

Planning to Save a Species: the Jaguar as a Model

ERIC W. SANDERSON,*† KENT H. REDFORD,* CHERYL-LESLEY B. CHETKIEWICZ,*
RODRIGO A. MEDELLIN,† ALAN R. RABINOWITZ,* JOHN G. ROBINSON,*
AND ANDREW B. TABER*

*Wildlife Conservation Society, 2300 Southern Boulevard, Bronx, NY 10460, U.S.A.

†Instituto de Ecología, Universidad Nacional Autónoma de México, Aparto Postal 70-275, 04510 D.F., Mexico

Abstract: *International conservation planning at the end of the twentieth century is dominated by coarse-filter, supra-organismal approaches to conservation that may be insufficient to conserve certain species such as the jaguar (Panthera onca). If we are to retain broadly distributed species into the next century, we need to plan explicitly for their survival across their entire geographic range and through political boundaries while recognizing the variety of ecological roles the species plays in different habitats. In March 1999 the Wildlife Conservation Society sponsored a priority-setting and planning exercise for the jaguar across its range, from northern Mexico to northern Argentina. Field scientists from 18 countries reached consensus on four types of information: (1) the spatial extent of their jaguar knowledge, (2) the known, currently occupied range of jaguars, (3) areas with substantial jaguar populations, adequate habitat, and a stable and diverse prey base, and (4) point localities where jaguars have been observed during the last 10 years. During the exercise, these experts also conducted a range-wide assessment of the long-term survival prospects of the jaguar and developed an algorithm for prioritizing jaguar conservation units occurring in major habitat types. From this work, we learned that the known, occupied range of the jaguar has contracted to approximately 46% of estimates of its 1900 range. Jaguar status and distribution is unknown in another 12% of the jaguar's former range, including large areas in Mexico, Colombia, and Brazil. But over 70% of the area where jaguars are thought to still occur was rated as having a high probability of supporting their long-term survival. Fifty-one jaguar conservation units representing 30 different jaguar geographic regions were prioritized as the basis for a comprehensive jaguar conservation program.*

Planeación para Salvar una Especie: El Jaguar como Modelo

Resumen: *La planeación de la conservación internacional al final del siglo veinte esta dominada por enfoques de grano grueso, supra-organísmicas que pueden ser insuficientes para conservar ciertas especies como el jaguar (Panthera onca). Si hemos de mantener especies ampliamente distribuidas en el próximo siglo, necesitamos planificar su supervivencia explícitamente en todo su rango geográfico a través de límites políticos al mismo tiempo que se reconozca la variedad de funciones ecológicas de las especies en diferentes hábitats. En marzo de 1999 la Sociedad de Conservación de Vida Silvestre promovió un ejercicio de definición de prioridades y de planeación para el jaguar en todo su rango de distribución, desde el norte de México hasta el norte de Argentina. Científicos de 18 países llegaron a consensos en cuatro tipos de información: (1) la extensión espacial de su conocimiento del jaguar, (2) el rango conocido, actualmente ocupado por el jaguar, (3) áreas con poblaciones importantes, hábitat adecuado y una base de presas estable y diversa y (4) localidades en las que se han observado jaguares durante los últimos 10 años. Durante el ejercicio, estos expertos también hicieron una evaluación de la supervivencia a largo plazo del jaguar en todo su rango y desarrollaron un algoritmo para priorizar unidades de conservación del jaguar en los tipos de hábitat más importantes. De este trabajo, aprendimos que el rango del jaguar conocido y ocupado se ha contraído aproximadamente al 46% de su rango estimado circa de 1900. El estatus del jaguar y su distribución en otro 12% del rango anterior, incluyendo extensas áreas en México, Colombia y Brasil. Sin embargo, más del 70% del área donde se piensa que todavía ocurre el jaguar fue considerada con una alta probabilidad de soportar la supervivencia a largo plazo. Se priorizaron 51 unidades de conservación representando 30 regiones diferentes como la base para un sólido programa de conservación del jaguar.*

†email esanderson@wcs.org

Paper submitted August 14, 2000; revised manuscript accepted April 25, 2001.

Introduction

Over the last 100 years the theory and practice of conservation has evolved from strategies originally intended to preserve natural resources or awe-inspiring scenery (Callicott 1990) to an intense concern for conserving biodiversity in all its facets, including genetic and species diversity and the diversity of ecosystem structure and function (Redford & Richter 1999). This evolution has been driven by the discoveries of twentieth century science that have revealed the vast diversity of biological species and the intricate and subtle ways in which organisms interact with one another and with human beings—and that have thus engendered horror at so many species being lost through human haste and greed (Ehrlich & Ehrlich 1981; Mann & Plummer 1995). At the end of the twentieth century, the new paradigm of conservation is biodiversity writ large, including genetic, ecosystem, and landscape perspectives.

Simultaneous with this increasing emphasis on biodiversity in all its components has been an increase in the scale of planning for conservation work, typically through mechanisms that emphasize entities other than the population or the species as a target for conservation effort (Noss 1991; Salwasser 1991). International conservation organizations, governmental and nongovernmental, have altered their approach to focus increasingly on strategies that are regional to global in scope and based on conserving supra-organismal entities: hotspots of species diversity (Myers et al. 2000), globally significant ecoregions (Olson & Dinerstein 1998), ecosystems (as in ecosystem management; Boyce & Haney 1997), endemic bird areas (Slattersfield et al. 1998), and continental networks (Soulé & Terborgh 1999). Such approaches seek to conserve ecosystem functions and the diversity of habitat types despite a lack of knowledge of the extent of biological diversity and the complex array of factors that maintain it (Hunter 1991; Franklin 1993). In short, they seek to conserve the whole when faced with the impossibility of knowing all the parts.

But the parts are important too. Here we provide an example of how one such important part, the jaguar (*Panthera onca*), can form the basis for large-scale conservation planning. Jaguars have much to teach us about the knotty problem of conserving broadly distributed species. Because jaguars as a species range across many different nations and habitat types, small-scale conservation efforts selected ad hoc and focused over narrowly defined areas have not succeeded in stemming the tide of jaguar extirpation (Weber & Rabinowitz 1996). Establishment of the first jaguar reserve in Belize (Rabinowitz 1986) and the creation of a conservation plan for the Pantanal (Quigley & Crawshaw 1992), although important, have not slowed the collapse of the jaguar's range. Moreover, range-wide conservation efforts have been inhibited by national and linguistic differences among conservationists, lack of knowledge on the overall status of jaguars, and the absence of a consensus on priorities for conservation of the species.

Saving jaguars requires international, range-wide planning that recognizes as a first priority ecological, not political, distinctions among jaguars. We postulate that saving a species means, at least, saving populations of the species in all the significantly different ecological settings in which they occur. As Wikramanayake et al. (1998) wrote about a related species, "in seeking to conserve representative populations of tigers, we must consider not only the genetic distinctiveness of tigers across the range, but also behavioral, demographic, and ecological distinctiveness." Thus, it is not sufficient to pursue jaguar conservation efforts only in tropical forests or only in tropical forests in Brazil and Belize; we must begin with the range-wide context that for the jaguar requires an international perspective.

Most species-based conservation efforts do not assume as a starting point consideration of the entire range. Conservation of endangered populations of the California Gnatcatcher (*Poliophtila californica*) is an imperative under the U.S. Endangered Species Act, even though substantial, unthreatened populations exist in Mexico (Zink et al. 2000). Moreover, most countries do not have endangered species legislation of any kind, and if they do, laws are unlikely to be consistent across the 18 nations where the jaguar is currently found. As a result, biological conservation plans often respect political boundaries more than ecological ones (Hunter & Hutchinson 1994.)

In 1999 the Wildlife Conservation Society and the Institute of Ecology at the National Autonomous University of Mexico initiated a geographically based, range-wide assessment and priority-setting exercise for the jaguar (Medellin et al. 2001). Our goals were to comprehensively assess the state of knowledge about the ecology, distribution, and conservation status of the jaguar, to identify priority areas for its conservation on a range-wide basis, and to build an international consensus for conservation of the species. This work was built on a geographic data framework that respected the kinds and qualities of information we now have while forming a baseline for future evaluations. From this information, the experts assessed the status of jaguars across the range and developed a prioritization mechanism to determine the most important areas for jaguar conservation in each regional habitat type, based on factors important for the long-term survival of jaguars. Although the results focus on the range-wide condition of jaguars, the methodology used and the conclusions drawn present a model for conservation planning that could be applied to many widely ranging species.

Methods

Data Definitions

Jaguar geographic regions (JGRs) are geographic units defined by potential habitat (*sensu* Hall et al. 1997) and

bioregion across the jaguar's historic range (Fig. 1). Presumably, the ecology of jaguars in tropical moist lowland forest is significantly different from that in xeric deserts because of differences in, for example, prey base and habitat use. Similarly, because of regional differences in species composition and geographic factors, the role of jaguars in the tropical moist lowland forests of Central America is substantively different from their role in the tropical moist lowland forests of the southeast Amazon. Representing these ecological differences geographically through JGRs provides a convenient, ecologically based unit for planning.

Each JGR is named by its geographic region, then its habitat type (e.g., northeast Amazon/tropical moist lowland forest). The limits of the historic range were approximated from Seymour (1989) as the range of jaguars around 1900. This historic range was subdivided into 36 JGRs by lumping together North American and South American ecoregions (Dinerstein et al. 1995) to create units similar to the regional habitat types used in a previous conservation priority-setting exercise for Latin America (Biodiversity Support Program et al. 1995). Lumping together geographic units required including some areas that likely were never occupied by resident jaguars, including some areas above 2000 m in the Andes and Tepuis, which may overestimate the historic range slightly. The historic range may be slightly underestimated on its margins, particularly in the southwestern United States, but we estimated that <5% of the area in the JGRs is subject to these problems. The total extent of the historic range, represented in this way, is approximately 19.1 million km².

Thirty-five jaguar experts from 12 nations attended the workshop on "Jaguars in the New Millennium" (March 1999) or contributed information through another expert (for a list of participants, see the Appendix). Prior to the workshop, each researcher was provided a base map for his or her self-reported area of expertise at 1:2,000,000–1:4,000,000 scale, showing a preliminary set of jaguar geographic regions and basic reference information such as national boundaries, major cities, and rivers (Lioutty 1996). We assumed that each expert could identify jaguar locations on the map within 1 cm (20–40 km in map units). These data were compiled in geographic information system databases (Arcview-GIS), and each datum was identified with the name of the contributing expert. At the workshop these data were examined systematically in regional groups to resolve contradictions and build a consensus information base.

Four basic data types were solicited from the jaguar experts: (1) the geographic extent of their knowledge about jaguar status and distribution—whether or not jaguars are present in an area ("extent of knowledge"); (2) the area where jaguars were present as of March 1999 ("known, currently occupied range"); (3) important areas for jaguar conservation as defined below ("jaguar

conservation units"); and (4) point localities where jaguars have been observed within the last 10 years ("point observations") (Fig. 1). Experts were asked to combine all observations within 20 km of the center coordinates of the point locality. Each point observation was characterized by dates of first and last observation, observation methods used, and observer.

Jaguar conservation units (or JCUs) were defined either as (1) areas with a stable prey community, currently known or believed to contain a population of resident jaguars large enough (at least 50 breeding individuals) to be potentially self-sustaining over the next 100 years, or (2) areas containing fewer jaguars but with adequate habitat and a stable, diverse prey base, such that jaguar populations in the area could increase if threats were alleviated. Jaguar conservation units were not restricted to or required to contain protected areas. After the workshop, each JCU was given a name based on an adjoining or encompassing protected area, river, administrative unit, or other geographic feature.

In addition, the experts developed a geographically comprehensive consensus on the status of jaguars across the range by assigning the following codes to entire JGRs or divisions of JGRs, as necessary. Areas that were unknown were designated "status unknown—priority for survey." Areas that were known but were no longer occupied by jaguars were designated "no jaguars." For areas that were known and currently occupied by jaguars, one of the following three classes was assigned: (1) high, (2) medium, or (3) low probability of long-term survival. These assignments were based on qualitative evaluation of habitat size and connectivity, the status of the prey base, the status of jaguar populations, and the level of threat from human activity.

Prioritization of Jaguar Conservation Units

The experts were asked to weight six factors (JCU size, connectivity, habitat quality, hunting of jaguar, hunting of prey, and population status) according to their relative importance for long-term jaguar survival, keeping the sum of all weights to 100 points. To ensure maximum input, weighting schemes were developed separately by two discussion groups and then an attempt was made to synthesize the schemes in plenary session. During the review period (described below), the authors determined the final weighting scheme in consultation with the workshop participants, as follows: JCU size (30 points), connectivity (23), habitat quality (23), hunting of jaguars (10), hunting of prey (10), and jaguar population status (4).

Each JCU was assigned to the JGR where the majority of its area occurred. In cases where a JCU overlapped more than one JGR, the JCU was assigned to JGRs with which it shared over 1250 km² of area, the equivalent of one point observation. (Each point observation represents a

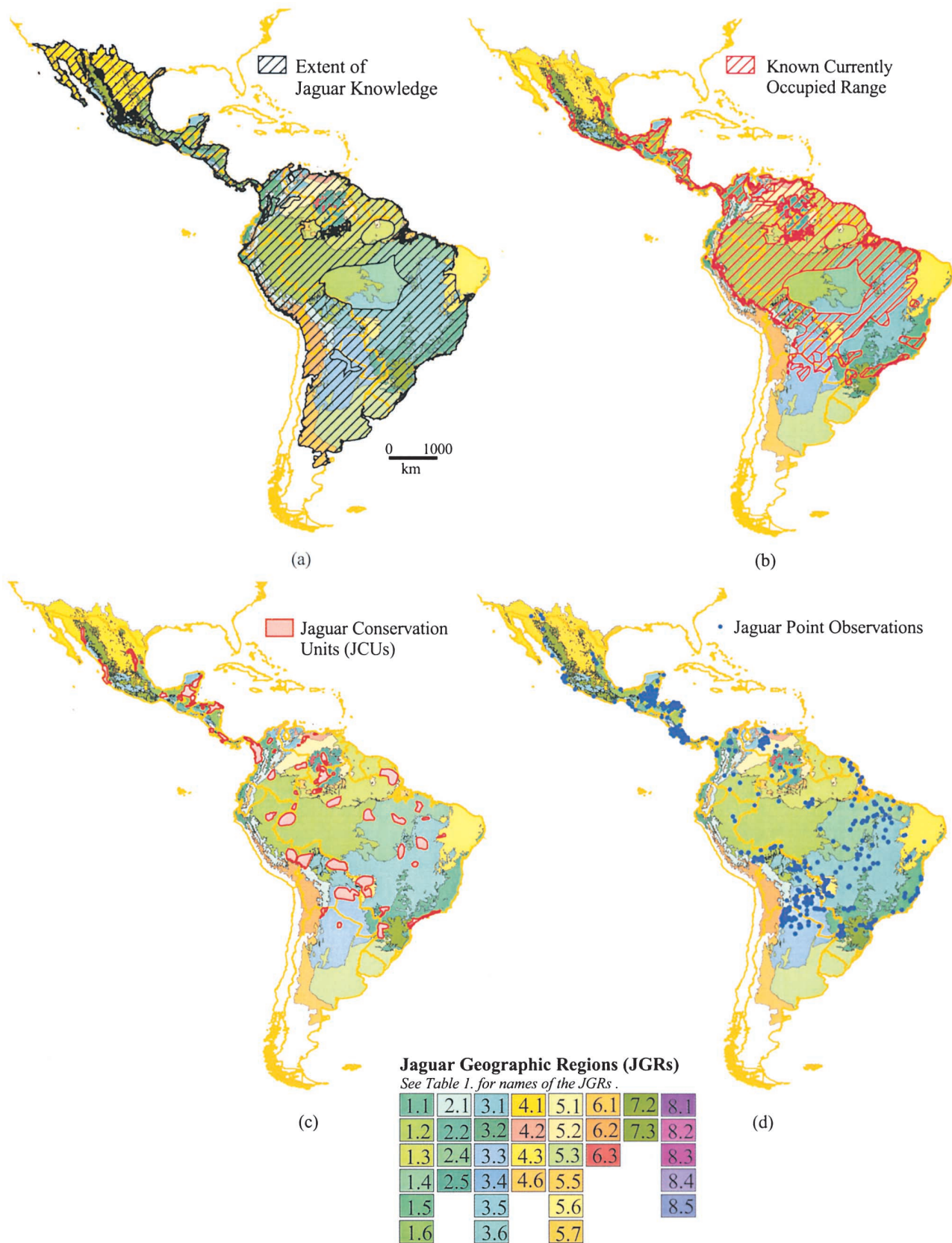


Figure 1. Spatial distribution of jaguar data across jaguar geographic regions (JGRs; background colors of each figure): (a) extent of current knowledge about the jaguar, (b) distribution of known, currently occupied jaguar range as of March 1999, (c) distribution of jaguar conservation units (JCUs), and (d) distribution of jaguar point observations from 1990 to 2000.

circular area of 20-km radius.) For those JGRs with less than three JCUs, the size criteria was relaxed to include all JCUs that occurred in that JGR, no matter the amount of overlap. The total size of the JCU, not the area of JCU within a given JGR, was used for calculating priorities, because jaguar populations were assumed to use the entire JCU, not just the portion within one habitat type.

The final prioritization score for each JCU was determined by multiplying the JCU's score for each of the six factors by its corresponding weight and then adding the score/weight products. The JCUs within the same JGR were then ranked to determine the most important JCU within each JGR.

The final results were compiled at the workshop and were subsequently reviewed during a post-workshop review period. In consultation with the appropriate experts, the authors made final decisions on inconsistencies between data sets. All data were distributed to the participating experts following the workshop, and all data were made available one year after the workshop at www.savethejaguar.com. More extensive details on all the methods are provided by Medellín et al. (2001).

Results

Extent of Jaguar Knowledge

The extent of knowledge about jaguars—including areas where jaguars are not present—covers 83% of the historic range of jaguars, indicating that approximately 17% of the range is unknown (Fig. 1a). Most of the area for which jaguar information is lacking is in several large regions in Mexico (over 848,000 km²) and in South America (over 2.3 million km² in Brazil alone). The distribution of jaguar knowledge by JGR reflects the distribution of these large, unknown areas (Table 1). The Mexican pine-oak temperate forests and the Caatinga xerics in Brazil are the least-known JGRs.

Known, Currently Occupied Jaguar Range

Jaguars are known to range over approximately 8.75 million km², or 46% of their historic range, broken into 48 separate areas that range in size from 114 km² to over 7 million km² (Fig. 1b). Unknown areas (Fig. 1a) were not included as part of the known, currently occupied range. The largest contiguous area of jaguar range is centered in the Amazon Basin (88% of occupied range) and includes adjoining areas in the Cerrado, Pantanal, and Chaco to the south, extending to the Caribbean coast of Venezuela and the Guianas. The Colombian Cordilleras sever the connections between this contiguous range and a series of large ranges that stretch across Central America from the Darien to the Selva Maya in Belize, Guatemala, and Mexico. At the northern end of the range

through Mexico, known jaguar range is limited to a strip along the western coast and three isolated observations in the southwestern United States.

Most of the loss of occupied range has occurred in northern Mexico, the southern United States, northern Brazil, and southern Argentina. Jaguars have been extirpated completely from the Argentine Monte and Pampas grasslands in southern South America and the western gulf coastal grasslands in the United States (Table 1). Because of elevation limits, jaguars are also not regularly found in the Pantepui or Puna montane grasslands. Jaguars are found in 10% of the area of Mexican xerics, Paramo, and Mexican pine-oak forests.

Jaguar Conservation Units

Based on present jaguar population size, prey base, and habitat quality in specific areas, the experts identified 51 areas (1.29 million km², 6.7% of the historic range, 13% of the currently occupied range) (Fig. 1c) important to the long-term survival of jaguars. By definition, each JCU represents a core population of jaguars on which conservation might be based.

Jaguar conservation units are found wholly or partially in 31 of the 36 JGRs and thus represent most of the ecological settings where jaguars occur (Table 1). Three of the six JGRs not represented by a JCU are in areas where jaguars have been extirpated or apparently were never present in large numbers: Argentine monte, western gulf coastal grasslands, and Pantepui montane grasslands. The western Andean tropical dry forests, Amazonian mangroves, and Amazonian savannas are also not represented by a JCU because of lack of information about jaguar status in those habitat types.

Jaguar Point Observations

The experts reported 5680 observations of jaguars at 535 separate localities during the last 10 years, representing a total area of observation of approximately 513,000 km², or approximately 2.7% of the jaguar's range that has been directly sampled (Fig. 1d). An average of 10.6 jaguar observations were made at each point, indicating concentrations of research at most points. Sixty percent of point observations recorded jaguars based on at least one of the more reliable observation methods: direct sighting by researcher, photograph, radiotelemetry, capture, or discovery of jaguar remains.

The density of point observations is uneven across the jaguar's range, reflecting concentrations of research rather than concentrations of jaguars. The most richly studied JGR is the Central American tropical moist forests (Table 1), due largely to research in Costa Rica, Belize, and Guatemala, although extensive research has also been conducted in Brazilian Cerrado and the Chaco dry tropical forests of Bolivia and Paraguay. The JGR of the northeast

Table 1. Distribution of jaguar data sets by jaguar geographic region.

Jaguar geographic regions (JGRs) ^a	Area (km ²) ^b	Extent of knowledge (%) ^c	Known, occupied range (%) ^d	JCU (%) ^e	No. JCUs ^f	No. points ^g	Percentage of area rated with given probability of jaguar long-term survival ^h		
							high (%)	medium (%)	low (%)
1.1 Atlantic/Tropical Moist Lowland Forest	951,120	98	20	7	3	36	1	0	19
1.2 Upper Amazon/Tropical Moist Lowland Forest	2,965,517	81	80	8	10	40	80	<1	0
1.3 Northeast Amazon/Tropical Moist Lowland Forest	1,520,518	81	81	11	5	15	80	<1	<1
1.4 Southeast Amazon/Tropical Moist Lowland Forest	1,358,285	61	61	5	5	29	60	1	0
1.5 Choco-Darien/Tropical Moist Lowland Forest	231,577	72	70	27	3	8	27	42	0
1.6 Central American/Tropical Moist Lowland Forest	522,443	95	77	24	11	118	71	1	2
2.1 Tropical Andes/Tropical Moist Montane Forest	756,615	91	27	5	5	38	1	22	4
2.2 Central American/Tropical Moist Montane Forest	190,510	65	25	8	8	17	1	9	14
2.4 Venezuelan Coastal Montane Forest/Tropical Moist Montane Forest	14,341	95	51	9	1	3	0	51	0
2.5 Guayana Montane Forest/Tropical Moist Montane Forest	337,586	100	100	18	4	2	100	0	0
3.1 North South American/Tropical Dry Forest	163,710	95	66	3	3	6	0	41	25
3.2 Western Andes/Tropical Dry Forest	104,683	60	10	0	0	0	0	8	3
3.3 Chaco/Tropical Dry Forest	1,153,437	93	35	8	3	79	30	0	5
3.4 Central American/Tropical Dry Forest	55,595	86	14	5	2	6	11	2	1
3.5 Mexican/Tropical Dry Forest	301,289	42	11	7	5	10	9	<1	1
3.6 Cerrado/Tropical Dry Forest	2,411,425	91	57	6	9	34	11	28	19
4.1 Mexican/Xeric	1,280,778	95	1	1	1	4	1	0	0
4.2 Caribbean/Xeric	123,232	98	44	1	2	2	<1	44	0
4.3 Caatinga/Xeric	759,625	27	10	1	1	5	0	<1	10
4.6 Argentine Monte/Xeric	409,040	100	0	0	0	0	0	0	0
5.1 Central American Pine Savanna/Herbaceous Lowland Grassland	18,847	96	96	35	1	4	<1	0	95
5.2 Llanos-Gran Sabana/Herbaceous Lowland Grassland	493,095	91	90	1	5	27	1	73	16
5.3 Pampas/Herbaceous Lowland Grassland	1,098,214	100	0	<1	1	0	<1	0	0
5.5 Amazonian Savanna/Herbaceous Lowland Grassland	173,461	53	53	<1	1	4	13	0	0
5.6 Pantanal/Herbaceous Lowland Grassland	171,053	100	100	48	3	17	99	0	1
5.7 Western Gulf Coastal Grassland/Herbaceous Lowland Grassland	42,653	100	0	0	0	0	0	0	0
6.1 Paramo/Herbaceous Montane Grassland	78,706	83	3	<1	1	0	<1	1	<1
6.2 Puna/Herbaceous Montane Grassland	589,486	100	0	<1	1	2	0	<1	<1
6.4 Pantepui/Herbaceous Montane Grassland	48,836	100	0	0	0	1	0	0	0
7.2 Brazilian Araucaria/Temperate Forest	220,917	100	27	6	2	9	6	0	21
7.3 Mexican Pine-Oak/Temperate Forest	460,465	20	8	8	6	4	<1	5	3
8.1 Northern Mexico/Mangrove	7,070	75	34	20	1	2	<1	34	0
8.2 Central American/Mangrove	38,237	65	35	9	9	12	6	2	25
8.3 Northern South America/Mangrove	20,272	53	16	4	1	0	5	8	0
8.4 Amazonia/Mangrove	33,235	82	82	0	0	1	74	4	0
8.5 Eastern South America/Mangrove	10,162	54	24	19	1	0	0	0	23

^aThe JGRs are named by region/habitat type. Numeric codes cross reference Fig. 1, and GIS data sets distributed through www.savethejaguar.com.

^bArea measured in equal area azimuthal projection, central meridian -72, reference latitude 0.

^cThe JGR area where status and distribution of jaguars is known.

^dThe JGR area where jaguars are known to exist.

^eThe JGR area with substantial jaguar populations, a stable and diverse prey base, and adequate habitat (JCU, jaguar conservation unit).

^fJaguar conservation units wholly or partially within each JGR.

^gJaguar point observations in each JGR.

^hSee text for details.

Amazon has been relatively undersampled in comparison with other tropical forest types. The density of sampling is lowest among xeric formations and herbaceous montane grasslands, where jaguars are relatively rare.

Range-Wide Assessment

The range-wide assessment showed variation in jaguar status across the range (Fig. 2). Of the jaguar's historic range, 18% is unknown, and jaguars are known to have been extirpated in an additional 37%. Within the known, currently occupied range, the probability of long-term survival of the jaguar in 70% of the area (over 6 million km²) is considered high. The largest of these high-probability portions of the range is centered on the Amazon Basin and the adjoining Gran Chaco and Pantanal. Two disjunct sections of the tropical moist lowland forests of Central America are also considered areas in which the probability of long-term jaguar survival is high: Selva Maya of Guatemala, Mexico, and Belize, and a narrow, continuous strip from the Choco-Darien of Panama and Colombia to northern Honduras. Areas in Jalisco, the Sierra Madre of Mexico, and in the Misiones district of Ar-

gentina were also identified as areas where the probability of long-term jaguar survival is high.

Of the currently occupied range, 18% or approximately 1.6 million km² was classified as areas in which the long-term survival of jaguars has medium probability. These areas are generally adjacent to high-probability areas and include a large portion of the northern Cerrado, most of the Venezuelan and Colombian Llanos, and the northern part of Colombia on the Caribbean coast. In Central America and Mexico, medium-probability areas were identified in the highlands of Costa Rica and Panama, southern Mexico, and the two eastern mountain ranges of Mexico where jaguars occur, Sierra de Tamaulipas and Sierra Madre Oriental.

The remaining parts of the range were classified as areas of low probability for the long-term survival of jaguars and thus are areas of immediate conservation concern. These include the Atlantic tropical moist lowland forest and Cerrado of Brazil; parts of the Chaco in northern Argentina; the Gran Sabana of northern Brazil, Venezuela, and Guyana; parts of the coastal dry forest in Venezuela; the Central American pine savannas and mangroves along the Caribbean coast of Nicaragua and Honduras; parts of

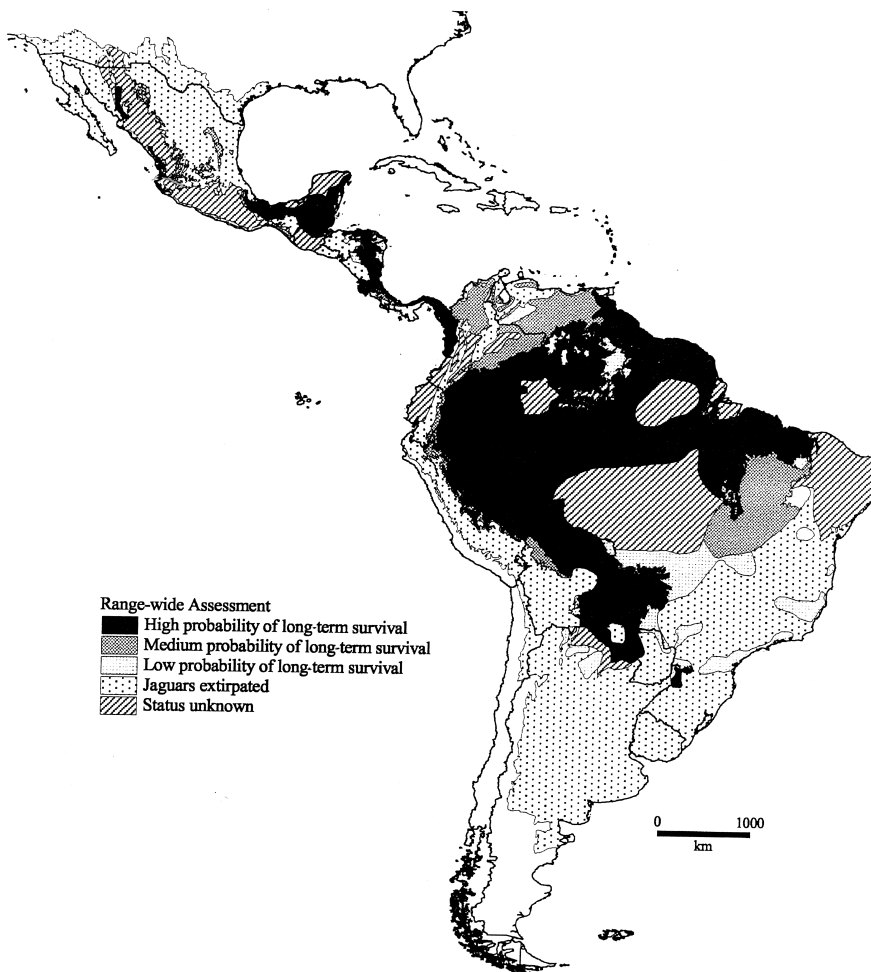


Figure 2. Consensus map of jaguar status across its range.

the Central American tropical moist montane forest in interior Nicaragua and Honduras and a narrow strip along the Pacific Coast of Mexico; and areas in the Mexican pine-oak forests in Jalisco, Mexico.

The JGRs with the largest proportions of areas ($>75\%$, area basis) with a high probability for the long-term survival of the jaguar were almost all in or surrounding the Amazon Basin. Central American tropical moist lowland forest has the largest proportion of area of high-probability in Central America and Mexico (71%). In fact, it is the only JGR north of Colombia with $>50\%$ of its area categorized as high-probability. Overall, only 12 out of the 36 JGRs had $>10\%$ of their area categorized as high-probability for the long-term survival of the jaguar. Twenty out of 36 had $\leq 1\%$ of their area so indicated.

JCU Prioritization

Although all JCUs are important areas for jaguars, they vary in level of threat to jaguars, size, habitat quality, and connectivity to other JCUs. According to the weighting scheme described above, JCUs were prioritized for each JGR, with JCUs within a given JGR compared only among one another (Table 2). For example, the highest-priority JCU for the upper Amazon JGR is in and around Amazonia National Park, Brazil (JCU 202). Other JCUs with higher levels of hunting or lower habitat quality ranked slightly lower.

Although all JCUs represent areas with substantial jaguar populations, a stable prey base, and adequate habitat, not all JCUs occur in areas classified as high-probability for the long-term survival of the jaguar (Table 2). Eleven JCUs had a majority of their area categorized as medium-probability for long-term survival, and 10 were categorized as low-probability for long-term survival. Six of these 10 JCUs fell entirely within areas of low probability of long-term survival. These JCUs are located in northern Argentina, central Honduras, the Osa Peninsula of Costa Rica, and the Atlantic forests of Brazil. These JCUs in areas categorized as low-probability for long-term survival contain the most endangered jaguar populations across the range. Fortunately, many other areas have strong jaguar populations and are considered areas of high probability for the long-term survival of the jaguar. Seventeen JCUs fell entirely within areas categorized as high-probability, and 23 had more than 90% of their area within high-probability areas.

Discussion

Although the methodology used in this exercise was pioneered for tigers and draws generally from a host of expert-driven, geographic, priority-setting exercises undertaken over the last decade, it contains a number of innovations that advance the methodology of geographic

priority setting, particularly for single-species-based conservation planning. The most important innovation is also the simplest: planning across the complete biological range of the species such that all conservation efforts could be placed in the most important context, the context of the species' biology. Most current species-based conservation plans are limited first by political boundaries. For example, habitat conservation plans under the U.S. Endangered Species Act deal mainly with populations within U.S. boundaries. Therefore, the few jaguars sighted recently in the southwestern United States are accorded high priority in United States conservation planning, whereas from a range-wide species perspective, other populations in other parts of the range are larger (e.g., Gran Chaco of Bolivia) or more endangered (e.g., Atlantic Forests of Brazil).

Another innovation is that the data sets were nested in a geographic hierarchy that accounted for the different types of knowledge we had about the species (Fig. 3). The most basic distinction separated areas in which we had knowledge of jaguars (extent of knowledge) from areas in which we lacked knowledge (unknown areas). Given the areas where jaguars are known, the next distinction was to separate areas where jaguars are found (the known, currently occupied range) from those where they have been extirpated. Finally, in those areas where jaguars are found, we identified where the best populations exist (JCUs) based on clearly defined criteria.

A third innovation is that we retained point observations throughout the analysis, which provided an important internal check on the more subjective polygonal data. The point observations provided the only objective information we had about jaguars: we knew that at each point, at least one jaguar had been observed. Even if we chose to eliminate some types of observation, the point database enabled us to identify the observation by method, date, and observer. Moreover, the analysis can be updated when significant new data become available. A mechanism is already in place to capture new information while distributing the compiled information (see www.savethejaguar.com). Data sharing is a key component to advancing international conservation efforts.

As a result of retaining the point observations, independent observers can question the data, providing an important check against the ever-present concern of bias in expert-driven systems. For example, several point observations fell in an area outside the extent of knowledge in southern Brazil, an apparent inconsistency (Fig. 1a & 1d). Review of these observations indicated that they were all >5 years old and not typical of the current situation along the rapidly changing frontier of the southern Amazon Basin.

Another innovation is that we limited conclusions about the currently occupied range to only known areas. The custom with range maps prepared previously has been to include all "internal" areas if habitat exists there, even if a

Table 2. Prioritized ranking of jaguar conservation units (JCU) by jaguar geographic region (JGR).

JGRs ^a and JCU ^b	Score ^c	Ranking in JGR	Area of JCU in (km ²) ^d	Total JCU area (km ²)	Percentage of area rated with given probability of jaguar long-term survival			Expert characterization of JCUs in terms of factors important for the long-term survival of jaguars				
					high (%)	medium (%)	low (%)	connectivity to other JCUs ^e	habitat quality	hunting of jaguar	hunting of prey	population status
1.1 Atlantic/Tropical Moist Lowland Forest												
JCU 252: Atlantic Forests (Brazil)	182	1	25,513	30,843	0	0	100	infrequent dispersal	high	much	much	decreasing
JCU 250: Upper Rio Paraná (Brazil)	182	1	15,269	17,731	0	0	100	infrequent dispersal	high	much	much	decreasing
JCU 257: Misiones (Argentina, Brazil)	113	3	26,131	36,716	47	0	53	no dispersal	medium	much	much	decreasing
1.2 Upper Amazon/Tropical Moist Lowland Forest												
JCU 202: Amazonia (Brazil)	292	1	17,980	38,414	100	0	0	frequent dispersal	high	none	none	stable
JCU 34: Manu (Peru)	252	2	38,162	43,387	88	12	0	frequent dispersal	high	some	some	stable
JCU 253: Madidi (Bolivia, Peru)	252	2	34,836	58,880	74	26	0	frequent dispersal	high	some	some	stable
JCU 79: Noel Kempff Mercado (Bolivia)	252	2	32,315	68,481	81	0	19	frequent dispersal	high	some	some	stable
JCU 63: Amacayacu (Colombia)	252	2	7,538	7,538	100	0	0	frequent dispersal	high	some	some	stable
JCU 207: Macarena (Colombia)	214	6	14,041	21,041	67	33	0	frequent dispersal	medium	some	some	stable
JCU 79: Noel Kempff Mercado (Bolivia)	252	2	32,315	68,481	81	0	19	frequent dispersal	high	some	some	stable
JCU 63: Amacayacu (Colombia)	252	2	7,538	7,538	100	0	0	frequent dispersal	high	some	some	stable
JCU 207: Macarena (Colombia)	214	6	14,041	21,041	67	33	0	frequent dispersal	medium	some	some	increasing
JCU 62: Rio Apaporis (Colombia)	182	7	4,145	4,145	100	0	0	frequent dispersal	high	some	much	stable
JCU 251: Pacaya Samiria (Peru)	179	8	22,930	22,930	100	0	0	no data	high	some	some	no data
JCU 201: Javari (Brazil)	no data	9	67,598	67,598	100	0	0	no data	no data	no data	no data	no data
1.3 Northeast Amazon/Tropical Moist Lowland Forest												
JCU 204: Amapá (Brazil, French Guiana)	252	1	71,746	71,754	100	0	0	frequent dispersal	high	some	some	stable
JCU 208: Vichada (Colombia)	252	1	22,394	22,714	99	1	0	frequent dispersal	high	some	some	stable
JCU 55: Upper Orinoco (Venezuela)	252	1	18,932	56,665	100	0	0	frequent dispersal	high	some	some	stable
JCU 200: Rio Jaú (Brazil)	no data	4	38,162	38,162	100	0	0	no data	no data	no data	no data	no data
JCU 203: Pico da Neblina (Brazil)	no data	4	11,687	11,758	100	0	0	no data	no data	no data	no data	no data
1.4 Southeast Amazon/Tropical Moist Lowland Forest												
JCU 256: Xingu (Brazil)	292	1	32,185	32,185	100	0	0	frequent dispersal	high	none	none	stable
JCU 202: Amazonia (Brazil)	292	1	20,433	38,414	100	0	0	frequent dispersal	high	none	none	stable
JCU 67: Gurupi (Brazil)	133	3	20,211	20,211	100	0	0	no data	medium	some	some	decreasing
1.5 Choco-Darien/Tropical Moist Lowland Forest												
JCU 206: Choco-Darien (Colombia, Panama)	252	1	53,387	70,029	93	6	0	frequent dispersal	high	some	some	stable
JCU 64: Inundables del bajo San Jorge (Colombia)												
JCU 65: San Vicente de Chucuri (Colombia)	146	2	6,916	6,916	0	100	0	infrequent dispersal	medium	some	much	decreasing
JCU 65: San Vicente de Chucuri (Colombia)	75	3	2,630	2,630	0	100	0	infrequent dispersal	poor	some	much	increasing
1.6 Central American/Tropical Moist Lowland Forest												
JCU 155: Selva Maya (Mexico, Guatemala, Belize)	252	1	62,593	63,550	100	0	0	frequent dispersal	high	some	some	stable
JCU 153: Southern Belize (Belize)	252	1	8,425	8,590	99	0	1	frequent dispersal	high	some	some	stable
JCU 206: Choco-Darien (Colombia, Panama)	252	1	7,130	70,029	93	6	0	frequent dispersal	high	some	some	stable

continued

Table 2. (continued)

<i>JGRs^a and JCU^b</i>	<i>Score^c</i>	<i>Ranking in JGR</i>	<i>Area of JCU in (km²)^d</i>	<i>Total JCU area (km²)</i>	<i>Percentage of area rated with given probability of jaguar long-term survival</i>			<i>Expert characterization of JCU in terms of factors important for the long-term survival of jaguars</i>				
					<i>high (%)</i>	<i>medium (%)</i>	<i>low (%)</i>	<i>connectivity to other JCUs^e</i>	<i>habitat quality</i>	<i>bunting of jaguar</i>	<i>bunting of prey</i>	<i>population status</i>
JCU 259: Lago Izabal (Guatemala)	248	4	3,894	5,353	95	0	5	frequent dispersal	high	some	some	no data
JCU 150: Talamanca (Costa Rica, Panama)	214	5	6,125	14,099	31	57	12	infrequent dispersal	high	some	some	increasing
JCU 151: Osa Peninsula (Costa Rica)	182	6	1,591	1,809	0	100	0	frequent dispersal	high	some	much	stable
JCU 154: Guanacaste (Costa Rica)	168	7	2,017	5,323	94	6	0	infrequent dispersal	medium	some	some	increasing
JCU 13: Istmo de Tehuantepec (Mexico)	160	8	9,439	9,579	100	0	0	infrequent dispersal	medium	some	some	stable
JCU 76: La Mosquitia (Honduras)	no data	19,679	30,389	63	0	36	no data	no data	no data	no data	no data	no data
JCU 78: Cordillera Nombre de Dios (Honduras)	no data	9	2,269	2,834	80	0	20	no data	no data	no data	no data	no data
JCU 77: Montaña de Yoro (Honduras)	no data	9	757	2,214	0	0	100	no data	no data	no data	no data	no data
2.1 Tropical Andes/Tropical Moist Lowland Forest												
JCU 253: Madidi (Bolivia, Peru)	252	1	15,436	58,880	74	26	0	frequent dispersal	high	some	some	stable
JCU 21: Baritu-Calilegua (Argentina, Bolivia)	252	1	11,654	12,572	0	0	100	frequent dispersal	high	some	some	stable
JCU 34: Manu (Peru)	252	1	5,227	43,387	88	12	0	frequent dispersal	high	some	some	stable
2.2 Central American/Tropical Moist Montane Forest												
JCU 206: Choco-Darien (Colombia, Panama)	252	1	2,756	70,029	93	6	0	frequent dispersal	high	some	some	stable
JCU 259: Lago Izabal (Guatemala)	248	2	1,166	5,353	95	0	5	frequent dispersal	high	some	some	no data
JCU 150: Talamanca (Costa Rica, Panama)	214	3	7,941	14,099	31	57	12	infrequent dispersal	high	some	some	increasing
JCU 76: La Mosquitia (Honduras)	no data	4	1,704	30,389	63	0	36	no data	no data	no data	no data	no data
JCU 77: Montaña de Yoro (Honduras)	no data	4	1,456	2,834	80	0	20	no data	no data	no data	no data	no data
JCU 78: Cordillera Nombre de Dios (Honduras)	no data	4	566	2,214	0	0	100	no data	no data	no data	no data	no data
2.4 Venezuelan Coastal Montane Forest/Tropical Moist Montane Forest												
JCU 54: Guatopo (Venezuela)	132	1	1,324	1,623	0	100	0	infrequent dispersal	high	some	much	decreasing
2.5 Guayana Montane Forest/Tropical Moist Montane Forest												
JCU 55: Upper Orinoco (Venezuela)	252	1	37,733	56,665	100	0	0	frequent dispersal	high	some	some	stable
JCU 56: Caura (Venezuela)	252	1	18,736	18,736	100	0	0	frequent dispersal	high	some	some	stable
JCU 205: Serra da Estrutura (Brazil)	no data	3	2,819	2,819	100	0	0	no data	high	no data	no data	no data
3.1 North South American/Tropical Dry Forest												
JCU 207: Macarena (Colombia)	214	1	4,074	21,041	67	33	0	frequent dispersal	medium	some	some	increasing
JCU 52: Chiriquare (Venezuela)	182	2	884	977	0	10	90	frequent dispersal	high	some	much	stable
JCU 53: Guaritico (Venezuela)	53	3	771	1,428	0	46	54	no data	medium	much	much	decreasing
3.2 Western Andes/Tropical Dry Forest												
none	—	—	—	—	—	—	—	—	—	—	—	—

continued

Table 2. (continued)

<i>JGRs^a and JCU^b</i>	Score ^c	Ranking in JGR	Area of JCU in JGR (km ²) ^d	Percentage of area rated with given probability of jaguar long-term survival				Expert characterization of JCU in terms of factors important for the long-term survival of jaguars				
				high (%)	medium (%)	low (%)		connectivity to other JCU ^e	habitat quality	bunting of jaguar	bunting of prey	population status
3.3 Chaco/Tropical Dry Forest												
JCU 80: Gran Chaco (Bolivia, Paraguay)	252	1	85,706	100	0	0		frequent dispersal	high	some	some	stable
JCU 24: Chaco (Argentina)	192	2	7,153	0	0	100		infrequent dispersal	high	some	much	decreasing
3.4 Central American/Tropical Dry Forest												
JCU 154: Guanacaste (Costa Rica)	168	1	2,935	94	6	0		infrequent dispersal	medium	some	some	increasing
3.5 Mexican/Tropical Dry Forest												
JCU 101: Jalisco (Mexico)	238	1	29,409	61	5	35		frequent dispersal	high	some	much	decreasing
JCU 100: Sonora (Mexico)	140	2	2,020	100	0	0		infrequent dispersal	medium	much	much	stable
3.6 Cerrado/Tropical Dry Forest												
JCU 68: Chapada das Mangabeiras (Brazil)	252	1	45,397	0	100	0		frequent dispersal	high	some	some	stable
JCU 79: Noel Kempff Mercado (Bolivia)	252	1	36,107	81	0	19		frequent dispersal	high	some	some	stable
JCU 253: Madidi (Bolivia, Peru)	252	1	8,607	0	0	100		frequent dispersal	high	some	some	stable
JCU 258: Pantanal (Brazil, Bolivia)	238	4	9,101	96	0	4		frequent dispersal	high	much	some	decreasing
JCU 69: Marinho (Brazil)	202	5	6,253	0	100	0		frequent dispersal	medium	some	some	decreasing
JCU 8: Araguaia (Brazil)	196	6	29,796	0	100	0		frequent dispersal	medium	some	much	stable
JCU 250: Upper Rio Paraná (Brazil)	182	7	2,462	0	0	100		infrequent dispersal	high	much	much	decreasing
JCU 7: Chapada dos Veadeiros (Brazil)	156	8	10,281	0	100	0		infrequent dispersal	medium	some	some	decreasing
JCU 255: Serra da Capivara (Brazil)	146	9	2,082	0	13	87		infrequent dispersal	medium	some	much	decreasing
4.1 Mexican/Xerics												
JCU 100: Sonora (Mexico)	140	1	10,470	100	0	0		infrequent dispersal	medium	much	much	stable
4.2 Caribbean/Xerics												
JCU 209: Llanos (Venezuela)	196	1	1,491	0	100	0		frequent dispersal	medium	much	some	stable
4.3 Caatinga/Xerics												
JCU 255: Serra da Capivara (Brazil)	146	1	5,111	0	13	87		infrequent dispersal	medium	some	much	decreasing
4.6 Argentine Monte/Xerics												
none	—	—	—	—	—	—		—	—	—	—	—
5.1 Central American Pine Savannas/Herbaceous Lowland Grassland												
JCU 76: La Mosquitia (Honduras)	no data	1	6,633	63	0	36		no data	no data	no data	no data	no data
5.2 Llanos - Gran Sabana/Herbaceous Lowland Grassland												
JCU 209: Llanos (Venezuela)	196	1	5,633	0	100	0		frequent dispersal	medium	much	some	stable
JCU 53: Guaritico (Venezuela)	53	2	657	0	46	54		no data	medium	much	much	decreasing
5.3 Pampas/Herbaceous Lowland Grassland												
JCU 257: Missiones (Argentina, Brazil)	113	1	18	47	0	53		no dispersal	medium	much	much	decreasing
5.5 Amazonian Savanna/Herbaceous Lowland Grassland												
none	—	—	—	—	—	—		—	—	—	—	—
5.6 Pantanal/Herbaceous Lowland Grassland												
JCU 80: Gran Chaco (Bolivia, Paraguay)	252	1	3,410	100	0	0		frequent dispersal	high	some	some	stable
JCU 258: Pantanal (Brazil, Bolivia)	238	2	77,932	96	0	4		frequent dispersal	high	much	some	decreasing

continued

Table 2. (continued)

<i>JGRs^a and JCU^b</i>	Score ^c	Ranking in JGR	Area of JCU in JGR (km ²) ^d	Total JCU area (km ²)	Percentage of area rated with given probability of jaguar long-term survival			Expert characterization of JCUs in terms of factors important for the long-term survival of jaguars				
					high (%)	medium (%)	low (%)	connectivity to other JCU ^e	habitat quality	bunting of jaguar	hunting of prey	population status
5.7 Western Gulf Coastal Grasslands/Herbaceous Lowland Grassland												
none	—	—	—	—	—	—	—	—	—	—	—	—
6.1 Paramo/Herbaceous Montane Grassland												
JCU 206: Choco-Darien (Colombia, Panama)	252	1	5	70,029	93	6	0	frequent dispersal	high	some	some	stable
6.2 Puna/Herbaceous Montane Grassland												
JCU 21: Baritu-Calilegua (Argentina, Bolivia)	252	1	911	12,572	0	0	100	frequent dispersal	high	some	some	stable
6.4 Pantepui/Herbaceous Montane Grassland												
none	—	—	—	—	—	—	—	—	—	—	—	—
7.2 Brazilian Araucaria/Temperate Forest												
JCU 252: Atlantic Forest (Brazil)	182	1	3,060	30,843	0	0	100	infrequent dispersal	high	much	much	decreasing
JCU 257: Misiones (Argentina, Brazil)	113	2	10,567	36,716	47	0	53	no dispersal	medium	much	much	decreasing
7.3 Mexican Pine-Oak/Temperate Forest												
JCU 101: Jalisco (Mexico)	238	1	10,150	29,409	61	5	35	frequent dispersal	high	some	much	decreasing
JCU 100: Sonora (Mexico)	140	2	1,369	13,859	100	0	0	infrequent dispersal	medium	much	much	stable
JCU 12: Sierra Madre Oriental (Mexico)	133	3	21,618	21,618	0	100	0	infrequent dispersal	poor	some	some	decreasing
JCU 102: Sierra Tamaulipas (Mexico)	90	4	1,387	1,387	0	100	0	infrequent dispersal	medium	some	much	stable
8.1 Northern Mexico/Mangrove												
JCU 101: Jalisco (Mexico)	238	1	1,430	29,409	61	5	35	frequent dispersal	high	some	much	decreasing
8.2 Central American/Mangrove												
JCU 206: Choco-Darien (Colombia, Panama)	252	1	660	70,029	93	6	0	frequent dispersal	high	some	some	stable
JCU 76: La Mosquitia (Honduras)	no data	2	1,919	30,389	63	0	36	no data	no data	no data	no data	no data
8.3 Northern South America/Mangrove												
JCU 206: Choco-Darien (Colombia, Panama)	252	1	772	70,029	93	6	0	frequent dispersal	high	some	some	stable
8.4 Amazonia/Mangrove												
none	—	—	—	—	—	—	—	—	—	—	—	—
8.5 Eastern South America/Mangrove												
JCU 252: Atlantic Forest (Brazil)	182	1	1,887	30,843	0	0	100	infrequent dispersal	high	much	much	decreasing

^aThe JGRs are named by region and habitat type. Numeric codes are in Fig. 1, and the geographic information system (GIS) data sets distributed through www.savethejaguar.com.

^bThe JCUs are named using encompassing or adjoining geographic features, including protected areas, rivers, mountain ranges, and/or states and provinces (Fig. 1). The numeric codes refer to indices in the GIS data sets distributed through www.savethejaguar.com.

^cFinal prioritization score for JCU in given JGR. Higher values indicate better conditions for long-term survival of jaguar.

^dArea measured in equal area azimuthal projection, central meridian -72, reference latitude 0.

^eConnectivity interpreted in terms of frequency of dispersal to or from this JCU.

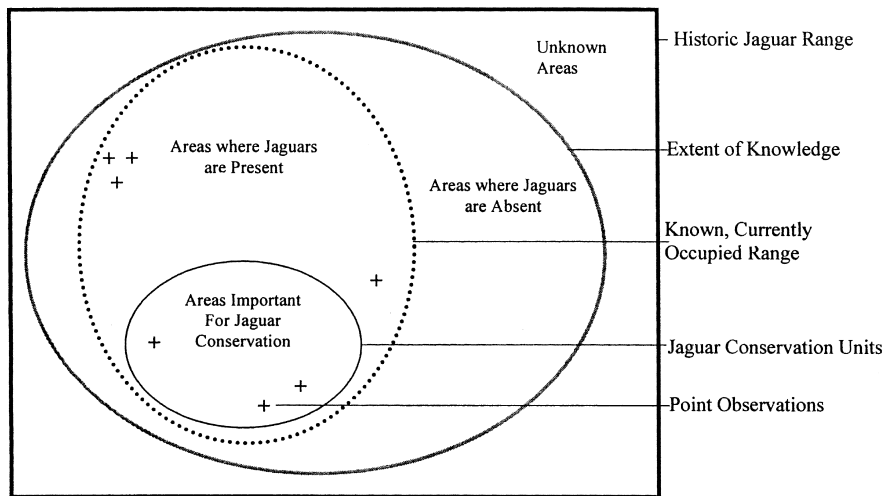


Figure 3. Conceptual framework of geographic data sets for range-wide species conservation planning.

species' status in those areas is unknown. We believe it is important to clearly distinguish between what is known and what is unknown, because conservation choices depend on the state of knowledge. As a result, our range map has several large "holes" because it represents only the known, currently occupied range (Fig. 1b).

Finally this exercise, like the preceding effort for the tiger (Wikramanayake et al 1998), differs from other species-based planning mechanisms because it is based on an ecogeographic framework for setting priorities. The goal is not to determine the most important site for jaguar conservation overall, or the most important site in a given country, but rather to find the most important sites for ecologically distinct populations of jaguars. Because information is insufficient to define these ecological distinctions a priori, we used a geographic proxy, the jaguar geographic regions, which provided the framework over which the data were summarized (Table 1) and JCU's prioritized (Table 2).

All these techniques are designed to limit errors due to the subjective nature of expert-based priority-setting systems by closely tracking how well certain facts are known, where extrapolations are made, and where knowledge is lacking. Moreover, these data are part of framework that provides to any future user the ability to reanalyze the results and draw his or her own conclusions.

Whether or not the end results are "scientific" in a formal sense seems less important than acknowledging the limits of what we can do when planning for species such as the jaguar. The jaguar historically ranged over 19.1 million km², an area over twice that of the United States including Alaska. Within that area there are perhaps 100 professionals working to study and conserve the jaguar; of them, 35 contributed information to this work. Those experts speak three different languages and come from 18 different countries. Through this exercise, they established a common data framework on which they all agreed and a broad consensus on priori-

ties for the species. The result is necessarily extensive in geographic scope and lacking in intensive detail, but it reflects the shared state of knowledge of jaguar status, distribution, and geographic priorities.

Finally, range-wide, species-based conservation planning for the jaguar, or any other broadly distributed species, complements other coarse-filter approaches to conservation planning by testing their generality through an emphasis on single-species requirements. In this case unfortunately, conserving supra-organismal entities such as hotspots or ecoregions provides no guarantee of conserving jaguars across all the ecological settings where they occur, because important locations for jaguars occur outside hotspots and across a large number of ecoregions (>100). Moreover, priorities determined for the jaguar alone may differ considerably from priorities determined through other mechanisms focused on overall biodiversity conservation. As a result, conservation efforts in the Atlantic forests of Brazil might prove an inefficient investment for conservation of the jaguar, given the range of needs and opportunities for jaguar conservation elsewhere. No planning tool meets all goals, but different planning tools can and should complement and enhance one another. With the jaguar exercise, we provide a model to reintroduce species to coarse-filter, international conservation planning efforts.

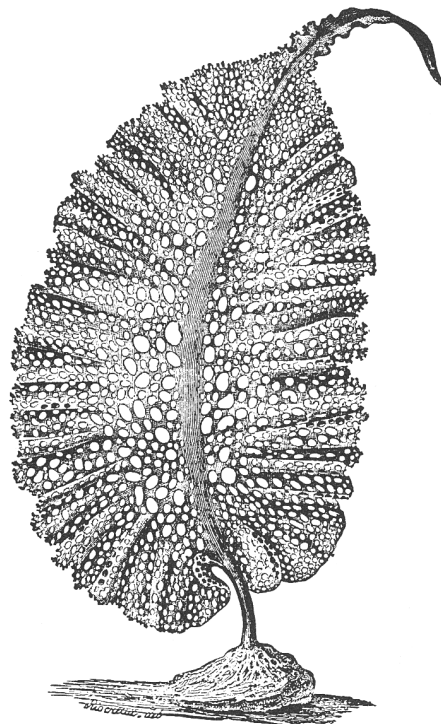
Acknowledgments

We thank H. Hung, G. Raygordetsky, K. Willett, and G. Woolmer for their assistance with data entry and geographic information system analysis and L. Pavajeau for Spanish translation. D. Olson, R. Sayre, and M. Grigione provided helpful advice for design of the priority-setting methodology. The editors and two anonymous reviewers also provided helpful critical reviews of an early draft of this manuscript. This work was funded by grants from

Jaguar Cars-US, the Prospect Hill Foundation, and software donations from the Environmental Systems Research Institute (ESRI).

Literature Cited

- Biodiversity Support Program, Conservation International, The Nature Conservancy, Wildlife Conservation Society, World Resources Institute, and World Wildlife Fund. 1995. A regional analysis of geographic priorities for biodiversity conservation in Latin America and the Caribbean. U.S. Agency for International Development, Washington, D.C.
- Boyce, M. S., and A. Haney. 1997. Ecosystem management: applications for sustainable forest and wildlife resources. Yale University Press, New Haven, Connecticut.
- Callicott, J. B. 1990. Whither conservation ethics? *Conservation Biology* 4:15-20.
- Dinerstein, E., D. M. Olson, D. J. Graham, A. L. Webster, S. A. Primm, M. P. Bookbinder, and G. Ledec. 1995. A conservation assessment of the terrestrial ecoregions of Latin America and the Caribbean. World Wildlife Fund and The World Bank, Washington, D.C.
- Ehrlich, P. R., and A. H. Ehrlich. 1981. Extinction: the causes and consequences of the disappearance of species. Random House, New York.
- Franklin, J. F. 1993. Preserving biodiversity: species, ecosystems or landscapes? *Ecological Applications* 3:202-205.
- Hall, L. S., P. R. Krausman, and M. L. Morrison. 1997. Importance of standardized terminology in habitat evaluation. *Wildlife Society Bulletin* 25:761-762.
- Hunter, M. L. 1991. Coping with ignorance: the coarse-filter strategy for maintaining biodiversity. Pages 266-281 in K. A. Kohm, editor. *Balancing on the brink of extinction*. Island Press, Washington, D.C.
- Hunter, M. L., and A. Hutchinson. 1994. The virtues and shortcomings of parochialism: conserving species that are locally rare, but globally common. *Conservation Biology* 8:1163-1165.
- Lioutty, A. A. 1996. ArcAtlas: our Earth (CDROM). Environmental Systems Research Institute and DATA+, Redlands, California.
- Mann, C. C., and M. L. Plummer. 1995. Noah's choice: the future of endangered species. Knopf, New York.
- Medellin, R. A., C. Chetkiewicz, A. Rabinowitz, K. H. Redford, J. G. Robinson, E. W. Sanderson, and A. Taber. 2001. El Jaguar en el nuevo milenio: una evaluación de su estado, detección de prioridades y recomendaciones para la conservación de los jaguares en América. Universidad Nacional Autónoma de México and Wildlife Conservation Society, México, D.F.
- Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. da Fonseca, and J. Kent. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403:853-858.
- Noss, R. F. 1991. From endangered species to biodiversity. Pages 227-246 in K. A. Kohm, editor. *Balancing on the brink of extinction*. Island Press, Washington, D.C.
- Olson, D. M., and E. Dinerstein. 1998. The global 200: a representation approach to conserving the Earth's most biologically valuable regions. *Conservation Biology* 12:502-515.
- Quigley, H. B., and P. G. Crawshaw. 1992. A conservation plan for the jaguar *Panthera onca* in the Pantanal region of Brazil. *Biological Conservation* 61:149-157.
- Rabinowitz, A. R. 1986. Jaguar: one man's battle to establish the world's first jaguar reserve. Anchor Books, New York.
- Redford, K. H., and B. D. Richter. 1999. Conservation of biodiversity in a world of use. *Conservation Biology* 13:1246-1256.
- Salwasser, H. 1991. In search of an ecosystem approach to endangered species conservation. Pages 228-265 in K. A. Kohm, editor. *Balancing on the brink of extinction*. Island Press, Washington, D.C.
- Seymour, K. L. 1989. *Panthera onca*. *Mammalian Species* 340.
- Slattersfield, A. J., M. J. Crosby, A. J. Long, and D. C. Wege. 1998. Endemic bird areas of the world: priorities for biodiversity conservation. BirdLife International, Cambridge, United Kingdom.
- Soulé, M. E., and M. Terborgh. 1999. Continental conservation: scientific foundations of regional reserve networks. Island Press, Washington, D.C.
- Weber, W., and A. Rabinowitz. 1996. A global perspective on large carnivore conservation. *Conservation Biology* 10:1046-1054.
- Wikramanayake, E. D., E. Dinerstein, J. G. Robinson, U. Karanth, A. Rabinowitz, D. Olson, T. Mathew, P. Hedao, M. Conner, G. Hemley, and D. Bolze. 1998. An ecology-based method for defining priorities for large mammal conservation: the tiger as case study. *Conservation Biology* 12:865-878.
- Zink, R. M., G. F. Barrowclough, J. L. Atwood, and R. C. Blackwell-Rago. 2000. Genetics, taxonomy, and conservation of the threatened California gnatcatcher. *Conservation Biology* 14:1394-1405.



Appendix

Expert contributors to the workshop on "Jaguars in the New Millennium" (March 1999).

<i>Region</i>	<i>Expert contributor</i>	<i>Institution</i>
Northern Mexico	Marcelo Aranda	Instituto de Ecología, A.C., Veracruz, México
	Gerardo Ceballos	Universidad Nacional Autónoma de México
	Carlos A. López González	Northern Rockies Conservation Cooperative
	Rodrigo Medellín	Universidad Nacional Autónoma de México
	Brian Miller	Denver Zoological Foundation
Central America	Bill Van Pelt	Arizona Game and Fish Department
	Eduardo Carrillo	Centro Agronómico Tropical de Investigación y Enseñanza (CATIE)
	Sharon Matola	The Belize Zoo
	Roan McNab	Wildlife Conservation Society
	Carolyn Miller	Wildlife Conservation Society
	John Polisar	Florida Museum of Natural History, University of Florida
	Alan Rabinowitz	Wildlife Conservation Society
	Howard Quigley	The Hornocker Wildlife Research Institute
	Joel Saenz	Universidad Nacional, Costa Rica, Heredia
	Christopher Vaughan	Universidad Nacional, Costa Rica, Heredia
Northern South America	Ernesto Boede	Centro Veterinario "Los Colorados," Venezuela
	Louise Emmons	Division of Mammals, Smithsonian Institution
	Antonio González-Fernández	Universidad Nacional Experimental de los Llanos Occidentales "Ezequiel Zamora"
	Tadeu Gomes de Oliveira	Maranhão State University/Pró-Carnívoros Association
	Rafael Hoogsteijn	Gerente Hatos de Apur, Prohesa y Grupo de Especialistas en Felinos
	Edgardo Mondolfi	Instituto de Zoología Tropical, Universidad Central de Venezuela
	John Robinson	Wildlife Conservation Society
	Leandro Silveira	Pró-Carnívoros Association/Universidade Federal de Goiás
	Melvin Sunquist	University of Florida
	Gerardo Zuloaga Villamizar	Instituto de Ciencias Naturales, Universidad Nacional de Colombia
Southern South America	Peter Crawshaw Jr.	Centro Nacional de Pesquisa para a Conservação de Predadores Naturais (CENAP/IBAMA)
	Julio Dalponte	Universidade de Brasília
	Warren Johnson	Laboratory of Genomic Diversity, National Cancer Institute
	Alicia Kuroiwa	Tambopata Research Centre, Rainforest Expeditions
	Maria Renata Pereira Leite	Duke University
	Ronaldo Morato	Pró-Carnívoros Association/University of So Paulo
	Pablo Perovic	Instituto de Biología de la Altura, Universidad Nacional de Jujuy
	Karina Schiaffino	Centro de Investigaciones Ecológicas Subtropicales, Administración de Parques Nacionales, Argentina
	Daniel Scognamillo	University of Florida
	Andrew Taber	Wildlife Conservation Society