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Title:

Analogies for a No-Analog World:
Tackling Uncertainties in Species Reintroductions

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ABSTRACT

Species reintroductions involve considerable uncertainty, especially in highly altered landscapes. Developing robust historical, geographic, and taxonomic analogies can help reduce this uncertainty, and integrating these analogies can enable conservationists to better assess the suitability of reintroduction sites. We illustrate this approach using the example of the California grizzly, an iconic species proposed for reintroduction despite significant knowledge gaps.

SPECIES REINTRODUCTIONS & ALTERED ECOSYSTEMS

Species reintroductions are among the most complex and high-stakes of all conservation projects. Given the many challenges these efforts face, it is not surprising that they often fail [1, 2]. To improve their chances of success, conservationists need more and better information. In a rapidly changing world of increasingly altered ecosystems, however, acquiring the information necessary to support sound reintroduction planning is growing more difficult by the day.

Conservationists often rely on analogies [3], logical arguments that compare two or more things or cases, to fill gaps in their knowledge and help them predict how reintroduced species may fare in today's altered ecosystems. We argue that by making their analogies more explicit and interdisciplinary—and by integrating them to paint a more coherent and comprehensive picture—conservationists can better understand the range of conditions under which reintroduced species may thrive, anticipate how they may fare in altered ecosystems, and support more informed decisions. Scientists like to say that we live in a “no-analog world” of increasingly unprecedented ecological conditions [4]. When considering reintroducing species into this no-analog world, useful analogies are more important than ever.

Analogies can aid a range of species reintroduction projects. We use the example of the California brown (grizzly) bear (*Ursus arctos*), which we have studied as members of the California Grizzly Research Network. Apex consumers with low fertility rates, large home ranges, diverse ecological roles, and complex human relations, brown bears represent many of the greatest challenges in species reintroductions. California's grizzly population, estimated to have numbered as many as 10,000 in 1848, went extinct by 1924. The definitive study on the California grizzly appeared in 1955 [5], followed by several decades with little follow-up research. The grizzly remained California's most iconic and enduring symbol, but by the 2010s, only one in four of this state's residents were aware that grizzlies no longer lived there [6]. In 2014, the Center for Biological Diversity proposed reintroducing grizzlies to California, launching a new era of public discussion and scholarly research on this state's missing mascot.

WHY ANALOGIES?

In conservation science, suitability refers to the quantity and quality of a species' potential biophysical habitat in a reintroduction site [7], as well as key contextual factors such as cultures, laws, and institutions [8]. Conservationists use several methods—including fieldwork, modeling, and soliciting expert opinion—to assess site suitability [9] and reduce uncertainties [10, 11] in reintroduction planning. In cases where reintroducing a species would involve placing it in an altered ecosystem, however, these established methods may leave many questions unanswered.

Analogies can help reduce this uncertainty. The best analogies are those that are most useful—that raise new questions, offer insights difficult to obtain using other methods, or suggest novel or counterintuitive solutions for real-world conservation problems. Building more useful analogies means making them more *explicit* by clearly identifying them, and describing the similarities and differences among comparable cases. It means making them more *interdisciplinary* by assembling diverse teams of scholars and practitioners, drawing from varied sources of information, and using multiple methods to collect and analyze data. And it means *integrating* them by cross-checking results to gauge their validity and find emergent patterns, a procedure known in the social sciences as triangulation [12].

THREE ESSENTIAL ANALOGIES

Historical analogies compare past conditions with current conditions in a reintroduction site to assess the site's suitability as habitat. They often start with baselines: descriptions of the past that enable conservationists to measure change over time. Baselines are problematic because they tend to represent snapshots in longer histories of change, and because historical records are often vague, biased, or incomplete [13]. Most restoration projects no longer attempt simply to recreate historical baseline conditions, but documents, artifacts, fossils, and other such records still contain a wealth of information that can inform reintroduction efforts.

The case of the California grizzly (Figure 1) shows how integrating diverse evidence produces more useful historical analogies. Prior to European contact, grizzlies ranged throughout non-desert California, but likely favored the region's rich coastlines, valleys, and foothills. Grizzlies ate diverse foods, including some of marine origin, but after 1800 they started to consume more terrestrial protein, a portion of which may have come from livestock [5]. This brought grizzlies into conflict with farmers, ranchers, and other settlers who poisoned, trapped, and shot them to extinction [5]. These insights suggest that although grizzlies lost much of their best habitat, persecution, rather than habitat loss, eliminated them from California. Large areas of suitable habitat probably remain in this state's vast protected areas.

Geographic analogies compare current conditions in a reintroduction site with conditions in other areas of a species' range where it still exists. Geographic analogies are useful because they may reveal that a species can persist across a

wider variety of conditions than those it historically encountered in the reintroduction site. They may also suggest how reintroducing a species could affect other species and ecosystem processes. Building useful geographic analogies requires diverse methods, including biogeographic research comparing ecological conditions across a species' range, public opinion surveys identifying patterns of ecological knowledge or sentiment, and ethnographic fieldwork exploring how attitudes, values, beliefs, and behaviors shape human relations with other species.

Geographic analogies suggest that although much potential grizzly habitat probably exists in California, the success of a reintroduction effort would depend on human management and tolerance. Though absent from California, brown bears remain widespread in temperate regions across the Northern Hemisphere. Montana and Slovenia are each home to brown bears living in habitats that, in various ways, resemble California's modern alpine, woodland, and grassland ecosystems. Yet the people living in these regions manage their bears differently. In Montana, conservationists are working to avoid conflicts with people by ensuring that brown bears cannot access human foods. In Slovenia, supplemental foods may constitute more than one-third of an average brown bear's diet [14]. These alternative approaches result from differing histories, cultures, laws, and institutions. Studying these and other regions reveals a spectrum of ecological conditions, social arrangements, and management techniques that could support brown bears in modern, human-dominated landscapes.

Taxonomic analogies compare the species being proposed for reintroduction with other species that currently live in the reintroduction site and have similar traits. Although most species differ, at least somewhat, in their social or ecological roles, comparing species with similar behaviors, habitat preferences, or human relations can generate useful insights about a reintroduction site's opportunities and challenges. Using the same methods as those employed in geographic analogies, conservationists can examine similar species to map biophysical habitat, gauge support for reintroduction among local communities, plan essential management actions, and avoid conflicts.

The case of the American black bear (*Ursus americanus*) shows that human coexistence with grizzlies in California would require sustained commitment to managing human behavior. California's black bear population grew from an estimated 10,000 in 1980 to as many as 40,000 by 2020. Black bears tend to be smaller, more herbivorous, and less aggressive than grizzlies, but these qualities can change when black bears gain access to human foods [15]. Since the 1990s, agencies and communities in California have worked to prevent black bears from acquiring human foods by investing in education, infrastructure, and law enforcement. In Yosemite National Park, for example, these efforts have dramatically reduced both black bears' consumption of human foods and the number of black bear-related conflict incidents [15]. Similar efforts to manage human behavior and reduce conflict would undoubtedly be required to support a population of reintroduced grizzlies.

REDUCING UNCERTAINTY AND INCREASING CONFIDENCE

Developing robust analogies is only the first step. The next is combining them. Comparing historical with geographic analogs increases knowledge about the species; comparing historical with taxonomic analogs deepens knowledge about the reintroduction site; and comparing geographic with taxonomic analogs improves knowledge about the present-day forces that could shape a reintroduction effort. This cross-validated species-specific, site-specific, and time-specific information can be used to test provisional conclusions, identify common themes, and search for emergent patterns. Triangulating in this way enables researchers to build conceptual models to develop more reliable habitat suitability maps, population viability models, conflict mitigation strategies, environmental impact statements, and species recovery plans.

Reintroducing grizzlies to California--a state with 40 million residents whose ecosystems have been dramatically altered over the past 250 years--may, at first, seem impossible. Our ongoing research suggests that, like most other species reintroductions, it is a complex and high-stakes decision that can only be made wisely with the best possible information.

Analogies can help. Historical analogies indicate that California probably still has much potential grizzly habitat; geographic analogies show that brown bears can coexist with humans in varied ecological and social contexts; and taxonomic analogies suggest that living with grizzlies would require tactics similar to those already widely used to manage the state's booming black bear population. The past is not the present, there is not here, and black bears are definitely not grizzlies. Together, however, the insights gained from these analogies suggest that reintroductions that seem untenable may be more possible than we think.

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FIGURE LEGENDS

Figure 1. Three Analogies: The Case of the California Grizzly

Historical analogies compare past conditions with current conditions in a reintroduction site to assess the site's suitability. In the case of the California grizzly, "past conditions" (a) refer to the social and ecological conditions prior to 1925 when grizzlies are presumed to have gone extinct in this state. *Geographic analogies* compare current conditions in a reintroduction site with conditions in other areas of a species' range where it still exists. Brown bears currently live in North America, Europe, and Asia; the above image (b) was taken in Alaska, which is home to around 30,000 brown bears. *Taxonomic analogies* compare the species being proposed for reintroduction with other species that currently live in the reintroduction site and have similar traits. California now contains as many as 40,000 American black bears (c) distributed throughout diverse habitats.

Credits: (a) "Grizzly bear fishing" (circa 1890), Courtesy of the Bancroft Library, University of California. (b) Grizzly bear in Denali, Alaska," by Gregory Smith, Creative Commons. (c) American black bear in Mammoth Lakes, CA, courtesy of Peter S. Alagona. (d) Yosemite Valley from Wawona Tunnel, Mark J. Miller, Creative Commons.

Figure 2. Integrating and Triangulating the Analogies

Historical, geographic, and taxonomic analogies provide conservationists with a wider range of information than would otherwise be available to use in assessing the suitability of altered ecosystems for species reintroductions. Combining this information increases site-specific, species-specific, and time-specific knowledge, and can help define the range of conditions that could support a reintroduced population. Conservationists can then cross-check this information, through a process known in the social sciences as triangulation, to identify, validate, and increase their confidence in the information that is most likely to be relevant for a given reintroduction.

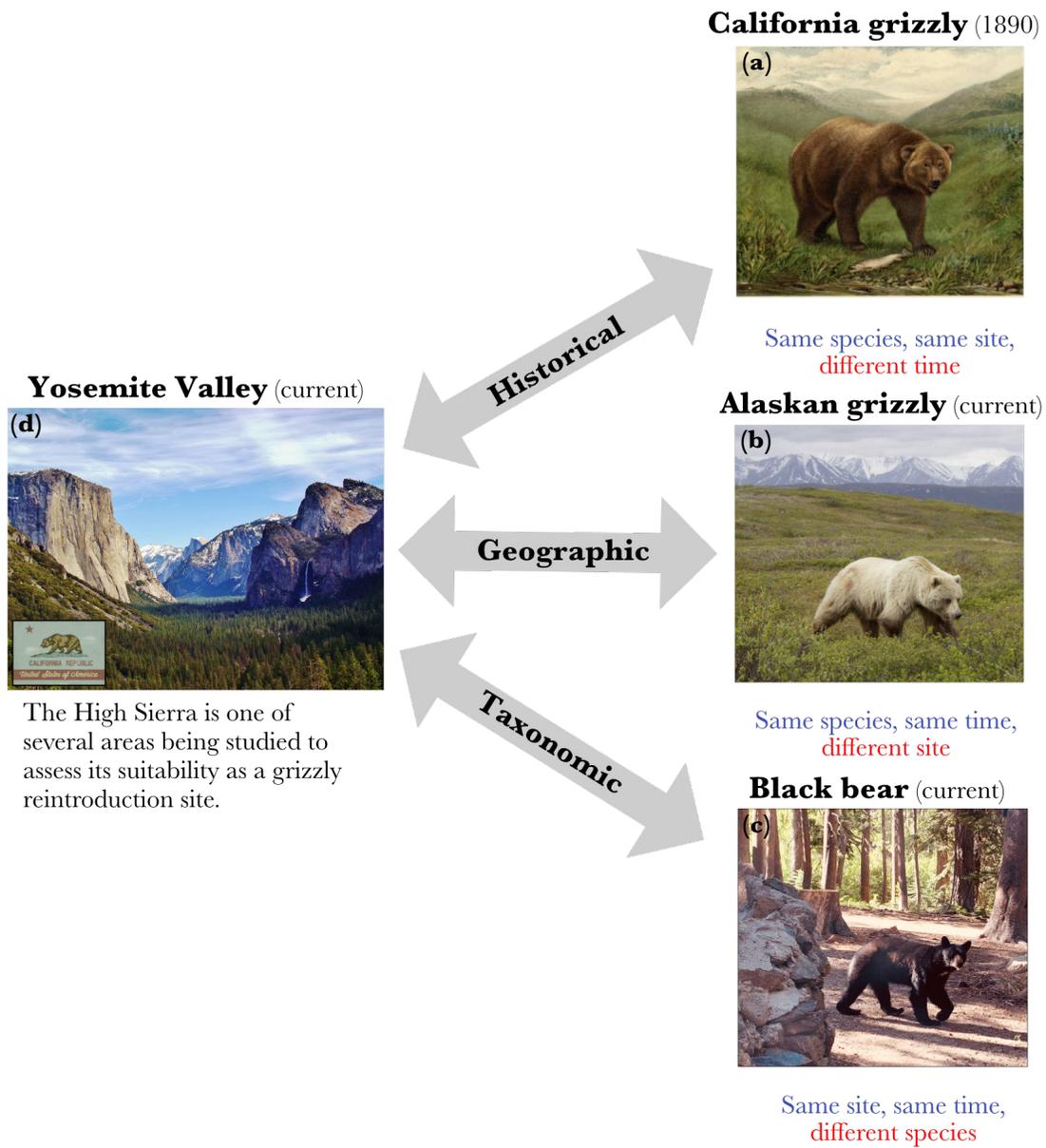


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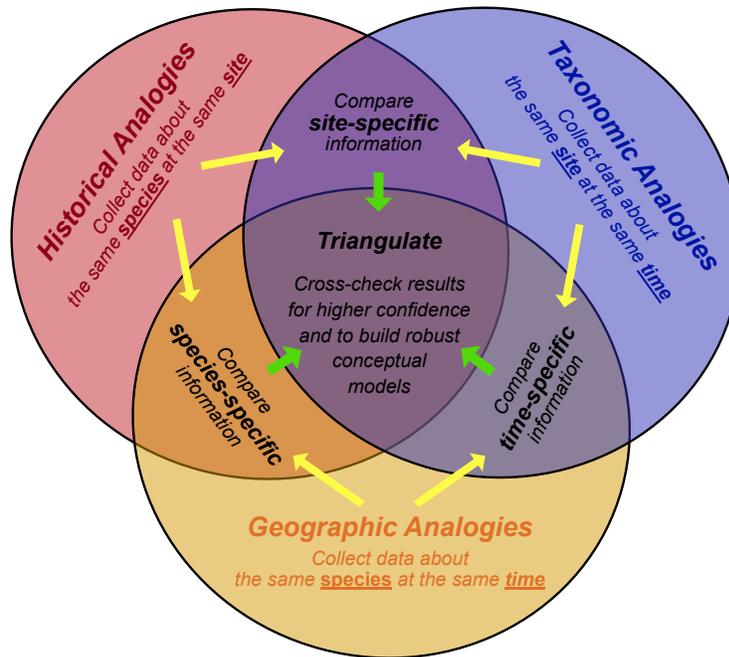


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