

Ecological effects of animal introductions



NPS PHOTOS

at Channel Islands National Park

By Kathryn McEachern

The California Channel Island archipelago is sometimes called the Galapagos of North America because of its high number of endemic species and unusual plant and animal community assemblages. Twelve islands make up the island group, scattered from near Point Conception, in California, USA, to the offshore waters near Baja California, Mexico. Channel Islands National Park manages the five northernmost islands: Anacapa, Santa Cruz, Santa Rosa, San Miguel, and Santa Barbara. The remaining islands are owned and managed by the U.S. Navy, private conservation or recreation organizations, or Mexico.

Natural environmental factors have played a prominent role in the evolution of the plants and animals of all the islands. The islands vary widely in geology, topographic complexity, and elevation. The climate of the islands to the north is influenced by the colder waters of the Humboldt Current coming from the north Pacific, while the southern islands lie in currents bringing warm waters from the south. Island size varies from less than a square mile to nearly 50 square miles

(2.6–129 sq km), and the islands lie between 15 and 60 miles (24 and 97 km) offshore. Some of the islands remain shrouded in dense fog for many days of the year, while others have fog-free areas in their interiors. These and other natural factors interplay to influence the development of a flora and fauna high in local endemism, with unusual combinations of mainland and endemic species in the plant and animal communities, and a high degree of diversity among the islands. Yet, all of the islands have been used for fishing, ranching, hunting, and other forms of development and recreation in the past. As a result, intentional and acci-

dental introductions of animals and plants to all of the islands have occurred, with pervasive effects on nearly all aspects of island ecology. Channel Islands National Park was established to preserve, protect, and interpret the natural and cultural resources of the northern islands. The National Park Service and USGS–Biological Resources Division (USGS–BRD) have taken steps to understand the ecological effects of these invasions through the establishment of ecological monitoring and research programs, and the National Park Service is moving forward with conservation management for recovery and restoration.

Animal introductions

The early economy of southern California developed around livestock production for hides, tallow, and wool; and the islands were among the first areas to be developed in the state. By the 1880s sheep ranches were established on the larger islands of Santa Cruz, Santa Rosa, and San Miguel for the production of wool. Livestock operations were sustained through the mid- to late-1900s

(fig. 1). Most livestock were introduced for wool or meat production, some were brought to the islands for recreational hunting, and others arrived by accident. The ranches on Santa Rosa and Santa Cruz were productive operations for more than a century. The Santa Rosa operation was converted

to cattle in the early 1920s; deer, elk, and European boar were introduced for hunting in 1930; and deer and elk hunts still occur on Santa Rosa under a special use permit today. On Santa Cruz, sheep and cattle were run simultaneously on different parts of the island. European boar and turkeys were introduced for hunting in the 1930s. Each of these two ranches had small herds of

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horses bred on the islands, and descendants of those herds persist on those islands as small managed groups today. A series of droughts in the early 1900s halted sheep production on San Miguel Island in 1949. Several donkeys were introduced during the filming of a Hollywood movie in the 1960s, and they developed into a small herd over nearly 12 years before being removed by the National Park Service.

Although Anacapa and Santa Barbara Islands are only about one square mile (2.6 sq km) in area each, and lack permanent water, sheep were grazed there for about two decades beginning in the early 1900s. The U.S. Life Saving Service developed a lighthouse operation on Anacapa in 1937, with quarters for up to five families on the island. Black rats (*Rattus rattus*) found their way to Anacapa and San Miguel in the 1930s, but they have not developed populations on any of the other park islands. House cats were brought to Santa Barbara Island by the sheep-farming operation in the 1920s. From 1942 to 1947, Santa Barbara Island was used as an aircraft early warning outpost. The U.S. Navy released Belgian hares and New Zealand red rabbits as an emergency food source for the staff there, in the event that they became stranded on the island during the war. When the Navy left Santa Barbara Island, the rabbits remained.

All of these ranching operations included some farming, along with the cultivation of

landscape plants. Hay pastures were plowed and planted on all but Anacapa Island. Vineyards were cultivated for production of a Santa Cruz Island red wine and table grapes for about 30 years in the late 19th and early 20th centuries. Olives were planted in the 1930s, and European honeybees were introduced for honey production around 1920. Ornamental eucalyptus, Italian stone pines, figs, and citrus were grown near the Santa Cruz Island ranch buildings, along with garden vegetables and flowering plants, throughout the ranching era. The U.S. Coast Guard acquired the Anacapa lighthouse operation in 1947, and planted an alien mat-forming figwort (*Malephora crocea*) in the ice-plant family for erosion control around the buildings, roads, and trails. Farming on Santa Barbara included plowing and planting of nearly one-half of the island in oats and potatoes.

Alien plant invasions

From an ecological perspective these historical operations can be seen as a powerful and prolonged disturbance that changed the environmental context for the

native flora and fauna, opening pathways for the invasion of island vegetation by nonnative plants. Ranching and farming altered soil structures and opened sites for the establishment of nonnative plants,

brought alien plants to the islands on the animals and

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Years: 1800-----1850-----1900-----1950-----2000

Anacapa Island	1853 Black rats	2001
Santa Cruz Island	1830 Cattle	1989
	1830 Horses	2004+
	1853 Sheep	1999
	1853 Pigs	(planned) 2006
Santa Rosa Island	1844 Sheep	~1950
	1844 Cattle	1999
	1844 Horses	2004+
	1853 Pigs	1993
	1881 Mule deer	(planned) 2011
	~1930 Elk	(planned) 2011
San Miguel Island	1800's Black rats	2004+
	~1950 Donkeys	1975
Santa Barbara Island	1926 Rabbits	1982
	1880's Cats	1978

Figure 1. A timeline of animal production on the northern Channel Islands. SOURCES: SUMNER 1958, JUNAK ET AL. 1995, LOMBARDO AND FAULKNER 1999, LIVINGSTON 2003



equipment, introduced vectors for the spread of nonnative seeds, changed native habitats used by island fauna, and replaced native plant cover with commercial crops. The results are apparent in the vegetation today.

The pre-ranching land cover of the islands was most likely a matrix of upland native scrub, riparian woodland, and coastal bluff and dune scrub, interspersed with small, native grass openings. Now, between 35% and 75% of each island is occupied by alien grasslands dominated by Mediterranean annual grasses, primarily in the genera *Bromus*, *Hordeum*, *Vulpia*, and *Avena*. Native plant communities are infiltrated with trails and erosion scars, or they are reduced to small, remnant stands on steep slopes inaccessible by ungulates (fig. 2). Understories of the fragmented native shrub communities, particularly coastal sage scrub, island chaparral, island woodlands, riparian areas, and coastal bluff scrub stands, have been invaded by the alien grasses dominant in other areas. One of the most pervasive effects of herbivory has been the

widespread replacement of shrub cover by annual grasses. This reduction in vegetation height from 1 to 2 meters for shrubs to several centimeters for grasses has resulted in a great reduction in fog drip, a major source of water for island plants (Ingraham and Matthews 1995). Not only do the grasses compete directly for water with germinating seedlings of native plants, they also effectively reduce the amount of water available in the system for native plant growth.

This conversion of the vegetation from one type to

another has had grave consequences for some of the endemic island taxa, which depend upon habitats no longer present. At least one native songbird is extirpated from the northern islands. An endemic lizard (*Xantusia riversiana*) that depends on boxthorn (*Lycium californicum*) cover is endangered. Slightly more than one-quarter of the 775 plants on the islands are not native to California or the islands. Botanical surveys show that sixteen plant taxa are thought to be lost from the islands

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Figure 2. Remnant stands of coastal sage scrub in alien island grassland, Santa Rosa Island, with San Miguel Island in the background. NPS PHOTO BY SARAH CHANEY

(Junak et al 1997), 14 taxa are listed as federally endangered or threatened, and 74 more are considered rare or of special concern. Channel Islands Vegetation Monitoring Program data show that nearly half of the plant cover on transects is nonnative (Johnson and Rodriguez 2001).

Cascading ecological effects

The effects of long-term predation, competition, herbivory, and trampling by nonnative animals pervade many levels of ecological organization on all of the Channel Islands. Channel Islands National Park and USGS-BRD scientists conduct a monitoring and research program that describes current conditions, tracks changes in terrestrial and marine systems, and investigates specific problems detected through monitoring efforts. Results provide information on conservation management options. Monitoring and research data show direct effects on guilds of native animals and individual plant taxa. Indirect effects are seen in the fecundity and mortality rates of individual native taxa persisting in altered environmental conditions.

Direct effects

Perhaps the most readily documented effects of sustained disturbance are those related to predation and herbivory. In several instances, data show reduced fecundity and higher mortality as the direct result of feral animal use. After arriving on Anacapa Island in the 1930s, black rats grew in number slowly for many decades. Population declines were seen in nesting seabirds, coupled with high rates of rat predation on eggs (Hunt et al. 1980, McChesney et al. 2000). Seabird monitoring data showed predation rates as high as 90% on the eggs of Xantus's murrelets (*Synthliboramphus hypoleucus*), which likely contributed to murrelet population declines documented by USGS-BRD research throughout the southern California Bight (Hamer and Carter 2002). In 2001–2003, Channel Islands National Park worked with the Island Conservation and Ecology Group to eradicate rats from the island using aerial applications of a rodenticide. Monitoring data show immediate responses in increased lizard density, much lower murrelet egg predation rates, and higher fledging success in nesting seabirds (Whitworth et al. 2003).

Botanical demographic research conducted by NPS scientists (Clark 1989) identified rabbit herbivory as a major factor in population decline in the Santa Barbara Island live-forever (*Dudleya traskiae*), and the plant was listed as endangered in 1984 (fig. 3). The National Park Service conducted a rabbit eradication campaign 1980–1981. Subsequent live-forever population censuses show recovery of individual plants, seed production,

and the establishment of juveniles, in a reversal of declining trends (McEachern et al. 2003 unpublished data). Similar studies of giant coreopsis (*Coreopsis gigantea*) soon after rabbit eradication on Santa Barbara Island demonstrated the positive demographic effects of reduced rabbit herbivory on plant stems, roots, and seedlings (Salas 1990.) In each of these instances, data showing direct and detrimental effects of an introduced animal on a particular native species were used to justify and obtain funding for animal eradication. In both instances, subsequent studies are showing positive effects on populations of other organisms in the island ecosystems. Such eradications benefit more than just the target species that served as the clear indicators of population losses from predation and herbivory by nonnative animals.



Figure 3. Santa Barbara Island live-forever (*Dudleya traskiae*), an endemic plant listed as endangered because of the effects of rabbit predation. PHOTO COURTESY OF CHARLES DROST

Indirect effects

Indirect effects of the sustained ranching activities on the islands are clearly demonstrated by the Channel Islands monitoring and research programs, too. Soft-leaved island paintbrush (*Castilleja mollis*) is an endangered plant that occurs in only two sites on Santa Rosa Island. Population demography data collected in the 1990s showed that the plant was in a slow decline, related partially to trampling and herbivory by cattle, deer, and elk that reduced seed production and increased individual plant mortality (McEachern and Chess 2000). Cattle were removed from the island in 1998, and deer and elk are culled semi-annually in the island paintbrush areas. However, demographic data show that populations of soft-leaved island paintbrush still do not include enough new plants germinating from seed for population expansion and recovery. Experiments show that annual production of viable seed is good, and germination rates are more than 80% in the greenhouse. Field outplanting experiments show that seedlings grow when planted within stands of coastal bluff scrub, but not when planted in nonnative annual grass openings in the scrub communities (McEachern et al. 2003). The coastal bluff scrub habitat where the paintbrush grows is highly fragmented, with small patches of scrub widely scattered within a matrix of annual grassland. The paintbrush is unlikely to

recover until the coastal bluff scrub recovers a more continuous canopy that allows seeds to fall into hospitable habitats for germination and survival. This is a case where the indirect effects of habitat fragmentation and annual

grass invasion compound the problems of higher plant mortality and reduced annual seed output brought on by herbivory and trampling.

Perhaps the most compelling case of indirect effects of development on island ecosystems is demonstrated in the island fox (*Urocyon littoralis*). The fox is a diminutive relative of the mainland grey fox (*Urocyon cinereoargenteus*), with different endemic subspecies on 6 of the 12 islands in the Channel Islands archipelago (fig. 4). Monitoring data showed drastic island fox declines over a five-year period on three national park islands in the 1990s (Coonan 2001), and subsequent research (Roemer et al. 2001) demonstrated that the proximal source of the problem is predation by nonnative golden eagles (*Aquila chrysaetos*). Bald eagles (*Haliaeetus leucocephalus*) were native to the islands, and they excluded the golden eagles through aggressive competition for nesting and roosting sites. Bald eagles feed mainly on fish. The bald eagles disappeared from the islands more than a decade ago because of high DDT bio-accumulation rates in their marine prey that rendered the eagle eggs too soft-shelled for survival. As a result, golden eagles have taken up residence on Santa

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Figure 4. The island fox has suffered population declines in the California Channel Islands. NPS PHOTO BY BILL EHORN

Cruz Island where they find an ample food base in young piglets, another introduced feral animal. Fox hunting is made easier for the eagles on Santa Cruz, Santa Rosa, and San Miguel Islands where annual grasslands have displaced the native shrub cover used by foxes to avoid avian predators.

This complex problem is being resolved under the guidance of a team of biologists (Coonan 2001), by simultaneously removing golden eagles and feral pigs from Santa Cruz, and reintroducing bald eagles to the northern islands, while protecting the foxes in a captive-breeding program. Pig eradication is complicated by acres of dense cover of monotypic stands of nonnative fennel (*Foeniculum vulgare*). The fennel established in the Central Valley vineyards when Santa Cruz Island wine production ceased, and it has invaded adjacent scrub where it is an aggressive competitor for light and water (Beatty and Licari 1992). Thus, an aggressive fennel eradication program is a first step in the pig eradication campaign, planned for 2003–2008. Recovery of scrub habitat for the foxes is so far a passive effort; research is under way to investigate ways to encourage the reestablishment of native plants on the islands (e.g., Corry and McEachern 2000, Levine et al. 2002, Carroll et al. 2003, Loehrer 2003, and Stratton 2003.)

Restoration and recovery

Changes wrought during the ranching era were widespread and pervasive, affecting all levels of ecological trophic organization on the islands. The best way to deal with these problems is a holistic approach to restoration and recovery that benefits many taxa. Agency scientists (NPS, USGS, USFWS) drafted a conservation strategy for the islands (Coonan et al. 1999) that directs restoration efforts at higher trophic levels and across broad habitat types for ecosystem recovery. The removal of feral animals from several islands (see fig. 1) has been an enormous contribution moving the islands in the direction of recovery. The positive effects are demonstrated in trends seen in some of the monitoring data and in the population responses of individual native species. To this point, however, habitat-based restoration and recovery has been largely a passive effort, under the assumption that feral animal eradication has and will jump-start the system in the direction of recovery. The next step will be to begin habitat-based recovery efforts, now that the animals are gone, targeted at the restoration of native scrub and woodland cover used by many plants and animals. This effort must be a multifaceted approach, involving an aggressive noxious weed eradication campaign, landscape-level treatments that encourage the spread of natives, and managed reintroduction of sensitive natives like the island paintbrush and the island fox.

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