*Cheirodendron trigynum*), ohelo (*Vaccinium reticulatum*), pilo (*Coprosma ochracea*), kolea (*Myrsine lessertiana*), naio (*Myoporum sandwicense*), and pukiawe (*Styphelia tamerameiae*) seedlings.

Equally exciting are the successes the refuge staff have had with two endangered plant species: *Clermontia pyrularia* and *Clermontia lindseyana*. A total of 128 *C. pyrularia* seedlings were planted on the refuge this year, joining the only 10 other plants of this species known to exist in the wild. Another 136 *C. lindseyana* seedlings were planted in

pig-free areas. *Cyanea shipmannii*, with only five wild plants known, is being raised in the greenhouse but has not yet been outplanted.

Volunteers play a major role in habitat restoration activities at Hakalau Forest. During Fiscal Year 1997, a total of 184 volunteers contributed 375 days of work to the refuge. About two-thirds of the effort went to native tree propagation and planting, with the remainder to controlling pest plant species. The refuge sponsors many other activities within its boundaries, including forest bird research by the University of Hawaii and the Biological Resources

Division (BRD) of the U.S. Geological Survey; avian disease and mosquito demographic research by the BRD; habitat management research by the U.S. Forest Service; nene or Hawaiian goose (*Branta (=Nesochen) sandwicensis*) reintroduction in cooperation with the State of Hawaii; and numerous monitoring studies of forest birds, feral ungulates, invasive weeds, yellow-jacket wasps (*Vespa pennsylvanica*), vegetation recovery, and native tree growth and survival in outplanting areas.

"There's always more to do," says refuge manager Wass, "but we're proud of our accomplishments to date. We only have to look at the native forest birds such as 'apapane, 'amakihi, and 'i'iwi foraging and nesting among the branches of the koa trees that were planted within the past 10 years to know that we're making progress."



Since 1985, when the first parcel of land was purchased to create Hakalau Forest National Wildlife Refuge, the refuge staff has been focused on improving the habitat for its vulnerable residents, animals and plants alike. The lower slopes of the refuge are covered with dense stands of ferns and trees, primarily 'ohi'a (*Metrosideros polymorpha*) and koa (*Acacia koa*), dissected by numerous streams and gullies. This area represents some of the best remaining native rainforest habitat on the Big Island. The upslope area grades into a grassland habitat, created over the past 150 years as grazing cattle, logging, and burning damaged native forest habitats.

Photo by Richard C. Wass

# BOX SCORE

Listings and Recovery Plans as of November 30, 1998

GROUP	ENDANGERED		THREATENED		TOTAL LISTINGS	U.S. SPECIES W/ PLANS**
	U.S.	FOREIGN	U.S.	FOREIGN		
 MAMMALS	59	251	8	16	334	49
 BIRDS	75	178	15	6	274	77
 REPTILES	14	65	21	14	114	30
 AMPHIBIANS	9	8	7	1	25	11
 FISHES	69	11	39	0	119	88
 SNAILS	18	1	10	0	29	20
 CLAMS	61	2	8	0	71	45
 CRUSTACEANS	17	0	3	0	20	10
 INSECTS	28	4	9	0	41	26
 ARACHNIDS	5	0	0	0	5	5
<b>ANIMAL SUBTOTAL</b>	<b>355</b>	<b>520</b>	<b>120</b>	<b>37</b>	<b>1,032</b>	<b>361</b>
 FLOWERING PLANTS	539	1	132	0	672	490
 CONIFERS	2	0	1	2	5	2
 FERNS AND OTHERS	26	0	2	0	28	28
<b>PLANT SUBTOTAL</b>	<b>567</b>	<b>1</b>	<b>135</b>	<b>2</b>	<b>705</b>	<b>518</b>
<b>GRAND TOTAL</b>	<b>922</b>	<b>521</b>	<b>255</b>	<b>39</b>	<b>1,737*</b>	<b>879</b>

**TOTAL U.S. ENDANGERED:** 922 (355 animals, 567 plants)  
**TOTAL U.S. THREATENED:** 255 (120 animals, 135 plants)  
**TOTAL U.S. LISTED:** 1177 (475 animals\*\*\*, 702 plants)

\*Separate populations of a species listed both as Endangered and Threatened are tallied once, for the endangered population only. Those species are the argali, chimpanzee, leopard, Stellar sea lion, gray wolf, piping plover, roseate tern, green sea turtle, saltwater crocodile, and olive ridley sea turtle. For the

purposes of the Endangered Species Act, the term "species" can mean a species, subspecies, or distinct vertebrate population. Several entries also represent entire genera or even families.

\*\*There are 517 approved recovery plans. Some recovery plans cover more than one species, and a few species have separate plans covering different parts of their ranges. Recovery plans are drawn up only for listed species that occur in the United States.

\*\*\*Nine animal species have dual status in the U.S.

## ENDANGERED Species BULLETIN

*U.S. Department of the Interior  
Fish and Wildlife Service  
Washington, D.C. 20240*

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