

Potential jaguar habitat in Arizona and New Mexico: Summary of work and recommendations of the Jaguar Habitat Subcommittee for the Jaguar Conservation Team

By William E. Van Pelt, Chair

INTRODUCTION

In March 1997, the Arizona Game and Fish Department (AGFD) and New Mexico Department of Game and Fish (NMDGF) entered into a Conservation Agreement with other state, local, and federal cooperators, with voluntary participation by many private individuals, to contribute to conserving the jaguar (*Panthera onca*) of Arizona and New Mexico and to encourage parallel efforts in Mexico (Johnson and Van Pelt 1997; Table 1). The two state wildlife agencies believed that if strong partnerships could be developed under this approach, it would be a significant step forward in bringing local governments, private landowners, and nongovernmental organizations directly into jaguar management.

The Jaguar Conservation Agreement provides opportunities and incentives for interested parties to become involved with conservation activities. These activities include collection of biological information (to provide a sound scientific basis for decisions); consideration of relevant cultural, economic, and political factors; design and implementation of a comprehensive approach to conservation (including public education); and monitoring, evaluation, and feedback.

In addition to an over-arching Memorandum of Agreement (MOA) among the signatories, the Conservation Agreement embraces two main components. The first is a Conservation Assessment, which describes the status of the jaguar in the United States and identifies threats to the jaguar in Arizona and New Mexico. The assessment focuses the second component, the Conservation Strategy, on reducing or eliminating threats in Arizona and New Mexico that might prevent expansion of the current range and distribution of the jaguar, and thus contribute to recovery of the species. While there are eight conservation objectives identified in the strategy, this summary focuses on activities associated with Objective 5-Identify, maintain, and promote existing and other suitable jaguar habitats.

There were eight tasks identified for Objective 5. They were: 1) review relevant scientific literature to identify habitat use patterns and develop range-wide habitat suitability criteria applicable to habitats in Mexico, Arizona, and New Mexico; 2) review proposed and on-going projects and activities for potential impacts on jaguars and jaguar habitats; 3) beginning 12 months after establishment of JAGCT (April 1998), AGFD and NMDGF will coordinate with land-management agencies and private landowners to inventory jaguar habitat; 4) in 24 months (April 1999), AGFD and NMDGF will produce maps delineating jaguar habitat and land ownership patterns; 5) encourage protection and enhancement of jaguar habitat and travel corridors; 6) AGFD and NMDGF will pursue protection and enhancement agreements for suitable jaguar habitat; 7) monitor and identify new, continued, and diminishing threats to jaguar population expansion; and 8) identify livestock depredation and control measures. This summary

will focus on the mapping efforts and make recommendations to the Jaguar Conservation Team on conservation measures for potential jaguar habitat.

BACKGROUND

In 1997, a Habitat Subcommittee (JAGHAB) was formed by the JAGCT. The first assignment completed was a literature search, which identified nearly 400 jaguar-related articles. In 1999, much of this information was included in a more extensive jaguar bibliography developed by independent researchers (Fitzhugh and others 1999). The JAGHAB reviewed the material referenced by Fitzhugh and others (1999) to glean information relevant to our efforts to develop habitat, depredation, and educational publications.

Starting in April 1998, the JAGHAB held 10 meetings and conference calls to develop and recommend habitat suitability criteria for Arizona and New Mexico using the information from the extensive literature review. Jaguars have been noted for their adaptability to a variety of environmental conditions (Rabinowitz and Nottingham 1986; Seymour 1989). Habitat studies in the core part of their range indicate a close association with water, dense cover (Schaller and Crawshaw 1980; Quigley and Crawshaw 1992), and sufficient prey (Seymour 1989; Swank and Teer 1989) and an avoidance of highly disturbed areas (Quigley and Crawshaw 1992). Jaguars have been found from sea level to 3800 m (Tewes and Schmidly 1987), but rarely over 1000 m (Seymour 1989). They have also been found in a wide variety of vegetation communities from tropical rainforest and flooded grassland mosaics to deciduous dry forest Madrean evergreen woodland, coniferous forest, semi-desert grasslands, and rocky canyons (Rabinowitz 1999, Brown and Lopez Gonzales 2001). The JAGHAB identified, and the Jaguar Scientific Advisory Group (JAGSAG) concurred with 4 criteria for determining potential jaguar habitat: 1) Jaguar Presence. A 50-mile radius polygon will be delineated around documented jaguar occurrence. This would include an entire mountain range, if a portion of that mountain range occurs within the 50 miles polygon.; 2) Vegetation type. In Arizona the following habitat associations that will be considered were based on Brown and Lowe (1980) habitat associations. The area must be in the Semi-desert Grassland, Plains Grassland, Great Basin Grassland, Interior Chaparral, Madrean Evergreen Woodland, Great Basin Conifer Woodland, or Petran Montane Conifer Forest, or in a riparian area or major wash in the Arizona Upland Sonoran Desertscrub. Areas in the Lower Colorado River Sonoran Desertscrub and Petran Subalpine Conifer Forest are not considered jaguar habitat.; 3) Prey densities. Area must have adequate prey densities to maintain a jaguar, at least seasonally. This is most likely not a limiting factor, as prey densities in areas that are otherwise jaguar habitat usually contain more than ample prey resources for jaguars.; 4) Human impacts. Areas with continuous row crop agriculture over an area greater than 1 square mile and any agricultural crop areas immediately adjacent to those areas are not considered adequate habitat. Areas with human residential development in excess of 1 house per 10 acres are not considered jaguar habitat. Areas developed for industrial purposes or a combination of industrial and residential development that create a footprint equal to or greater than 1 house per 10 acres are not suitable jaguar habitat.; and 5) Water presence. Areas must have seasonal water available for jaguar use. This would include springs, streams, rivers, and stock tanks. JAGSAG identified the lack of connectivity between habitats as a threat to jaguars and recommended that a “terrain

ruggedness index” be included to identify connectivity, and elevation be removed from the criteria.

Even though habitats in Arizona and New Mexico have been described to varying degrees in quality and quantity, even by members of JAGSAG, it was recommended by JAGSAG to continue modeling potential jaguar habitat in Arizona and New Mexico using the general criteria mentioned above and that specific habitat-use data from jaguars be incorporated when it becomes available. Justification for this recommendation, and for conservation activities, revolved around the recognition that a jaguar on the periphery of its range could contribute to the maintenance of a metapopulation.

An example of this metapopulation maintenance provided in the JAGSAG response was the black-footed ferret (*Mustela nigripes*). In that case, the last remaining population of the species was discovered in an area considered to be outside of its historic range (based on museum skins and published in Hall 1981). That single population has been the source for reintroduction projects to establish wild black-footed ferrets populations in South Dakota, Montana, Colorado, Arizona, and Wyoming (Miller et al. 1996).

The JAGSAG also explained that range-collapse does not always occur from the periphery in toward the center in all populations, and in some cases, individuals of an endangered or threatened species are important whether they exist on the periphery or in the core of the historic range.

In addition, the members of JAGSAG have commented that jaguars in other parts of the species’ range are known to move long distances and return to establish a territory in its original area. This may indicate that the any habitat found in Arizona and New Mexico may be important to maintaining the population of jaguars found in Sonora, Mexico. Even if such habitat is only used for a short period of time, it may allow a dispersing animal to survive until a territory opens in the breeding population. The important issue conveyed by JAGSAG was to maintain, and if necessary, restore connectivity of habitats throughout the range and to allow for movement. In addition, for years, wildlife management has recognized that it is better, and less expensive, to maintain the existing habitats than trying to restore them in the future.

MAPPING EFFORTS USING JAGCT HABITAT CRITERIA

After having JAGSAG review the criteria, JAGCT approved the criteria, the Sierra Institute Field Studies Program in Arizona (Institute; University of California Extension, Santa Cruz, CA) used them in a report and map submitted to the Habitat Subcommittee in June 2000 (Appendix 1). The report identified potential jaguar habitat including important travel corridors (mountain ranges, canyons, riparian areas, and major washes and wash complexes) in southeastern Arizona and southwestern New Mexico. The report also examined historical changes to habitat and discussed how habitat information can be used within the framework of the Jaguar Conservation Agreement.

The subcommittee asked JAGSAG to review the report. JAGSAG generally agreed with the approach taken, but not with all its recommendations (for example, using reintroduction as a tool to study habitat use). JAGSAG agreed with the finding of the report that insufficient prey should not automatically eliminate an area as potential jaguar habitat, as prey numbers may be manipulated through appropriate management.

In September 2000, the JAGHAB asked JAGSAG to answer 12 questions relating to jaguar conservation and identification of potential habitat. The responses to these questions were made available at the January 2001 meeting. A summary of the JAGSAG's recommendations can be found at the end of their response: "A top priority, therefore, is studying the habitat-use of territorial adult jaguars (particularly females) in the northern population of Sonora, Mexico. If the habitat that those animals use resembles the physical structure and dominant plant forms available in the U.S., then one can say that jaguar habitat (or potential habitat) exists in the U.S. Until those data are gathered, modeling should continue using the general categories of plant forms, physical structures, terrain ruggedness, human population, etc. that are now being placed in GIS systems."

In October 2000, the Arizona Game and Fish Department initiated a GIS analysis for identifying jaguar habitat in Arizona. Jim Hatten, GIS Senior Analyst for AGFD, modeled the habitat components for the jaguar. Jim stressed that this was more of a "land use/land cover suitability model" rather than a "habitat suitability" model. There is a lack of data on jaguar habitat use for a quantitative, GIS-based modeling effort for jaguars in the northern portion of their range. Keeping this in mind, this modeling exercise would identify relationships between historic jaguar sightings and physical factors identified by the JAGHAB (e.g., distance to water, vegetation biomes, prey abundances, and human densities) and determine the suitability of constructing a GIS-based model with any or all of the above variables.

At the January 2001 JAGCT/JAGWG meeting, GIS Senior Analyst Jim Hatten (AGFD) presented a land-cover/habitat suitability map for the jaguar in Arizona created using overlays of the habitat criteria identified by the subcommittee. The general conclusions of the modeling exercise were that jaguars have been most often observed in low human density areas; jaguars were more common in javelina, white-tailed or mule deer habitats, less common in elk habitats; jaguars were usually within 16-km of perennial or intermittent waters; and jaguars were observed twice as often in scrub grasslands as any other biome classification. Jaguar sightings were clumped in southern and southeastern Arizona and scattered in the central part of the state, with "hotspots" to the north and south of Tucson. The land-cover/habitat suitability map identified three distinct areas of potential jaguar habitat in Arizona: southeastern Arizona, central Arizona, and north-central Arizona.

The report was sent to the JAGSAG for review in June 2001. Alan Rabinowitz, JAGSAG member, responded on July 17, 2001 by saying, "It is a good presentation and analysis of known data and it provides a good starting point for assessing potential jaguar habitat in the United States. One word of caution to the authors, however, since the jaguar sightings data were never based on any kind of methodical data collection or survey techniques, any correlation between existing sightings and habitat characteristics must be viewed very critically. The authors should

point this out in the report as a potential bias or source of error. Otherwise, the report is well done.”

Revisions to the Arizona report occurred in 2002 and the final review by JAGHAB occurred in September 2002. The final report identified “the amount of area as potential suitable jaguar habitat in Arizona ranging from 21 to approximately 30 percent of the state.). Of the 3 models run, Model A is the most restrictive and resulted in a more patchy arrangement of potential habitat across the landscape. By omitting the Terrain Ruggedness Index (TRI) filter (Models B and C), approximately 8% more of the state was classified as potential habitat and the habitat patches became more connected, particularly in the southeastern part of the state. Model C, which included all potential biomes, added very little to the model and only improved the classification rate of Class 3 sites. The lack of potentially suitable jaguar habitat in riparian areas can largely be attributed to agricultural and urban development and the concurrent loss of 90% of Arizona’s historic cottonwood (*Populus fremontii*) and willow (*Salix* spp.) gallery forest (Krueper 1993). The lack of suitable habitat in other habitat classifications can be attributed mostly to proximity to water.”

The Arizona report recommended, “The best-suited area for jaguar conservation is located in southeastern Arizona in Santa Cruz, Pima, Cochise and Graham Counties. This area resembles an inverted V with the southern end separated by a swath of agricultural and developed land, or land that is >5 km from a spring or >10 km from perennial/intermittent waters. When the TRI filter is not applied, habitat corridors form to the south and north of the Cochise/Graham County boundary. Based upon the jaguar distribution patterns in southeast Arizona, we suspect there are habitat corridors in Mexico that connect southeast Arizona to the northern-most established jaguar population in the Sierra Madres. These habitat relationships will become clearer when a biogeographic analysis similar to the one described in this paper is completed for Sonora, Mexico. “

Although some of the criteria in the Arizona report were modified from the original ones identified by JAGHAB, no fatal flaws were identified for any of these modifications during the reviews by JAGHAB or JAGSAG. The report was submitted and accepted by the JAGCT at the January 2003 meeting (Appendix 2). Upon acceptance by JAGCT, the Arizona habitat report was submitted to the Journal of Wildlife Management, where it was peer reviewed, accepted, and published in 2005 (Hatten and others 2005).

At the July 2001 JAGCT meeting, the NMDGF announced they were going to contract with the Earth Data Analysis Center of the University of New Mexico to model potential jaguar habitat in the state. At the January 2002 JAGCT meeting, NMDGF distributed the handout *Developing a model to help evaluate the relative suitability of potential jaguar habitat in New Mexico*. New Mexico took a different approach to the modeling effort than Arizona. Arizona determined thresholds of suitability for each criterion. New Mexico looked at a combination of habitat variables (listed below) to determine relative suitability of areas within New Mexico for jaguars. In addition, not all class I and II sightings were included in the draft New Mexico map. By not including all of the sightings, New Mexico’s analysis was restricted to the southwestern quadrant

of the state. Nor were all of the documented jaguar occurrences within the area analyzed included in the draft New Mexico map.

Variables used in New Mexico's analysis of potential habitat were terrain ruggedness, prey distribution, road density, proximity to water, and the presence of Madrean evergreen woodland community. New Mexico's analysis differed from Arizona's in the following manner:

1. *Terrain Ruggedness*: the same parameters were used for the New Mexico and Arizona analyses except NM compared the elevation in each cell to the neighboring 8 rather than 4 cells.
2. *Prey Species*: New Mexico looked at the distribution of 5 prey species (elk, mule deer, white-tailed deer, javelina, and coati) for their model. Arizona did not examine the distribution of jaguar prey because the JAGSAG believed it to be too restrictive of a criterion.
3. *Human Density Patterns*. Both New Mexico and Arizona excluded a direct examination of human-density patterns obtained from census data. New Mexico used road density as an index of human populations, and Arizona excluded urban and high-density rural areas and agricultural areas from analyses.
4. *Distance to Water*. New Mexico included areas within 16 km from streams and lakes and 1 km from springs as potential jaguar habitat, and weighted perennial waters over intermittent waters. Arizona included areas within 10 km of perennial/intermittent creeks or rivers and 5 km of springs as potential jaguar habitat.
5. *Vegetation Associations*. New Mexico only examined the relationship between jaguar sightings and the Madrean evergreen woodland community (based on NM-GAP) due to the low number of jaguar occurrence records. Arizona examined the relative frequency of jaguar sightings in different biomes and vegetation series based on AZ-GAP covers.

The report was given to JAGWG for review at the January 2002. The composite map of potential jaguar habitat in New Mexico was confusing because of the transition from the methodology mentioned in the paper to the final map. The report was modified and sent out for review to JAGWG and JAGSAG after the July 2002 JAGCT meeting. While no comments were received from JAGSAG, a member of JAGWG expressed a concern that the NMDGF "did not attempt to establish a threshold for suitable vs. unsuitable potential habitat" in its report, though the assignment was to identify potential habitat.

At the January 2003 JAGCT meeting, the NMDGF presented another version of its habitat maps for New Mexico. The NDMDGF made some modifications to the criteria established by JAGHAB in an effort to fit data layers that were available in New Mexico.. Comments were requested for the individual maps or on the composite map. At the July 2003 JAGCT meeting, the report *Evaluation of the relative suitability of potential jaguar habitat in New Mexico* was distributed by NMDGF for finalization (Appendix 3). A proposal was received prior to the January 2004 from a member of JAGHAB to not accept the report as final because it did not meet the requirements of the assignment. Although the NMDGF agreed the analysis could be built upon and improved, the 2003 New Mexico habitat report is considered the final and is intended to be a starting point. Although it was discussed at the January JAGCT 2004 meeting,

action on this item was tabled. At the August 2004 JAGCT meeting, it was agreed upon the JAGHAB would meet in Albuquerque by the end of the month to review the conflicts identified in the New Mexico habitat report.

At the August 2004 JAGHAB meeting, it was recommended that the New Mexico report be redone using the established criteria and incorporating the comments made during the meeting. However, NMDGF informed the group the earliest it could work on the report would be July 2006 due to the lack of funds available or programmed at the time. The Center for Biological Diversity (CBD), volunteered to assist with developing the GIS layers for New Mexico. It was decided to contract with CBD to produce a new report and maps.

In August 2005, the CBD draft of the report was sent out for review. Comments were provided and a second version *Suitable habitat for jaguars in New Mexico* was sent out prior to the November 2005 JAGHAB meeting (Appendix 4). At the meeting, some JAGHAB members were concerned that by strictly applying the habitat criteria a map is produced that does not accurately reflect potential jaguar habitat. They questioned previously approved habitat suitability criterion #5, arguing that the fifty miles around each sighting is an arbitrary distance.

To complete the habitat assignment, a compromise was reached by JAGHAB. It was agreed that the maps in the CBD report accurately represented and strictly applied the criteria agreed upon by JAGCT, and that the report and maps would be conditionally accepted pending edits proposed by JAGHAB. In addition, the NMDGF's jaguar habitat suitability report and map products also would be accepted as a analysis/interpretation of potential habitat using modifications to the agreed upon criteria. Both of these are identified as assignments in the Jaguar Conservation Agreement. The CBD would also include a map of Arizona with the criteria strictly applied. A report summarizing the mapping efforts would be produced highlighting the differences between the mapping efforts and recommendations to the JAGCT for action. This report is to reflect this compromise.

RECOMMENDATIONS

The JAGHAB recommends the following:

- A. The Jaguar Habitat Subcommittee is forwarding the four maps and their underlying documentation to the Jaguar Conservation Team. The maps meet Objective 5 of the Conservation Agreement and are the following:
 - o The Arizona map produced by the CBD, which strictly apply to the habitat criteria approved by the JAGCT,
 - o The New Mexico map produced by the CBD, which strictly apply to the habitat criteria approved by the JAGCT,
 - o The maps from the July 2003 NMDGF as an alternative analysis not based on the habitat criteria approved by the JAGCT; and
 - o The maps in the AGFD and Sierra Institute reports as an alternative analysis not based on the habitat criteria approved by the JAGCT.”

- B. The Jaguar Habitat Subcommittee recommends that the JAGCT use the completed maps to prioritize conservation efforts for potential habitat. Prioritization would begin with areas where the maps are in agreement.”

DISCLAIMER

“The findings, opinions, and recommendations in the attached reports are those of the investigators who have received partial or full funding from members of the Jaguar Conservation Team. The findings, opinions, and recommendations do not necessarily reflect those of the individual members of the Jaguar Habitat Subcommittee of the Jaguar Conservation Team.”

LITERATURE CITED

- Brown, DE and CA Lopez Gonzalez. 2001. Borderland jaguars/Tigres de la frontera. The University of Utah Press. Salt Lake City, Utah.
- Fitzhugh, E.L., G. Rios, P.M. Gros, W.E. Van Pelt and R. Valdez. 1999. An extensive bibliography of the jaguar. University of California, Davis. Unpublished report.
- Hall, E.R. 1981. The mammals of North America. John Wiley and Sons, New York, New York.
- Hatten, J.R., A. Averill-Murray, and W.B. Van Pelt. 2005. A spatial model of potential jaguar habitat in Arizona. *Journal of Wildlife Management* 69(3):1024-1033.
- Johnson, T.B. and W.E. Van Pelt. 1997. Conservation assessment and strategy for the jaguar in Arizona and New Mexico. Nongame and Endangered Wildlife Program Technical Report 105. Arizona Game and Fish Department, Phoenix, Arizona.
- Miller, B., R.P. Reading, and S. Forrest. 1996. *Prairie night: Recovery of the black-footed ferret and other endangered species.* Smithsonian Institution Press, Washington D.C.
- Quigley, H.B. and P.G. Crawshaw, Jr. 1992. A conservation plan for jaguar *Panthera onca* in the Pantanal region in Brazil. *Biological Conservation* 61:149-157.
- Rabinowitz, A.R. 1999. Present status of jaguars (*Panthera onca*) in the southwestern United States. *Southwest. Nat.* 44(1):96-100.
- Rabinowitz, A.R. and B.G. Nottingham, Jr. 1986. Ecology and behaviour of the jaguar (*Panthera onca*) in Belize, Central America. *Journal of the Zoological Society of London* 210:149-159.

Seymour, K.L. 1989. Mammalian species *Panthera onca*. American Society of Mammalogists Species Accounts No. 340:1-9.

Swank, W.G. and J.G. Teer. 1989. Status of the jaguar-1987. *Oryx* 23:14-21.