

When Will Female Jaguars Cross the Border? Socio-Demographics of the Northern Jaguar

Peter Warshall

Northern Jaguar Project, Tucson, Arizona

Abstract—Conservation biologists, NGOs, and the USFWS have established a goal of returning a viable population of jaguars into the United States. The source population for this recovery will come from Sonora, Mexico, the closest sub-population of the species. To maintain a viable population there must be females and an active corridor that allows passage of jaguars between Sonora, Arizona, and New Mexico. While considerable attention has been paid to the corridor, little attention has been paid to the potential rate of expansion of the existing population and the importance of female jaguars to dispersal. This paper's purpose is to highlight what is known of the socio-demographics of northern jaguars, the differing role that females play in dispersal, the possible return-times for females to the U.S. Sky Islands, as well as conservation priorities.

Introduction

To the best of our knowledge, jaguars (*Panthera onca*), in the 1800s, lived year-round in some areas of Arizona and New Mexico. About 60 sightings have been more or less confirmed in Arizona and New Mexico in the twentieth century (Brown and Lopez-Gonzalez 2001). Most recently (between 1996 and 2012), five male jaguars have been photographed in the Animas, Peloncillos, Whetstones, Atascosas and Baboquivari Sky Islands of the United States. Dispersal male jaguars have been known to range widely; by analogy with other large cats, hundreds of miles per year (Brown and Lopez-Gonzalez 2001; Hoogesteijn and Mondolfi 1992).

No female jaguars have been recorded in the United States since 1963. The last female with a cub was shot in 1910 in Cheylon Canyon, Arizona. The nearest female jaguar to the U.S. border was shot south of Moctezuma, Sonora in 1998. A female with cub has been recorded by camera-traps on the Northern Jaguar Reserve (about 125 miles from the border) in 2011. As opposed to adult males, adult female jaguars are not known to range widely (Brown and Lopez-Gonzalez 2001; Hoogesteijn and Mondolfi 1992).

Jaguar males have large home ranges that may contain smaller female home ranges (Hoogesteijn 1992; fig. 1). In addition, there appear to be nomadic males that are dispersing and wandering and may not have any settled home range. The dispersal of female jaguars can be visualized as the creation of home ranges within the boundaries of one or two male home ranges (fig. 1).

A 1,100 square mile area in Sonora (Lopez-Gonzalez and others 2000, Lopez-Gonzalez and Brown 2002) has been delineated as the area with the highest jaguar numbers and the most likely source area for U.S. jaguars. The population of jaguars in this and adjacent areas has been estimated at 80 to 120. Two general "corridors" that may be

used by Sonoran jaguars to return to the U.S. Sky Island mountains have been suggested (fig. 2; Valera-Aguilar and others, abstract, this volume). However, the rates of population expansion and dispersal through these corridors are unknown. This paper presents the social and demographic factors that may contribute to population expansion and dispersal, including very simple math-based scenarios to provide various timeframes for return of adult female jaguars to the United States. The results of these scenarios pose two conservation biology questions: Would it be better to re-introduce female(s) to the potential jaguar habitat in the United States (pro-active restoration) or wait for dispersing females to reach the United States (passive restoration)? What does knowing probable timeframes contribute to the decisions necessary for return of a U.S. reproductive population?

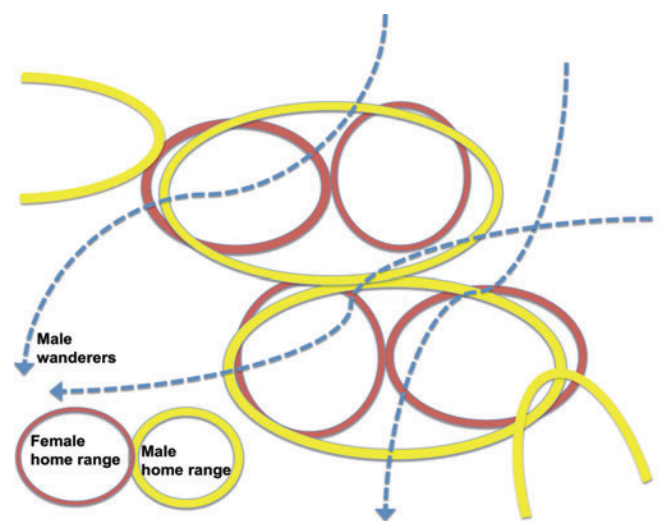


Figure 1— Home ranges of jaguars (based on Hoogesteijn and Mondolfi 1992). The yellow circles are male home ranges; the red circles are female home ranges; and the dotted blue lines are male wanderers without home ranges.

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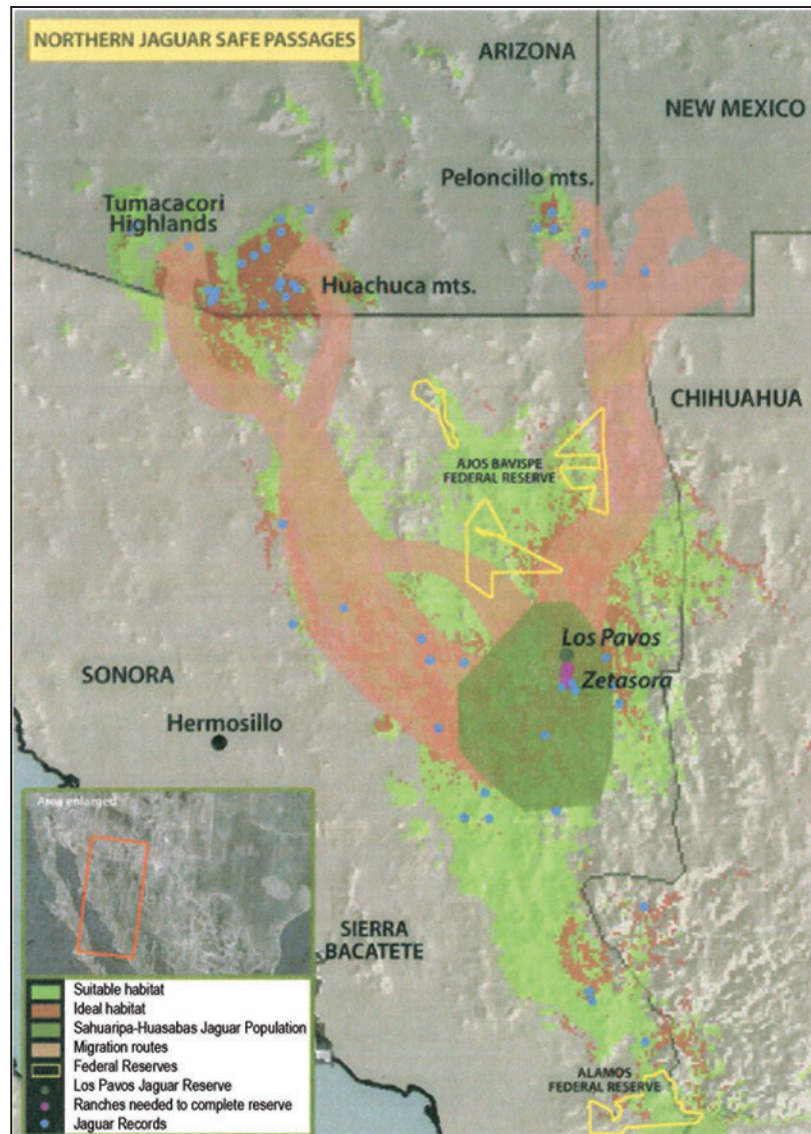


Figure 2—Locations of Northern Jaguar Reserve, core area of northern jaguar population (green polygon) and probable dispersal corridors to the Sky Islands in the United States. Blue dots are recent jaguar sightings.

Methods

To estimate the probable minimum times for return of female jaguars, I first assembled what is known and not known of their life history phenomena in their northern range or, if unavailable, for southern jaguars in the most open or arid habitats (table 1). Southern jaguars, especially those living in tropical humid forests (as opposed to thornscrub, pinyon-juniper woodland, riparian and montane biotic communities), have differing life-history phenomena (Hoogesteijn and Mondolfi 1992). Life-history phenomena include (1) sex ratio at birth, (2) the number of cubs (litter size), (3) age of first reproduction, (4) average lifespan, (5) number of years between litters, and (6) pre-reproductive mortality of cubs.

In addition, I assembled what is known about home range size and dispersal (age at dispersal, overlap with mother's home range, residency

time in home range and direction of dispersal; table 2). For each data point (tables 1 and 2), the degree of reliability is noted. These two sets of admittedly incomplete data were combined into a simple iterative model to estimate the miles per generation that a female might move north (table 3). "Optimistic" and "conservative" scenarios were used to frame the probable number of miles per generation. The numbers of years for return was calculated from the closest female sightings to the border to the nearest U.S. Sky Island in which males have been seen.

The scenarios include many assumptions that require further refinement: (1) more accurate life-history phenomena and dispersal data; (2) the verification of the postulated corridors and pathways; (3) further understandings of directional choice and female home range use; and (4) the use of a circle to define home range shape.

Table 1— Life-history phenomena of female jaguars (data from Brown and Lopez-Gonzalez 2001, Hoogesteijn 1992).

Life-history phenomena	Data	Reliability and notes
Sex ratio of litter	Unknown	
Number in litter	Average: 2 Range: 1-4	One NJR litter of one. Extrapolated from other populations.
Pre-reproductive mortality	Unknown	Expert opinion estimates 3–6 cubs reach adulthood per generation.
Age at first reproduction	2.5–3 years	Extrapolated from southern jaguar.
Time between litters	3 years	Well documented
Lifespan (years)	Average: unknown From fieldwork: 10–13 From zoos: 20-25	No northern jaguar data. Reproductive lifespan maybe 7–10 years in field.
Number of cubs per lifespan (cpl)	Litter of one cub every 3 years = 3–4 cpl Litter of two cubs every 3 years = 6–9 cpl	If sex ratio is 1:1, the number of female cpl ranges from 2–5.

Table 2— Dispersal phenomena of female northern jaguars (data from Brown 2001; Hoogesteijn 1992; Gutierrez-Gonzalez and others, this volume).

Dispersal phenomena	Data	Reliability and notes
Home range size	Venezuela: 10-15 sq mi Jalisco, MX: 10-25 sq mi NJR: 25-37 sq mi	NJR has limited data.
Age at dispersal	1–1.5 years	Well documented.
Overlap with mother's home range	Range: Adjacent to 85% Venezuela: 17–40%	No NJR or northern jaguar data.
Residency time in home range	South America: 6 years plus?	NJR: very limited data.

Table 3— Scenarios for return of female jaguars to the United States.^a

Scenario	A. Size of new home range needed by daughter	B. Daughter's movement outward from mother's home range ^b	C. Years to disperse 100 miles and 125 miles when daughters move outward every three years ^c
Daughter does not share mother's home range but settles adjacent to it	25 sq mi	5.6 miles	54 to 67 years
	37 sq mi	6.8	44 to 55
Daughter shares 40% of mother's home range	15 sq mi	4.4 miles	68 to 85 years
	22 sq mi	5.2	58 to 72
Daughter shares 85% of mother's home range	2 sq mi	1.6 miles	188 to 243 years
	6 sq mi	2.8	107 to 134

^aAll calculations available on Excel by request from information@northernjaguarproject.org.^bDistance outward = diameter of added home range = 2 X square root of area in column A/π.^cReturn times = 100 or 125 miles X 3 years/miles in column B.

Results

To the best of my knowledge, table 1 summarizes life-history knowledge and table 2 presents information on dispersal of female jaguars. Since nothing is known of sex ratios at birth, pre-reproductive mortality, or how females chose which direction to extend their home ranges, these numbers are subject to significant revision. A young female could theoretically create her home range in any direction. As few as 25% of all daughters might extend the female population's range in a northward direction.

Other numbers may also be significantly altered as more is known of the impact of the northern jaguar's arid landscape on home range size and shape and litter size. Jaguar home ranges change widely with season, the location and number of roads, prey size, and the first months of raising cubs (Hoogesteijn and Mondolfi 1992). The quantitative impacts of prey density, human settlements and riparian habitat on northern jaguar home range shape and size have just begun to be investigated. Two "wildcards" exist: a female could be discovered much closer to the border or a female might (although never reported) wander with a male a much greater distance.

Scenarios

For the purposes of these scenarios, it is important to emphasize that young females do not appear to move great distances from their natal home range. There is some evidence that a female cub may be given perhaps 17 to 40% of their mother's home range and, should the mother die, may take over 75-85% of her home range (Hoogesteijn and Mondolfi 1992). It is not known how mother jaguars divide up their home ranges when they have two female cubs at the same time or in sequential litters.

A northern jaguar female's home range size will be considered 25 square miles (a diameter of approximately 5.6 miles) to 37 square miles (a diameter of approximately 6.8 miles). This is about half the known home range size of a male on the NJR (Gomez-Gutierrez and others, abstract, this volume) and about the size reported for several more open landscapes in South America (table 2). The scenarios assume that each mother has a new daughter every 3 years, which is the spacing between a mother's pregnancy and the first litter by the daughter.

Three scenarios (table 3) for the smallest and largest home ranges were used to frame the number of years for female jaguars to return to the U.S. Sky Islands. The first assumed that the daughter's home range did not overlap with her mother's but was adjacent to it. The second assumed a 40% overlap. The third assumed an 85% overlap (the mother dies). All scenarios make the optimistic assumptions that home ranges moved north and every litter included at least one female cub. They all assume the home range's shape is a circle.

When the mother and daughter home ranges are adjacent to each other (do not overlap), a daughter moves north 5.6 to 6.8 miles every 3 years. In the more conservative scenario a dispersing subadult female shares 40% of her home range with her mother and the daughter moves north 4.4 to 5.2 miles every 3 years. The most conservative assumes an 85% overlap with a northward crawl of 1.6 to 2.8 miles every 3 years.

Since 1990, there have been six verified sightings of females with a cub in northern Sonora (Brown and Lopez-Gonzalez 2001).

The direct, straight-line distances to the U.S. border Sky Islands for females have ranged from about 100 to about 125 miles and could easily be twice as large given the rugged terrain. Given all the assumptions, it may be reasonable to speculate that the fastest female inter-generational lineage might return to the U.S. Sky Islands in 45 to 70 years; conservatively 60 to 85; and if many of our assumptions are too optimistic, from 100 to 250 years (table 3).

Discussion

From these scenarios, it is clear that, if passive restoration is preferred, jaguar conservation in the U.S. Sky Islands will require a long-range view, and U.S. lands and prey densities of deer, javelin, cattle, and smaller prey may need to be protected for a half-century or more before a female appears. Although not studied in any detail, the pathways north to the U.S. Sky Islands may become more difficult over the next 50 to 150 years as borderland habitats become increasingly fragmented, settled by humans, and the border fence "permanently" blocks some potential routes. In addition, the border highway in Sonora will be widened within the next few years.

A bi-national discussion of how conservation funding should be spent most effectively is necessary. Should funding be spent in Sonora to improve dispersal from the core zone in *all* directions or spent primarily on helping northern jaguar females move north? Which is the more effective way to raise the population from the present 40 or 50 female jaguars to a more viable population size? Should funding preferentially address land protection within the "corridor" to the south from the Northern Jaguar Reserve to Sinaloa, which restocks the small northern population and may provide genetic diversity? Should active restoration by transferring females north into the U.S. Sky Islands be attempted?

The scenarios will hopefully improve in accuracy in the next decade or two. Perhaps a female will be photographed much closer to the border. The scenarios provide a framework for decision-making that elevates the importance of females and rates of dispersal in addressing conservation issues.

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