Recovering the jaguar *Panthera onca* in peripheral range: a challenge to conservation policy

Tony Povilitis

Abstract The recovery goal for the jaguar *Panthera onca* in the USA should be to restore significant presence with some reproduction, consistent with historical records. Nevertheless, the prevailing conservation strategy for the jaguar does not include restoration in peripheral range and merely seeks long-term survival of the jaguar within its existing northern range, which is almost entirely in Mexico. Broader issues are whether recovery programmes should include peripheral populations, range expansion and species representation across ecoregions. Considering jaguar history, habitat, population requirements, wildlife management and other factors in the southwestern USA, efforts to re-establish the species would have a reasonable chance of success. Recovery of the jaguar in the USA would improve prospects for the adaptation and survival of the species within its northern range, given habitat loss, conflicts with humans and climate change.

Keywords Conservation policy, jaguar, *Panthera onca*, peripheral range, species recovery

Introduction

In 2010 the U.S. Fish and Wildlife Service (USFWS) decided to prepare a recovery plan for the jaguar *Panthera onca*, which historically occurred in the southern USA (Fig. 1), at the northern edge of its global range. The jaguar is endangered in the USA and categorized as Near Threatened on the IUCN Red List (Caso et al., 2008; USFWS, 2012a). However, the agency has subsequently focused not on jaguar recovery in the USA but rather on sustaining the species within its broader northern range, which is almost entirely in Mexico (USFWS, 2012a). The USFWS regards species conservation fundamentally as the avoidance of global extinction and defines a 'significant portion of a species range' for conservation as one without which the entire species would be at risk of extinction (Carroll et al., 2010; USFWS & NOAA, 2011). In its view, only a large portion of the jaguar's northern range meets that requirement.

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Received 18 May 2013. Revision requested 23 July 2013.
Accepted 9 September 2013. First published online 14 February 2014.

I advocate for a recovery plan to restore the jaguar to its former range in the south-west USA (Arizona and New Mexico) as part of an expanded binational effort to conserve the northernmost jaguar population, now restricted mainly to neighbouring Sonora, Mexico. Vertebrate population segments merit conservation when they occur in a unique ecological setting for the species or are separated from other populations by physical, ecological or other factors, including differences between countries in terms of wildlife law enforcement, habitat management and regulatory mechanisms (USFWS & NMFS, 1996). As I propose here, a recovery plan for the Southwest would draw on knowledge of historical presence of jaguars, conservation requirements in adjacent Mexico, regional habitat features and corridors, and programmes elsewhere to re-establish large carnivores and promote their coexistence with people.

Historical occurrence in the Southwest

Historical accounts of jaguars in Arizona and New Mexico for 1900–1998 include 71 adult animals reported dead (or in two cases photographed), including 16 males, 9 females and 46 of uncertain sex. Brown & López-González (2001) listed 61 of these records and Grigione et al. (2007) tallied seven mortalities in Arizona that appear distinct, including a female with young cited by Hoffmeister (1986). Robinson (2006) found records of two additional kills in New Mexico. Fisher & Bell (1927) referenced two female jaguars among at least five jaguars killed in Arizona in the mid 1920s, at least one of which appears different from jaguars reported by later authors. Around or just prior to 1900 more than four jaguars were reported killed in Arizona, including a female with young in the Grand Canyon (Lange, 1960).

Of eight adult female jaguars accounted for by Brown & López-González (2001) and Hoffmeister (1986), four occurred in southern and three in northern Arizona. Three of the females had cubs, with two of these groups occurring in northern Arizona. Applying the percentage of females among jaguars of known sex (36%, 25 records) to the number of animals of unknown sex (46 records), 17 additional females were probably among reported kills during the past century.

Apart from accounts with physical evidence, Lange (1960) and Grigione et al. (2007) tallied 15 sightings of jaguar in Arizona for 1900–1998, including reports of a female and two cubs in the Grand Canyon (Hoffmeister, 1986) that may

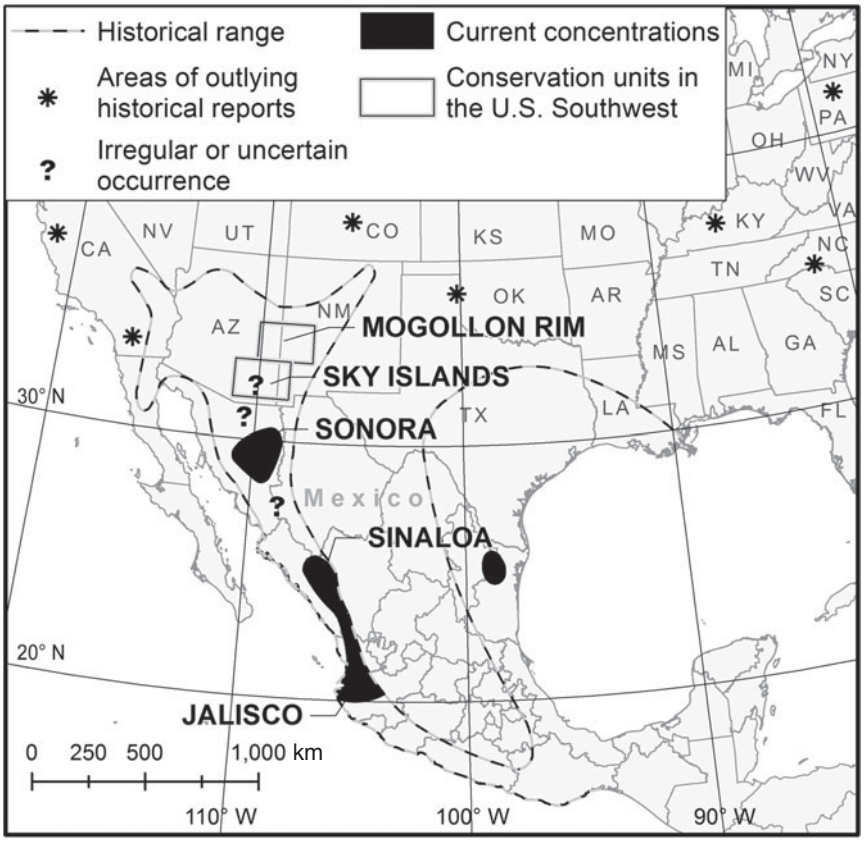

FIG. 1 Historical and current distribution of the northern jaguar *Panthera onca* (based on Rafinesque, 1832; Matthiesen, 1959; Daggett & Henning, 1974; Hall, 1981; Navarro-Serment et al., 2005; Robinson, 2006; Zeller, 2007; Grigione et al., 2009; Judd, 2009; Mahler, 2009).

have been subsequently killed. For New Mexico, Robinson (2006) included eight additional observational records for that time period. Native Americans reported jaguars in these states and neighbouring California (Daggett & Henning, 1974; Mahler, 2009). Hall (1981) delineated the jaguar's historical range to include portions of Arizona and New Mexico, as well as California, Texas and Louisiana (Fig. 1).

Since the late 1990s 5–6 individual jaguars have been recorded in the Southwest (USFWS, 2012a), one by remote cameras over a 12-year period (McCain & Childs, 2008). These jaguars appeared to originate in the neighbouring state of Sonora, Mexico, where a concentration of jaguars occurs c. 220 km south of the USA (López-González, 2004).

The distributional pattern and decline of jaguar records in the Southwest provides strong evidence for a historical population of the jaguar. Kill records for 1900–1980, when plotted at 10-year intervals, showed a decrease characteristic of an overexploited resident population (Brown, 1983). Hunting, trapping and poisoning (Brown & López-González, 2001) were primary factors in the extirpation of the jaguar from most of the Southwest, beginning with bounties on the animal imposed by Spanish authorities (Matthiessen, 1959).

The northern jaguar population

Estimates of jaguar numbers in Sonora, Mexico, are 50–271 (USFWS, 2012a). Jaguars there face heavy human-induced mortality (Rosas-Rosas, 2006), and the effect of hunting on prey is also of concern (Brown & López-González, 2001). Zeller (2007) estimated that only 4% of jaguar habitat in Sonora receives some protection. With poaching common throughout Mexico, jaguar numbers will decline further (Carrillo et al., 2007).

Population viability prospects for northern jaguars could improve with range expansion into the Southwest, and with sustained connectivity to a jaguar population in southern Sinaloa south to Jalisco, where the number of jaguars has been estimated to be 479–>500 (USFWS, 2012a). As male jaguars are capable of long-distance dispersal, connectivity along the 400 km corridor between concentrations in Sonora and southern Sinaloa (Navarro-Serment et al., 2005) is plausible. However, any existing connectivity may be lost if the Sinaloa–Jalisco population, believed to be in decline (Zeller, 2007), is significantly reduced.

Estimated population sizes required for viability are generally much greater than the combined estimate of 530–800 jaguars for Sonora and Sinaloa–Jalisco. Reviews of population viability studies have found that thousands

of individuals are generally needed for populations to withstand environmental fluctuation and catastrophic events, and to ensure continuation of evolutionary processes (Traill et al., 2010; Flather et al., 2011). Thus, the long-term prospect is not good for <1,000 animals, especially with uncertain population stability and connectivity. For northern jaguars renewed presence in Arizona and New Mexico could improve overall population size and habitat options, genetic integrity, and the outlook for survival of the species given human-induced environmental changes range-wide (Boydston & López-González, 2005).

Habitat in the Southwest

Jaguars in Arizona, New Mexico and Sonora historically occurred within six ecological regions not found elsewhere, with three of these unique to the USA (Hall, 1981; North American Atlas, 2006). A coarse-scale classification of geographical regions for the jaguar places the Southwest and Sonora in Mexican xeric and temperate pine-oak forest categories, with Mexican tropical dry forest prevailing further south (Sanderson et al., 2002).

At the community level the jaguar's historical range in Arizona and New Mexico encompassed 12 major biotic communities (Brown & Lowe, 1994), half of which occur only in the USA. Records of adult jaguars killed or photographed suggest a very distinct habitat configuration for the species in the Southwest, even compared with neighbouring Sonora. Jaguars were associated with Madrean evergreen woodland (31%), Rocky Mountain montane conifer forest (17%), semi-desert grassland (13%), Great Basin conifer woodland (9%), riparian habitat (8%) and other or uncertain biotic communities (22%; Brown & López-González, 2001). In contrast, specimens from Sonora were reported mostly in Sinaloan thornscrub (63%) and deciduous forest (10%), with fewer in Madrean evergreen woodland (5%), Sonoran desert scrub (5%) and other or uncertain communities (17%). Female jaguars killed in Arizona were associated in four instances with Rocky Mountain montane conifer forest and in single instances with subalpine conifer forest, semidesert grassland and Madrean evergreen woodland (Brown & López-González, 2001). Jaguars in the Southwest have occurred in varied topography including lowland flats, valley basins, canyons, mountains and subalpine environments (Brown & López- González, 2001; Boydston & López-González, 2005; McCain & Childs, 2008).

Large portions of Arizona and New Mexico have been identified as potential jaguar habitat, based on historical occurrences, vegetation cover, topography, prey availability, proximity to surface water and other factors (Menke & Hayes, 2003; Boydston & López-González, 2005). Hatten et al. (2005) identified 21–30% of Arizona (62,000–88,600 km^2) and Robinson (2006) indicated approximately half of New Mexico (c. 156,800 km^2) as potential habitat, much of it federally-managed and protected natural resource lands.

Grigione et al. (2009) specifically identified the Sky Island and Mogollon Rim areas of the Southwest as jaguar conservation units (Fig. 1), within a broader region of jaguar habitat (102,530 km^2) with comparable portions in the USA and northern Mexico. Federally-managed national forest lands in the Sky Island (7,200 km^2) and Mogollon Rim (17,745 km^2) areas could potentially support 249 jaguars, applying a density estimate of 1 jaguar per 100 km^2 for Sonora, Mexico (Carrillo et al., 2007).

Potential movement corridors for the jaguar in Arizona have been identified (AWLW, 2006; Corridor Designs, 2012) and require protection, given threats to habitat connectivity, including land development and US–Mexico border fencing (USFWS, 2012b). Multi-state planning for landscape-level connectivity for wildlife is underway (WGA, 2012; WRP, 2013).

Jaguars hunt large and medium-sized animals, including common species of the Southwest (USFWS, 2012b). Large prey dominate the diet of jaguars in Sonora, including deer (*Odocoileus* spp.) and peccary *Pecari tajacu* (Rosas-Rosas, 2006). In the Southwest ungulate populations are monitored and managed by state game authorities and are considered healthy. Post-hunt population estimates of adult white-tailed deer *Odocoileus virginianus*, mule deer *Odocoileus hemionus* and elk *Alces americanus* for 2009 in Arizona (exclusive of national parks and tribal lands) were 70–75,000, 75–80,000 and 30–35,000, respectively, and c. 5,000 peccaries were legally taken (AGFD, 2011). Identification of areas with prey concentrations, along with connecting habitat linkages, would guide habitat management for a newly established jaguar population.

The presence of elk in much of the jaguar's historical range in Arizona and New Mexico adds a potentially important large prey item that is absent in the south (Carrera & Ballard, 2003). Jaguars would almost certainly kill elk, given that they often select larger prey than pumas (Laundré & Hernández, 2010), which commonly take elk in the Southwest (Mattson et al., 2007).

Surface water is widely available for jaguar in the Southwest, most notably in mountainous terrain (Hatten et al., 2005). Widespread creation of artificial water sources, such as livestock ponds and troughs, may offset losses of some perennial sources as a result of excessive withdrawal of groundwater and livestock overgrazing.

The risk of jaguar poaching in the USA appears minimal, especially since the species received federal protection in 1997 (USFWS, 2012a). Jaguar poaching has not been reported since 1986 and Arizona and New Mexico have active anti-poaching programmes that include law enforcement and rewards to citizens for information on poachers. Nevertheless, to increase public interest and

acceptance of jaguar conservation in the Southwest, outreach and education programmes have been proposed and could be implemented (AGFD & NMDGF, 2007). Programmes to promote coexistence between people and large carnivores are ongoing elsewhere in the USA (Clark et al., 2005) and would help inform efforts to reduce livestock-related and other conflicts related to jaguar presence.

Habitat in arid areas such as the Southwest would be expected to naturally support lower jaguar densities than moist tropical areas. However, peripheral or marginal jaguar habitat (Rabinowitz, 1999) does not equate with poor habitat unable to sustain healthy, reproducing individuals. Southwestern jaguars tend to be as large as or larger than those in Mexico (Brown & López-González, 2001) and a jaguar captured in Arizona in 2009, estimated to be 15–16 years old, was reportedly the oldest recorded anywhere in the wild (AGFD, 2009).

The range of the jaguar in the Southwest and Mexico may dry significantly this century (Seager et al., 2007), with corresponding changes in species distributions, biotic communities and wildfire regimes (Gray, 2008). At the same time, tropical and subtropical ecoregions in South America may be particularly vulnerable to climate change and may soon face extreme conditions relative to past climate variability (Beaumont et al., 2011).

With climate change, human manipulation of present-day species ranges may be needed (Hadly & Barnosky, 2009), including, in the case of the jaguar, expansion to higher latitudes. The availability in the Southwest of upper-elevation habitats with relatively cool, moist climates could provide vital habitat for the species, especially in the event of severe or abrupt climate change.

Reintroduction option

The last female jaguar recorded in the USA was killed in 1963, over 200 km north of the USA–Mexico border (Brown & López-González, 2001). Since then, five males have been killed and four other individuals believed to be males have been photographed (Brown & López-González, 2001; USFWS, 2012a). The pattern suggests that males, but not females, disperse into the USA from Sonora. Future presence of females in the Southwest may depend on established home ranges closer to the USA border. This is problematic given the relatively open, unprotected lands between jaguar concentrations in Sonora and the USA (Grigione et al., 2009), poaching in northern Sonora, and the significant presence of border security fencing, which is impermeable to large mammals (Abhat, 2011; USFWS, 2012a,b).

Barring natural movement of female jaguars from Sonora to the Southwest, their reintroduction should be considered. The USFWS has yet to formally evaluate this option and has no plans to reintroduce jaguar (USFWS, 2012c). Examining the feasibility of reintroducing the jaguar, Kelly & Silver (2009) concluded that behavioural and ecological flexibility makes it amenable to reintroduction, and that genetic constraints are minimal given that the jaguar is outbred, with no strong geographical structure (Eizirik et al., 2001). For the Southwest, animals for translocation could originate from nearby Mexico and Guatemala, where jaguars represent an incompletely isolated phylgeographic group. Surplus jaguars are often captured and placed in wildlife rehabilitation centres and zoos (Kelly & Silver, 2009). Jaguars likely to disperse from protected areas or subject to high risk of human-caused mortality along reserve boundaries or in habitat fragments may also be available for translocation without compromising core populations.

Translocation of female jaguars into the Southwest would be a complex and challenging undertaking but one that could draw on prior experience of establishing wild felids in the USA (Onorato et al., 2010; CDOW, 2013) and elsewhere (Hayward & Somers, 2009).

Conservation policy

Should a nation embark on wildlife restoration in areas peripheral to core populations occurring beyond its borders? Biologists generally promote conservation of peripheral populations (Lesica & Allendorf, 1995; Nielsen et al., 2001; Vucetich & Waite, 2003; Gibson et al., 2009). Such populations may survive as well as or better than those in core range, depending upon the geography of human impacts (Abbitt et al., 2000; Channell & Lomolino, 2000) and the strength of local recovery efforts. Considerations addressed here include habitat features, ecological distinctiveness of peripheral range, ability to control threats (such as poaching and habitat fragmentation), and significance of restoration to the nearest core population.

The reluctance to undertake a recovery programme for the jaguar in the USA suggests overemphasis on its nearly extirpated status, general scepticism about habitat suitability (Rabinowitz, 1999), political aversion to large carnivore restoration (Povilitis & Becker, 2010), and the absence of peripheral range recovery in global strategies for jaguar conservation (Sanderson, et al., 2002; Rabinowitz & Zeller, 2010). Although a temporary focus solely on existing populations may be justified for species in immediate crisis, such as the tiger *Panthera tigris* (Walston et al., 2010), conservation strategies limited to core areas to the exclusion of unoccupied range should be reconsidered. The concept of recovery mandates healthy, self-sustaining wildlife populations across historical ranges and ecological settings (Redford et al., 2011).

Acknowledgements

This work was sponsored by Life Net Nature (USA), and benefited from discussions with C.D. Becker and M. Robinson. I thank the ManTech GIS Team, USA (G. Lovasz, N. Mustain, N. Look and R. Hoopes) for preparing Fig. 1.

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Biographical sketch

Tony Povilitis founded Life Net Nature, a non-profit organization devoted to community-based conservation, citizen science, and improved public policy toward wildlife. He pioneered studies of the Endangered huemul deer, leading to protected areas in Chile, was involved in the creation of a coral reef recovery team for Maui, Hawaii, and has developed international and U.S. field programmes for university students in conservation biology, natural resource management and wilderness education.