# A Bird in Our Hand: Weighing Uncertainty about the Past against Uncertainty about the Future in Channel Islands National Park

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## Introduction

Climate change threatens many species and ecosystems. It also challenges managers of protected areas to adapt traditional approaches for setting conservation goals, and the philosophical and policy framework they use to guide management decisions (Cole and Yung 2010). A growing literature discusses methods for structuring management decisions in the face of climate-related uncertainty and risk (e.g., Polasky et al. 2011). It is often unclear, however, *when* managers should undertake such explicit decision-making processes. Given that not making a decision is actually a decision with potentially important implications, what should trigger management decision-making when threats are foreseeable but not yet manifest?

Conservation planning for the island scrub-jay (*Aphelocoma insularis*) may warrant a near-term decision about non-traditional management interventions, and so presents a rare, specific case study in how managers assess uncertainty, risk, and urgency in the context of climate change. The jay is restricted to Santa Cruz Island, one of the five islands within Channel Islands National Park (CINP) off the coast of southern California, USA. The species also once occurred on neighboring islands, though it is not known when or why those populations went extinct. The population currently appears to be stable, but concerns about long-term viability of jays on Santa Cruz Island have raised the question of whether a population of jays should be re-established on one of those neighboring islands, Santa Rosa. To address that question, managers need to understand when and why the jay population went extinct on Santa Rosa Island: did it go extinct "naturally" in prehistoric time, or did it go extinct more recently due to anthropogenic factors? Depending on which it is, a reintroduction either would be consistent with a general interpretation of National Park Service (NPS) policy—i.e., restoring parks to their historic, natural condition—or it would be a more interventionist manipulation of the landscape, possibly even an "impairment" of the park. Case studies like this highlight potential conflicts between existing policy and broader conservation goals, and

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can be especially helpful because they might illuminate how conservation philosophy, policy, and practice can be adapted to meet the realities of conservation in a changing world (Cole and Yung 2010).

The aim of this paper is not to evaluate whether to translocate jays to Santa Rosa Island *per se* (e.g., how to rank translocation as a priority for management, how to estimate or increase the likelihood of a successful introduction.) There are many resources that can help with that (e.g., Ewen et al. 2012; IUCN 2012b). Rather, the aim of this paper is to explore more prerequisite questions raised by the prospect of translocating jays: if threats are foreseen that could potentially necessitate an action, how and when should managers respond to that information? Addressing these questions in the case of the jays requires an examination of historical ecology, and how managers should weigh uncertainties about both the past and the future in their management planning. Survival of a CINP-endemic species may hang in the balance.

### Uncertainty about the jay's past

Channel Islands National Park encompasses five of the eight California Channel Islands, of which Santa Cruz Island is the largest. The Nature Conservancy (TNC) owns the westernmost 76% of the island; NPS owns the remainder. Prior to their conservation management, islands in CINP were used for livestock production, and overgrazing caused widespread loss and degradation of the islands' native vegetation. All ungulates have since been removed from the park islands, which are generally at an early stage of vegetation recovery (Morrison 2011).

The island scrub-jay, the only insular passerine species in the continental United States, occupies one of the smallest ranges of any bird, the 250 $km^2$ of Santa Cruz Island. Multiple lines of evidence indicate the species occurred on neighboring Santa Rosa Island at least into the early Holocene. Genetic studies suggest that island scrub-jays diverged from a common ancestor of the mainland western scrub-jay (*A. californica*) approximately 1 million years ago (McCormack et al. 2011), which means that island scrub-jays were present on the island when sea levels were lower during the last glacial, approximately 10,000 years ago, and the areas that now comprise the northern Channel Islands were connected as a single land mass, Santarosae Island (Delaney and Wayne 2005; Figure 1).

Until recently, it was assumed that the island scrub-jay "died out on Santa Rosa during peak postglacial warm interval (hypsothermal), approximately 8,000 years ago, when drier conditions reduced woodland habitat" (Curry and Delaney 2002). Fossil remains dating from greater than 10,000 years BP have been found on Santa Rosa Island (Collins 2009); interestingly, no scrub-jay fossils have been found on Santa Cruz Island, which highlights the incompleteness of the archeological record on the islands (Collins 2009). More recent remains, however, perhaps dating to less than 1,000 years ago, have been found on neighboring San Miguel Island (P.W. Collins, Natural History Museum of Santa Barbara, pers. comm.), which narrows the uncertainty about when jays disappeared on the islands closer to the historic period. That more recent baseline of likely presence on neighboring islands helps interpret other evidence—and the absence of evidence—from the historical period.

No systematic biological surveys occurred on the northern islands prior to the introduction of livestock in the mid-1800s (Collins 2009). Sheep (*Ovis aries*) grazing in particular had a profound effect on the park islands, which were largely devegetated. Collins (2009)

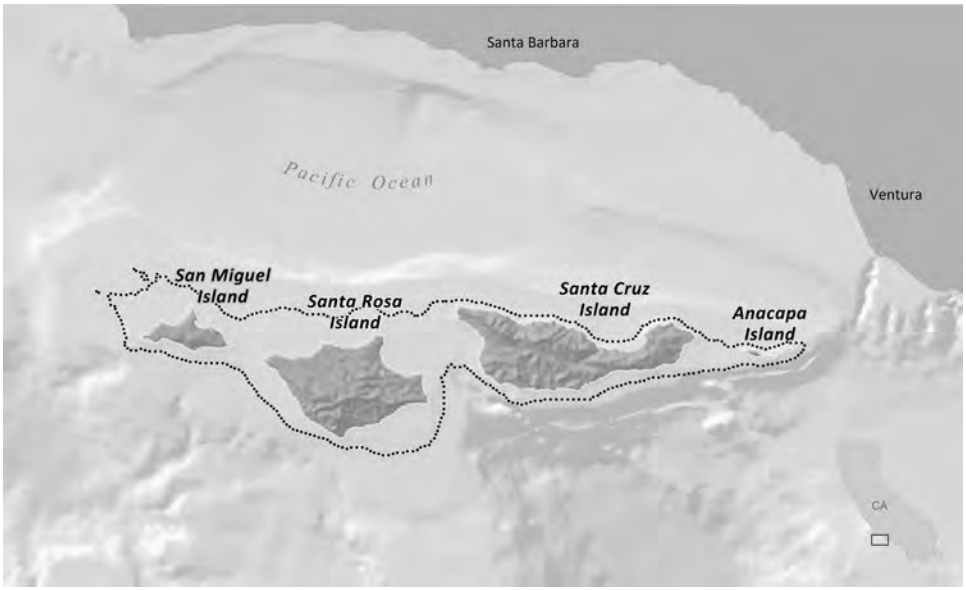


**Figure 1.** The northern Channel Islands of California. Channel Islands National Park includes these islands plus Santa Barbara Island to the south. Dotted line depicts the coastline of Santarosae Island, 16,000 BP (adapted from Johnson 1978).

reviewed specimen collections and written records by visitors, collectors, and scientists to the northern islands in the 1800s and early 1900s to assess not just whether there were any observations of jays by early visitors, but also whether there were even observers on Santa Rosa Island in the mid-1800s who could have collected or recorded observations of jays if they were there. (Collins also reviewed ethnographic records pertaining to the Native American history on the islands and found few clues as to how the Chumash may have interacted with the jays, e.g., for feathers or food). Few biological surveyors visited Santa Rosa Island in the 1800s, and no surveyor records have been found prior to the introduction of sheep, which took place around 1844 (Collins 2009). In fact, there were few biological surveys on Santa Rosa Island even up through the mid-20th century; Miller (1951), in a comparison of avifauna of Santa Cruz and Santa Rosa islands, noted that "the scanty attention given Santa Rosa [results in] the necessary dependence on single reports of occurrence derived from hasty visits."

One of the few ornithologists to visit Santa Rosa Island in the 1800s was Smithsonian biologist Clark P. Streator, who visited the island for three days in 1892. Collins (2009) discovered field notes in which Streator recorded the species he observed, as well as species he did not directly observe but that were reported to him as occurring on the island by on-island staff (Streator 1892). One of those staff was the manager of the sheep operation, John F. More, who at the time had been on the island for about 20 years. Streator wrote, under the heading of "*Aphelocoma,*" that "Mr John Moore [sic] informs me that there are Jays on the island." Although Streator himself did not see or collect a jay on the island, the other species he reported as being present based on interviews with the island staff are all known to be present on the island. For example, the authority of his note regarding "*Mimus polyglottos*" is

not doubted: "Mr. Moore and others inform me that there are mockingbirds on the island." Similarly, "all of the old employees of the Island as well as Mr John Moore manager of the Island informed me that they had seen small skunks on the Island." Despite not seeing the "*Spilogale*" skunk, he accurately ascribed the genus as a spotted—not a striped (*Mephitis* spp.)—skunk.

If island scrub-jays existed on Santa Rosa Island as recently as the late 1800s, what could have precipitated their extirpation? Extinction can result from a vortex of interacting effects (Gilpin and Soulé 1986). Sheep grazing would have had a profound direct and indirect effect on jay population viability. By the 1880s, as many as 125,000 sheep occurred on the 215-km$^2$ Santa Rosa Island (Collins 2009). Sheep would have reduced the coverage of vegetation types that on Santa Cruz Island are associated with jay habitat (Figure 2) (Sillett et al. 2012). Woody vegetation could have been lost due to direct and indirect effects of grazing (e.g., herbivory, soil erosion), pasture clearing, and gathering of fuel wood to support ranching and rendering operations. The reduction in quantity and quality of habitat would have reduced carrying capacity and so increased risk of extinction due to stochastic effects of small population size.

Additional factors could have compounded the reduction in habitat and heightened the extinction risk of jays on Santa Rosa Island. Food abundance may have been reduced, in part due to loss of oak (*Quercus* spp.) and pine (*Pinus* spp.) habitat, but also because of likely competition by the non-native feral pigs (*Sus scrofa*) on the island that would have rooted up and consumed seeds cached by the scatter-hoarding jays (Sweitzer and Van Vuren 2002; Pesendorfer 2014). Drought conditions, which are not uncommon in this region, could have further limited acorn supply (e.g., Pérez-Ramos et al. 2010). Perhaps there was direct persecution of the jays. In that era, bounty hunting and persecution of corvids was not uncommon in the western United States (e.g., Erickson 1937; Hooper 1938). As Bent (1946) observed, "organized [western scrub-jay] shoots are popular in some parts of California, under the pretext of reducing numbers of a destructive bird, but largely, too, as a pleasant recreation and an interesting competition for the shooters." Matthiessen (1959) wrote that the "destruction of birds of all shapes and sizes had reached the proportion of a national pastime in the last quarter of the nineteenth century." Some passerines were also harvested for food (e.g., Hornaday 1913; Bolen and Robinson 1995). A large blue passerine may have been especially

**Figure 2.** Santa Rosa Island vegetation. (Left) Modeled potential extent of *Quercus tomentella* (adapted from Kindsvater 2006), which may approximate distribution prior to the introduction of sheep. (Right) Extent of oak (gray) and pine (black) communities today.

conspicuous on an island with a depauperate fauna that—except for marine species—offered little other wild 'game.'

The few written accounts of life on Santa Rosa Island in the 1800s offer few clues. An early visitor to the island, identified as "K," wrote:

> There is a storeroom in the barn, where all the things the men need are kept, and here also is a perfect arsenal of fire arms—one might think there was danger of a foreign invasion, but they are only used to shoot *birds*, foxes, and wild hogs. *The latter are very numerous*, and sometimes attack and kill the lambs ("K" 1893, emphases added).

Whether jays were among the "birds" targeted by the sheep shearing men she described as "swart Spanish–Californians" was not specified. Her account does illustrate that the ranching era brought about changes in the community composition on the island, e.g., feral pigs. How ranching affected abundance and behavior of island fox (*Urocyon insularis*) is unknown; foxes are nest predators of island scrub-jays on Santa Cruz Island (Caldwell et al. 2013).

An especially intriguing insight into possible community-level changes on Santa Rosa Island might be embedded in an account by Gustav Eisen, former curator of biology at the California Academy of Sciences, who visited the island for perhaps "several weeks" in roughly June of 1897. He wrote:

> Birds of several kinds visit the island, but for some reason none ever breeds there. Doves come by the thousands, but do not stay long. This is hard to explain, as the island would appear to be a safe and comfortable nesting place; but not a nest can be found. Thousands of very vicious ravens visit the island at intervals. They are of the common species, but for some reason are very wicked and do considerable damage if they are not watched. Their worst habit is to fly at the eyes of sheep until the animal is blinded. The eyes are then eaten out and another sheep attacked. Where these ravens come from or where they go after their periodical visits is a mystery (Eisen 1897).

Although the account contains inaccuracies (many species of land bird surely nested on the island), that Eisen did not observe evidence of nesting (such as active nests, food provisioning, fledglings) may indicate low reproductive success of passerines generally, which—again—could have been due to low habitat quantity or quality. What may well have contributed to low habitat quality would be "thousands" of ravens (*Corvus corax*). Numerous visitors to Santa Rosa Island during the sheep era noted the abundance of ravens (P.W. Collins, Santa Barbara Museum of Natural History, pers. comm.). Ravens are predators of eggs and nestlings of open cup nesting birds, including island scrub-jays (Caldwell et al. 2013). The current abundance of ravens on Santa Cruz Island (with no introduced prey subsidy, such as tens of thousands of sheep) is generally low. Perhaps the large flocks of ravens seen on Santa Rosa Island, likely attracted by the food subsidy provided by sheep, also increased nest predation of jays (and other birds), which may have been concentrated in the remaining patches of habitat. Interestingly, that potential mechanism of hyperpredation by a predator population elevated by a food subsidy provided by introduced ungulates was observed a century later: golden eagles (*Aquila chrysaetos*), subsidized by feral pigs, established a resident

population on the northern Channel Islands and through incidental predation drove island fox populations to near extinction (Roemer et al. 2002) (Figure 3).

Confounding the uncertainty about why the Santa Rosa Island jay population went extinct is the fact the Santa Cruz population did not, even though the islands experienced generally similar ecology and land use histories (Collins 2009). Why would sheep overgrazing lead to extinction on one island and not another? Perhaps Santa Cruz Island, which is larger and more physiographically complex, provided jays with sufficient refugia from predation and habitat loss. Perhaps local variation in land use practice or climate affected the jay populations differently. In the end, we can only speculate about what may have happened on the islands (e.g., Figure 3) and model various scenarios of population viability. Without the discovery of unequivocal evidence (e.g., through archaeological excavation or finding of a misplaced museum specimen), the uncertainty about the date and cause of extirpation might not ever be resolved. Regardless of the uncertainty surrounding when and why the populations disappeared, however, the fact the species no longer occurs on three islands in its former range does highlight its vulnerability to extinction on Santa Cruz Island (Delaney and Wayne 2005).

### Why "when" matters

Although it is not known and may not be knowable when jays went extinct on Santa Rosa Island, the date and cause are relevant to NPS policy. The Organic Act (1916) directed the new agency to conserve resources in a "natural" and "unimpaired" condition: "the condition of resources that would occur in the absence of human domination of the landscape" (NPS 2006). Thus, if jays went extinct on Santa Rosa Island before the "human domination" of the ranching era, then the jay could be said to "not belong" on the island and translocating it to Santa Rosa Island could be seen as an "impairment" of park resources. If, on the other hand, the population went extinct because of human-induced habitat degradation, then translocating it to Santa Rosa would almost assuredly be a management goal. For example, a population of song sparrows (*Melospiza melodia gram-*

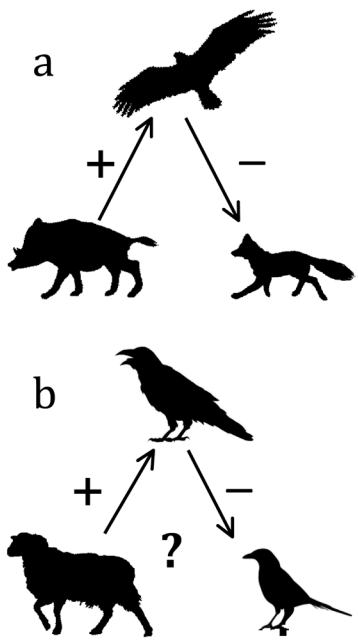


**Figure 3.** Observed and hypothesized hyperpredation trophic relationships on the Channel Islands. (a) In the late 1900s, golden eagles established a resident population on the northern Channel Islands that was supported in part by a food subsidy provided by feral pigs on Santa Cruz Island; golden eagle predation drove island fox to near extinction on Santa Cruz, Santa Rosa, and San Miguel islands (Roemer et al. 2002). (b) Perhaps a similar hyperpredation scenario occurred on Santa Rosa Island in the late 1800s, in which introduced sheep may have subsidized a population of ravens that in turn may have increased nest failure and extinction risk of that island's population of island scrub-jays.

*inea*) is known to have been driven extinct on CINP's Santa Barbara Island due to 20th-century habitat degradation (Collins 2008), and managers are currently developing strategies for its reintroduction. In contrast, uncertainty about whether or not Santa Rosa Island's jay population went extinct "naturally" has effectively deferred a decision regarding jay translocation. Were it not for climate change, such limbo might not have significant stakes. However, a consideration of some of the uncertainties associated with climate change reveal risks of status quo—not only to the viability of the jay but also to the ecological resiliency of the park.

### Uncertainty about the jay's future

The island scrub-jay faces a number of threats to its viability that acting alone or in concert could increase extinction risk. Small, restricted populations are vulnerable to population problems, ranging from inbreeding to catastrophic events (Gilpin and Soulé 1986). Island populations are particularly vulnerable, as evidenced by high extinction of island birds, often caused by invasive alien species (King 1985). In recent years, purported sightings of rats (*Rattus* spp.) have occurred on Santa Cruz Island with sufficient credibility to trigger a management response (Boser et al. in revision). Introduced Argentine ants (*Linepithema humile*), which are known to depredate contents of passerine nests, occur in multiple, expanding infestations on the island (Randall et al. 2011).What effects these would have on jays is unknown.

Climate change will likely exacerbate many threats to jays. How climate change will affect the Channel Islands is not well understood, in part because the climate of the islands is so dependent on local marine conditions and fog (Snyder et al. 2003). Generally, however, we might assume that conditions expected for coastal southern California apply to the islands. Warmer and drier conditions in southern California (Cayan et al. 2008; LaDochy and Witiw 2012) may render areas of a species' current distribution unsuitable; species that are restricted to islands and have limited dispersal abilities may be stressed if the climate to which they are adapted shifts (Walther et al. 2002). Changes in precipitation would affect wildfire risk (Westerling and Bryant 2008). Drought may reduce production of acorns (Pérez-Ramos et al. 2010), which are an important food resource for jays. Global warming may increase the prevalence of mosquito-vectored diseases, such as West Nile virus (WNV), which causes high mortality among the Corvidae and has been prevalent on coastal mainland California since 2003, but has yet to establish on Santa Cruz Island (Boyce et al. 2011). At least five species of mosquito are present on the island that can vector the disease. Another WNV vector, the daytime-feeding Asian tiger mosquito (*Aedes albopictus*), has recently invaded nearby Los Angeles County (GLACVCD 2013). Jays are dependent on oak habitats, so arrival of oak pests or pathogens to the island, such as the goldspotted oak borer (*Agrilus auroguttatus*) that is currently expanding its range and causing high mortality of some oak species in San Diego County (CISR 2013), could have significant impact on jay populations.

Managers are implementing a number of strategies to reduce threats to the island scrub-jay and other native species on Santa Cruz Island. Managers are attempting to eradicate Argentine ants (Randall et al. 2011) and implement biosecurity measures to reduce importation and establishment of new pests (Boser et al. in revision). Protocols are in place to reduce risk of accidental wildfire ignition. Managers also vaccinate some island scrub-jays to help reduce the population-level impact of WNV (Boyce et al. 2011). In recent decades managers also

have removed nonnative mainland vertebrates, including sheep, which caused widespread habitat loss and degradation, and pigs and wild turkeys (*Meleagris gallopavo*), which were likely competitors of jays for acorns and other small prey items (Morrison 2011).

In consideration of the challenges of managing risks to the island scrub-jay on one island, and in light of the jays having at one time been present on Santa Rosa Island, Morrison et al. (2011) discuss potential benefits of establishing a second population of jays on that island. It would increase range and add population structure, effectively creating two populations that could be managed as a metapopulation to reduce risk of global extinction and improve prospects for persistence on Santa Cruz Island. Marine conditions are a strong driver of climate on the California islands, and because Santa Cruz and Santa Rosa islands occur along a marine ecoregional divide (Spalding et al. 2007), the islands differ in climate and may experience the effects of climate change differently. Those differences, even if slight, may have important climate adaptation benefits for jays. For example, mosquito-borne disease risk can be highly influenced by temperature, and even slightly cooler temperatures on Santa Rosa Island could reduce impact of West Nile virus (Boyce et al. 2011).

How climate change will affect species and ecosystems is an emerging science laden with uncertainty. Consequently, managers face uncertainty about risks to jays, and the need or urgency to manage them. Currently, the jay population on Santa Cruz Island appears not to have a population problem (Sillett et al. 2012). However, managers of the Channel Islands know from recent experience with the island fox how quickly populations of endemic taxa can crash, and how expensive and demanding the subsequent recovery efforts can be (Coonan et al. 2010). Indeed, based on recent estimates of population size (Sillett et al. 2012) and considerations of disease risk (Boyce et al. 2011), the IUCN uplisted jays to "vulnerable" on its Red List of threatened and endangered species (IUCN 2012a). As managers consider management options for the jay, the expected costs and benefits of proactive versus reactive management should factor into the decision about whether or when to act. Implementing management proactively could lessen the biological, financial, administrative, and ethical stakes relative to managing a population in decline or peril. Management options also must be evaluated in context of the other objectives and management responsibilities the managers have across the archipelago.

### Uncertainty about an island's future

The prospect of translocating jays to Santa Rosa Island raises a number of questions regarding the condition of habitat on that island and the potential impact of jays in that ecosystem. The legacy of the ranching era has created a substantial restoration challenge for CINP in its own right. The last of the introduced ungulate populations that had long suppressed native woody vegetation recruitment were removed from Santa Rosa Island in 2011. Although some native vegetation communities have responded positively to the release from grazing pressure (Wagner et al. 2004), others remain highly degraded. Indeed, given the reduction of native vegetation communities, loss of soil, the prevalence of weedy species (like annual grasses), and the effects of climate change, Santa Rosa Island might be considered a "novel ecosystem" (*sensu* Hobbs et al. 2009).

Consideration of introducing populations requires extreme diligence to minimize risks both to the species and the ecosystem to which it is being introduced, even if it is a reintro-

duction to its former range. For example, jays are predators of open cup nests, and so could have an adverse impact on other passerines of conservation concern, such as loggerhead shrike (*Lanius ludovicianus anthonyi*) (Stanley et al. 2012). However, some island birds have demonstrated plasticity in nesting behavior to reduce risk of nest predation by jays (Peluc et al. 2008; Sofaer et al. 2013).

Reintroduction of jays may have positive ecosystem effects. For example, restoration of predators can enhance resiliency of ecosystems (Ritchie et al. 2012). Aphelocoma jays also are renowned as ecosystem engineers, as their scatter hoarding of oak and pine seeds helps facilitate long-distance dispersal and recruitment of those keystone plants (Grinnell 1936; Pesendorfer et al. in submission).The pine and oak communities on Santa Rosa Island are currently very restricted, and the island has no animals that function as long-distance dispersers of heavy-seeded species. Restoration of these communities could benefit a variety of other native species, including two trees listed by IUCN as "vulnerable," *Q. tomentella* and *P. torreyana* (IUCN 2012), and the island fox, listed as "endangered" (increased high-stature vegetation could reduce its exposure to predation by golden eagles; Coonan et al. 2010). The caching behavior of jays can be leveraged to accelerate cost-effective restoration, including by providing seeds of desired tree species as a food subsidy—a restoration technique used in other systems (Pesendorfer et al. in submission). Indeed, the presence of island scrub-jays may have contributed to the rapidity of the native vegetation recovery on Santa Cruz Island following the removal of sheep (Pesendorfer 2014).

Concerns about climate change underscore the importance of restoring native vegetation on Santa Rosa Island. Although it is not well understood how climate change will affect the islands, it seems precautionary to prioritize accelerating the return to robust native vegetation communities, as that may in turn enhance the resiliency of the system to climate-related stress. More high-stature vegetation on the island will increase moisture harvest from fog (an important water input in this semi-arid ecosystem) and so drive important restorative feedback processes (Fischer et al. 2009). Native vegetation recovery also would enhance sequestration of carbon, and so help offset greenhouse gas emissions, a goal in western national parks (Jarvis 2009). Establishing jays on Santa Rosa Island may be an example of a translocation that has climate change adaptation benefits for both the focal species and the destination ecosystem (e.g., Lunt et al. 2013).

### Weighing the uncertainties

Managers need to decide the extent to which uncertainty about the past should factor into decisions regarding island scrub-jay management into the future, vis-à-vis whether to formally consider translocation to Santa Rosa Island. Because the uncertainties about the past may not be resolved, it may be helpful to evaluate the risks of making a decision based on an incorrect assumption:

- **Scenario I:** Managers assume that jays went extinct on Santa Rosa Island due to "natural" causes before the ranching era, and so opt not to reintroduce jays to the island, but that assumption is actually incorrect; jays went extinct relatively recently due to human impacts.
- **Scenario II:** Managers assume that jays went extinct on Santa Rosa Island due to re-

cent human impacts (e.g., direct and indirect effects of sheep overgrazing) and so reintroduce jays to the island, but that assumption is incorrect; the jays went extinct due to "natural" causes long ago.

Possible harms of Scenario I include a heightened risk of global extinction of jays, deprivation of an important ecosystem process (seed dispersal) and ecological role (apex predator) on Santa Rosa Island, and slowed pace and or increased costs of ecosystem restoration (because of the presumed reliance on human labor). Possible harms of Scenario II include potential adverse effects on native taxa that otherwise may have had "natural" refuge from the direct and indirect effects of jays on Santa Rosa Island. How managers rank their possible regrets may help them differentiate between more or less desired futures (Polasky et al. 2011).

When weighing management options, tipping the balance may be a desire to reduce the likelihood of unwanted futures (Stephenson and Millar 2012). Managers of the Channel Islands know well how disruptive and expensive a sudden extinction crisis can be: three island fox subspecies within CINP were near extinction in the past decade, requiring intensive management interventions (Coonan et al. 2010). Proactive management of threats may provide considerable return if it can reduce risks, direct costs, and opportunity costs of high-stakes reactive management. Strategies that increase ecological resiliency and reduce extinction risk may help provide managers more flexibility in a future that will likely see increased strain on ever-limited conservation resources. Indeed, managers of the future may well look at today's managers as having an enviable opportunity to efficiently and appreciably enhance resiliency.

### Deciding when to decide

Managers of protected areas today are likely well aware of the threat of disruption and extinction posed by climate change. Many likely also have general hypotheses about how it will impact resources in their charge. Some even may be observing ecological changes consistent with predictions. Less common, however, are examples of managers altering their conservation goals and management prescriptions in the face of climate change, and fewer still are undertaking actions that may be considered non-traditional, such as managed relocation (Bierbaum et al. 2013). Managers of Santa Cruz Island are already implementing non-traditional approaches to manage climate-exacerbated risk (e.g., Figure 4). However, a comprehensive assessment of management objectives and action alternatives regarding island scrub-jay conservation has not yet been undertaken. The value of doing so may be great, not only to clarify the management strategy for the jay but also to document a process for making decisions that managers elsewhere can examine as a possible model.

The management challenge facing CINP and TNC may be a helpful early case study in making decisions that likely will become more prevalent and complicated in protected areas in the future (Johnson and Mow 2011). Issues pertaining to jay conservation brings into sharp focus issues of climate change adaptation that are typically abstract or theoretical. Managers already can estimate a variety of impacts of climate change on a clear management priority (an endemic species that plays keystone ecological roles). Managers also have unusual decision-making prerogative: because they manage the full extent of its current and former range, they can implement a wide array of management alternatives. This is often not the case

**Figure 4.** An island scrub-jay being vaccinated against West Nile virus on Santa Cruz Island. Since 2008, approximately 100 individuals per year have been vaccinated to reduce extinction risk posed by that disease. The efficacy of the vaccine has not yet been tested on island scrub-jays. Photo: Al Seib © 2010 *Los Angeles Times*. Reprinted with permission.

on mainland systems where multiple landowners, land uses, and jurisdictions can constrain or complicate decision-making or implementation.

When, then, should managers decide what to do? Critical for addressing that question is assessing the urgency. The difficulty of characterizing urgency, however, is that unlike the *impact* of certain threats (such as population effects of epidemic disease, or catastrophic fire) the probability of those threats happening is difficult to estimate. West Nile virus, for example, could become established on Santa Cruz Island next year—or never. Nevertheless, climate change impacts are underway (Walther et al. 2002). Perhaps the greatest time sensitivity is the need to improve the resilience of the Santa Rosa Island ecosystem ahead of the climate stress that will worsen in the decades ahead. Practical constraints and opportunities also should be factored into the timing of decisions. If ultimately managers decided to proceed with jay translocation, implementation would not be immediate because of planning, permitting, monitoring, and other requirements, and even if the initial introduction is successful there would be additional lags before the desired outcome (e.g., population viability, restoration of ecological role) would be achieved (McDonald-Madden et al. 2011). In the meantime, CINP may make other decisions that affect its management flexibility in the future. For example, CINP is considering wilderness designation for most of Santa Rosa Island (CINP 2013); that designation could be an important safeguard of many conservation values of the islands, but could also complicate management in the face of climate change (e.g., Vucetich et al. 2012).

Finally, one condition that managers can work with today, but which may not exist in the future, is that the island scrub-jay population is currently robust. This lessens the biological, ethical, and policy stakes of harvesting birds for a translocation.

Managers need to define a path forward that takes into account the possibility that the uncertainty about the historic condition on Santa Rosa Island may never be resolved. In doing so, managers may need to assess the relevance of that baseline in the context of global change (Cole and Yung 2010). One path forward may be a facilitated structured decision analysis, in which conservation objectives and then management alternatives to best meet those objectives are articulated. Through such a process, managers can determine whether they have sufficient information to evaluate and undertake a translocation; if they do not, at least key information gaps would be identified. Some uncertainties, such as whether Santa Rosa Island has sufficient habitat to support a population of jays, are not likely fully resolvable ahead of action. But managers can mitigate risks associated with some uncertainties by proceeding in a manner that is science-based and adaptive.

## Conclusion

Humans have had profound effects on the California islands for millennia (Rick et al. in review). Indeed, humans were present on Santa Rosa Island when jays went extinct on that island, although it is not known what role (if any) they played in the extinction. Similarly, through action or inaction, our influence on the ecology and evolution of the islands will be pronounced into the future. If jays experience an extinction crisis in this era of unprecedented global change, it will likely be due to our direct or indirect effects. Especially in that light, uncertainty about the date and cause of extirpation on Santa Rosa Island cannot be cause for inaction. As the NPS *Climate Change Response Strategy* (2010) cautions, "inaction may be the riskiest decision of all because climate change is a long term problem that carries a huge procrastination penalty."

The NPS *Climate Change Action Plan* (2012) states that "as a national and world leader in protecting our collective natural and cultural heritage, the NPS can and should deliver perspectives and approaches to climate change adaptation, mitigation, and communication that no other organization can" (USNPS 2012). Because island scrub-jay conservation may be an issue where "management creativity and innovation are most needed" (Johnson and Mow 2011), the legislation that established CINP seems especially prescient: it calls for the protection of "nationally significant natural, scenic, wildlife, marine, ecological, archaeological, cultural, and *scientific values* of the Channel Islands" (*emphasis added*). The distinctive focus on science may have presaged an important role for CINP. Given the relative clarity of the climate change threat to jays, the limited set of management options, and the full prerogative managers have to implement most of them, managers can be at the forefront of efforts to develop science-based approaches to address uncertainty, make decisions, and enhance resiliency of protected areas. That imperative of science can well serve managers as they navigate the ecological and policy issues of island scrub-jay conservation—and create a case study of adaptation in decision-making, management, and policy that likely would have resonance well beyond the islands.

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