JAGUAR CONSERVATION ASSESSMENT FOR ARIZONA, NEW MEXICO, AND NORTHERN MEXICO

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Draft Final: March 16, 2009

NOTE: Public comment on this document will be accepted through close of business on Friday, April 17, 2009. Please submit comment to either of the following:

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ACKNOWLEDGMENTS

We thank the following: the Arizona-New Mexico Jaguar Conservation Team and its Scientific Advisory Group for providing comment as we worked through drafts of this document; Emil McCain and Jack Childs for editorial suggestions, sharing a wealth of information from the Borderlands Jaguar Detection Project, and persistent diligence in the field despite grossly inadequate funding (we're sorry Emil's truck did not survive); the Malpai Borderlands Group, Sky Island Alliance, and Wildlands Project for providing Web site descriptions of their organizations into this document; Kim Vacariu for allowing us to use a Wildlands Project map depicting jaguar movement corridors in the borderlands; Steve Spangle, Sherry Barrett, Mark Crites, and Erin Fernandez of the U.S. Fish and Wildlife Service for commenting on every draft; Steve Ferrell of the Arizona Game and Fish Department for reviewing the semifinal draft; Melissa Swain for chasing down various publications, sometimes in very obscure places; Alan Rabinowitz for commenting on the semifinal draft; and, last but not least, Ernesto Enkerlin, Oscar Ramirez, Rodrigo Medellin, Gerardo Ceballos, and other colleagues in Mexico who, through discussions in workshops, Trilateral Committee meetings, and other formal and informal venues, helped us shape this document to complement their ongoing work on jaguar conservation strategies for Mexico.

NOTE TO READERS

Borrero (1967) lamented that "possibly no other animal has been more persecuted by humans [than the jaguar], nevertheless it is not the best known species with respect to its habits." Fortunately, although there is still much to be learned, especially in the AZ-NM borderlands, there is now an extensive, rapidly-growing scientific literature on the jaguar and its conservation. Some JAGCT stakeholders wanted us to incorporate all of that literature into this document. We understand their desire, but neither time nor space allowed us to cite or provide a bibliography of all published jaguar works, most of which pertain to South America or Central America. Instead, we cite those that seem most relevant to AZ-NM borderlands issues.

For readers who want to read more about jaguars, we suggest that among the better overall resources (all are included in our Literature Cited section) are: Cavalcanti (2008), Chávez and Ceballos (2006), Brown and López-González (2001), Medellin and others (2002), Nowell and Jackson (1996), Rabinowitz and Nottingham (1986); Seymour (1989); Tewes and Schmidly (1987); and Valdez (2000). Notably, Childs (1998), Childs and Childs (2008), Glenn (1996), McCain and Childs (2008), and Rabinowitz (1986a) also have special relevance to this document, because those authors and the experiences about which they wrote have played crucial roles in AZ-NM borderlands jaguar conservation.

Finally, Alan Rabinowitz, the central figure in jaguar conservation, merits special mention. He has authored, co-authored, edited, and inspired a plethora of publications that provide entry into the world of jaguar ecology and conservation. Perhaps even more important is his jaguar conservation work rangewide, now carried out through Panthera (http://panthera.org), in cooperation with the Wildlife Conservation Society "Save the Jaguar" program, accessible online at: http://www.savethejaguar.com. Start at either Web site and the rest of the jaguar world will rapidly come into focus.

ABBREVIATIONS AND ACRONYMS

For reader convenience, we list below names and terms that are sometimes abbreviated in this document. Also, a Glossary is included (pages 75-78) to define "technical" terms particularly important to concepts in this document (such terms are in **bold** typeface the first time they appear in this document). Both resources were suggested by several JAGCT stakeholders who commented on drafts of this document.

AGFD	Arizona Game and Fish Department
AZ	Arizona
BJDP	Borderlands Jaguar Detection Project
BLM	Bureau of Land Management
CITES	Convention for International Trade in Endangered Species of Wild Fauna and Flora and Fauna (1973, as amended in 1979)
CONANP	Comisión Nacional de Áreas Naturales Protegidas (Mexico's National Commission for Protected Natural Areas)
DHS	Department of Homeland Security
DNA	Deoxyribonucleic acid
EPA	Environmental Protection Agency
ESA	Endangered Species Act (1973, as amended)
HSA	Homeland Security Act
IUCN	The World Conservation Union (previously known as International Union for Conservation of Nature)
JAGCT	Jaguar Conservation Team
JAGSAG	Jaguar Scientific Advisory Group
MBG	Malpai Borderlands Group
MOU	Memorandum of Understanding
NGO	Non-Governmental Organization
NM	New Mexico
NMDGF	New Mexico Department of Game and Fish
PHVA	Population and Habitat Viability Analysis
PROFEPA	Procuraduría Federal de Protección al Ambiente (Mexico's Federal Ministry for Environmental Protection)
SEDESOL	Secretaría de Desarrollo Social (Mexico's Secretariat of Social Development)
SEDUE	Secretaría de Desarrollo Urbano y Ecología (Mexico's Secretariat of Urban Development and Ecology)
SEMARNAT	Secretaría de Medio Ambiente y Recursos Naturales (Mexico's Secretariat of Environment and Natural Resources)
US or USA	United States of America
USCBP	U.S. Customs and Border Protection Agency
USFWS	U.S. Fish and Wildlife Service
WCS	Wildlife Conservation Society
WP	Wildlands Project (now known as Wildlands Network)

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REGARDING MACHO B

Just as the final public-review draft of this document was about to be announced at a Jaguar Conservation Team (JAGCT) meeting on February 19, 2009, the Arizona Game and Fish Department (AGFD) announced to those present that the previous day it had captured a jaguar southwest of Tucson, placed a GPS collar on it, and released the jaguar on-site. The details of these events are more appropriate for a document of a different nature than this conservation overview. However, because of the massive public interest in the events we will summarize in this section the information that is available now (AGFD unpublished data). For more detail, please access http://azgfd.gov/jaguar and click the link that takes you to the Macho B page.

AGFD incidentally captured an adult male jaguar on February 18, 2009, southwest of Tucson, Arizona. The jaguar was caught in a leg-hold snare AGFD had set for mountain lions. The capture site was at approximately 4000 ft elevation, in a transition between desert grassland and oak woodland. AGFD researchers involved in a comprehensive study of wildlife moment corridors were trapping that area because it held three lions and two bears. The research team needed to replace a previously-collared lion from that same area that had been lawfully killed by a hunter. To date, 8 bears and 3 lions have been collared in the study.

AGFD had been authorized by the U.S. Fish and Wildlife Service (USFWS) since 1998 to capture and collar a jaguar. The protocol under which Macho B was handled post-capture was developed by JAGCT, vetted in 2006 and 2007 with JAGCT's Scientific Advisory Group (which includes several renowned experts in jaguar ecology and conservation), and revised by JAGCT in 2007. The JAGCT protocol invokes a jaguar handling-immobilization protocol published by the Wildlife Conservation Society in 2005. Further, while opening their snares in February 2009, the AGFD research field team consulted with veterinarians Roberto Aguilar[1] and Sharon L. Deem[2] to ensure that, if a jaguar were captured incidentally to the lion work, the most-current preferred drug and dosage were prescribed and used (T. Smith personal communication).

The jaguar was immobilized with Telezol so it could be removed from the snare. This had to be done even if the animal were released without any processing or GPS-collaring. However, since the jaguar had to be tranquilized anyway, the research team appropriately took advantage of the situation to physically examine and GPS-collar it. Hair, swab, feces, and blood samples were taken for laboratory analysis and to enable comparison with samples collected in the future. Preliminary examination of its teeth suggested the jaguar was about 14-15 years old. Some teeth were missing or broken, which is typical of an old jaguar. A portable scale indicated the jaguar weighed 118 pounds; 120 lbs is thought to be average for an adult male "northern" (borderlands) jaguar. Overall, the jaguar appeared to be in excellent physical condition, with a full belly.

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[1] Doctor of Veterinary Medicine. Lecturer and veterinary clinician at the New Zealand Wildlife Health Centre. Formerly Director of Conservation and Science at The Phoenix Zoo and Senior Veterinarian at the Audubon Zoo in New Orleans, Louisiana.

[2] Doctor of Veterinary Medicine. Research Veterinarian at the National Zoo (Washington, D.C.), veterinary advisor for the Jaguar Species Survival Plan, and Co-chair of the Infectious Diseases Committee of the American Association of Zoo Veterinarians.

Prior to release, the jaguar was fitted with a 1 lb 12 oz (800 g) Global Positioning System (GPS; a satellite-based navigational system) collar. GPS data downloads were programmed for every three hours for the life of the collar battery (at least 15-18 months and perhaps as much as 24 months). When overhangs and other cover prevented the signal from reaching the satellite network, uploads would be delayed until the signals could re-connect with the satellites. This feature would also prolong battery life.

The jaguar was released on-site six hours after being immobilized (about 3 pm). Delayed release was required under protocol for the drug (Telezol) that was used to calm the animal in the snare. As the jaguar regained its faculties, it began to move away, travelling 2-3 miles before stopping high on a steep, rocky canyon-side. The research team observed the animal until it was out of sight. Then they hiked out to a point at which their cell phone would work, so they could notify their supervisor and Emil McCain of the capture. McCain needed to be notified because he and Jack Childs[3] would be receiving the GPS data and advising AGFD as to the jaguar's movements.

The GPS collar placed on Macho B was donated to the Borderlands Jaguar Detection Project (BJDP) by North Star Science and Technologies specifically for use on a jaguar, if the opportunity ever presented itself. On behalf of AGFD and USFWS, the BJDP had instructed the AGFD bear-lion research team on jaguar handling and use of the GPS collar because they were trapping lions and bears in many areas along the AZ-Mexico Borderlands and occasionally jaguars had been documented in some of those areas since 1996. Simply put, preparedness met opportunity and as a result accurate information began to flow on how one jaguar uses the AZ-Mexico borderlands.

On the evening of February 19, asked Childs and McCain to compare spot (rosette) pattern photographs of the captured jaguar to file photographs of previously-documented jaguars. They immediately confirmed that the captured animal was "Macho B;" a "Betty Boop" spot was evident on the jaguar's left side and a "Pinocchio" spot was evident on the right side. For more information on Macho B and its Betty Boop and Pinocchio spots, see:

> Jack L. Childs and Anna Mary Childs. 2008. Ambushed on the jaguar trail: hidden cameras on the Mexican border. Tucson (AZ): Rio Nuevo Press.

Previous camera-trap photographs had confirmed Macho B's presence in the Arizona borderlands from August 31, 1996 through January 21, 2009. When first photo-documented in 1996, Macho B was estimated to be 2-3 years old. This would make him about 14-16 years old in 2009, which is consistent with the preliminary tooth examination results. More definitive testing is now underway.

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[3] It is impossible to overstate the extent to which the Borderlands Jaguar Detection Project (Jack Childs and Emil McCain), the field arm of the Jaguar Conservation Team, made this capture-and-collaring event possible. Hopefully, Jack's and Emil's contributions to borderlands jaguar conservation will become more evident as this document is read, but for now we wish to again extend our profound appreciation for their past and ongoing efforts. Lots of folks have ready reasons why something should not be tried or will not work. Jack and Emil are always ready and willing to pioneer and are always wonderfully focused on minimizing the inevitable risks.

For several days, GPS data indicated Macho B was recovering from capture stress and moving and resting as expected. Frequently the cat moved between resting sites in boulder piles high on a steep ridgeline and a stream in the bottom of the canyon. The monitoring team speculated that it was initially recovery from the capture and sleeping off the large meal it appeared to have had just prior to capture. The team was elated as data continued to flow in, when overhangs and other obstacles did not block the GPS signals.

Unfortunately, the February 27 GPS locations from Macho B suggested possibly abnormal behavior (a prolonged period of restricted movement). An AGFD field team investigated on February 28 but was unable to locate the jaguar. On March 1, Macho B's movements became more erratic and shorter in distance. Late that day, an expanded field team (including a veterinarian) was able to locate the cat and get a good visual. Clearly, the jaguar was not in good condition. The veterinarian suggested that renal failure was likely and treatment was urgently needed.

Consequently, under exigent circumstances, with hours rather than days or weeks of preparation and through extraordinary cooperation among many agencies and individuals, Macho B was re-captured on the morning of March and immediately extracted by helicopter to The Phoenix Zoo for detailed clinical examination that was not possible in the remote, rugged area where it had been active. At the zoo, the examining veterinarians confirmed that Macho B was suffering from complete renal failure, a terminal condition. Renal failure is common in old cats (and dogs) and it might well have been occurring even before the jaguar was snared. It is also possible that the stress of unanticipated capture exacerbated or even caused the condition. In any event, the zoo veterinarians recommended, and AGFD and USFWS authorized, immediate euthanasia of Macho B, which occurred late in the afternoon on March 2. A comprehensive necropsy is underway, with multiple independent analyses that will hopefully determine the true cause of death and any factors that might have contributed to it. The results are not expected for several weeks.

Any capture of a wild animal entails risks for the captured animals and for those who do the capturing. The key is to manage the risks for all involved. In this case, ten years of preparation and a wealth of hemispheric experience with jaguars had identified the potential risks and procedures by which to manage them. The information expected from GPS collaring was and is needed to guide jaguar conservation efforts in the borderlands. Inadvertent capture unexpectedly provided an opportunity to gather such information. Unfortunately, a medical condition that was not detectable under the capture procedures or in any comparable field situation resulted in a vastly different outcome than was desired or expected. JAGCT, its Scientific Advisory Group, AGFD, and USFWS are already revising those procedures to integrate what has been learned from this experience.

The media and public attention to the capture, monitoring, and death of Macho B has truly been amazing. The initial reaction among the media, the public, and borderlands jaguar stakeholders was of course almost universally positive, as would be expected with the first capture and radiocollaring of a jaguar in the United States. JAGCT member agencies and participating individuals and organizations were ecstatic, but the tide soon turned.

The euthanasia of Macho B on March 2 is now generating considerable recrimination and criticism from some circles. Constructive criticism is always helpful, and in fact is essential to improvement,

but some of the allegations are at best ill-informed, if not blatantly, perhaps even self-servingly, speculative and inaccurate. We make no effort herein to defend the agency actions or to rebut the criticisms. We simply make note of them now because to ignore the events and public attention of February 18 through today while releasing this public comment draft seemed silly. For the better part of February, we seemed on the verge of beginning to fill in so many of the borderlands information gaps that will become evident as one reads this document. Now, as Bill Van Pelt said in an interview after Macho B had been euthanized, now those secrets will remain unveiled. We all share the sorrow about what happened with Macho B but we also look forward to future borderlands jaguars and future opportunities to learn more about them.

For now, we close with the words of Theodore Roosevelt:

> It is not the critic who counts; not the man who points out how the strong man stumbles, or where the doer of deeds could have done better. The credit belongs to the man who is actually in the arena, whose face is marred by dust and sweat and blood; who strives valiantly; who errs, and comes short again and again; who knows the great enthusiasms, the great devotions; who at the best knows in the end the triumph of high achievement, and who at the worst, at least fails while daring greatly, so that his soul shall never be with those cold and timid souls who know neither victory nor defeat.

On February 18, 2009, the AGFD field team was the man in the arena. Some of us are still there and will undoubtedly be there again. Wildlife conservation depends on an abundance of solid information and it is our responsibility to get that information. Risks must be managed carefully, but they cannot always be eliminated. The knowledge gained through experiences with Macho B will help improve our efforts in the future but do not doubt that those efforts will be made. They must be made. The AZ-NM borderlands wildlife legacy to future generations depends on them.

JAGUAR CONSERVATION ASSESSMENT
FOR ARIZONA, NEW MEXICO, AND NORTHERN MEXICO

This is an assessment of issues relevant to jaguar **conservation** in the borderlands that are shared by Arizona, New Mexico, and Mexico. It focuses on a variety of biological and legal (regulatory) issues, but also addresses aspects of the human dimension that affect the conservation effort. It was developed to update and replace a *Conservation Assessment and Strategy for the Jaguar in Arizona and New Mexico* (Johnson and Van Pelt 1997). The Arizona Game and Fish Department (AGFD) and the New Mexico Department of Game and Fish (NMDGF) also used drafts of this document to develop a *Jaguar Conservation Framework for Arizona, New Mexico, and Northern Mexico* (AGFD and NMDGF 2007). The Framework, the Assessment, and a 2007 Memorandum of Understanding (MOU) between AGFD and NMDGF now collectively provide an **adaptive management** umbrella under which the two state wildlife agencies lead the array of government cooperators and stakeholders known as the AZ-NM Jaguar Conservation Team (JAGCT).

1. Introduction

Despite a long history of jaguar (*Panthera onca)*[4] presence in the AZ-NM/Mexico borderlands, jaguar conservation in the area did not begin until 1996. In March and August (respectively) of that year, Warner Glenn (1996) photographed a jaguar in New Mexico and Jack Childs (1998) photographed a different one in Arizona. By early 1997, Glenn's and Childs' sightings and their interest in doing something positive for jaguars had helped spur AGFD and NMDGF to complete a *Conservation Assessment and Strategy for the Jaguar in Arizona and New Mexico* (Johnson and Van Pelt 1997), execute a companion Memorandum of Agreement, and establish the JAGCT to develop a borderlands jaguar conservation effort (Van Pelt and Johnson 2002). In 2006-2007, AGFD and NMDGF discussed JAGCT progress with cooperating agencies and stakeholders from nongovernmental organizations and the public. The process culminated in this assessment and the 2007 MOU and 2007 Conservation Framework mentioned above.

Most, perhaps all, participants in JAGCT have at least one thing in common: an interest in jaguar conservation. Many also agree on specific elements of the conservation effort. But, typical of diverse groups, sometimes stakeholders disagree with each other. For example, they agree or disagree to varying degrees on: historical presence (i.e. natural or anthropogenic?) and current status (i.e. resident or transient? discrete **population** or part of a larger population centered in Mexico?) of the jaguar in Arizona and New Mexico; approaches to conservation (e.g. regulatory vs. voluntary) and management (e.g. hands-off vs. hands-on); what the **scientific method** involves; uses of public lands (e.g. ranching vs. recreation; multiple-use vs. wilderness designation); private property rights; and issues pertaining to illegal immigration and national security needs along the U.S.-Mexico border. Sometimes it seems that JAGCT participants reject something not because it is not credible or worthwhile but because of how (or by whom) it was presented or where it might lead. This can lead to frustration that affects the thrust of further discussion and sometimes constrains progress. Frankly, some topics seem almost as contentious

[4] *Panthera* is used herein as the genus for the jaguar, per Pocock (1939), Nowak (1999), and others. Various earlier publications, including some referenced herein, referred it to the genus *Felis*.

today as they were in 1997. Although discourse in JAGCT meetings is almost invariably courteous and respectful, at times distrust is readily apparent. This makes it all the more remarkable that so many stakeholders have been engaged in this effort for the past decade and that they continue to work – much, much more often cooperatively than not – toward a better tomorrow for borderlands jaguars.

In light of the above, it occurred to us that JAGCT tends to focus too much on jaguars and not enough on the human dimension on which success of borderlands jaguar conservation depends. Perhaps more attention to that aspect in JAGCT meetings might bring closure on key issues and enable greater progress. In keeping with that thought, we will endeavor to use this document as a vehicle for acknowledging and addressing some of the more important "bones of contention" that a decade of JAGCT discussion and activity, and in some cases independent peer-reviewed scientific publications, have not put to rest. Perhaps in doing so we can help the JAGCT "close the circle" of jaguar science, social issues, and commitment to public process and fair play (see Bormann and Kellert 1991). In any event, this effort has made this document something other than a "typical" status assessment, a fact that several individuals who commented on earlier drafts noted (with varying degrees of comfort and agreement).

2. Species Biology

The jaguar is the largest wild cat native to the Western Hemisphere and the only one that roars. It is mostly nocturnal, with considerable activity taking place in the early-morning and late-evening hours (some authors include these two periods in nocturnal, others do not). Jaguars are also active in daylight hours sometimes, though much less so in very hot, dry environments such as the AZ-NM/Mexico borderlands. Physical attributes of this species are well known, as are its food habits. Relatively recently, its movement, **habitat** use, and reproductive behavior patterns have begun to be well understood but accurate information about jaguar social relationships and **population dynamics** remains scarce. As will become clear below, by far most of the available information on all aspects of jaguar biology comes from portions of the historic and **occupied range** south of the AZ-NM/Mexico borderlands.

2.1. Taxonomy

The 1997 jaguar conservation assessment (Johnson and Van Pelt 1997) reflected the understanding of jaguar taxonomy current at that time. Five subspecies were recognized by Hall (1981) but eight by Pocock (1939) and Seymour (1989); all three authors recognized two subspecies with **historical range**s extending into the United States: the Arizona jaguar (*Panthera onca arizonensis*) and the northeastern jaguar (*P. o. veraecrucis*). Records from Arizona, New Mexico, and California were attributed to *arizonensis*, the type specimen of which was collected in 1924, near Cibeque, Navajo County, Arizona (Goldman 1932).

More recent work suggests that subspecies recognition might not be warranted in jaguars. Larson (1997), using 11 skull characters and multivariate statistics to evaluate 170 skulls of known origin, re-evaluated skull morphologies that led some predecessors to assign jaguars to as many as eight subspecies. Larson found that variation in skull characteristics within the previously-recognized subspecies exceeded variation between the subspecies; thus, he opined that subspecies recognition

was not warranted. Molecular genetics subsequently supported that conclusion (Eizirik and others 2001; Johnson and others 2006), which is consistent with the treatment in *Walkers Mammals of the World* (Nowak 1999): *Panthera onca* is monotypic, i.e. it is a species that has no subspecies. Nevertheless, other investigators have continued to come to different conclusions about how many forms of jaguar warrant recognition. Johnson and others (2002) found that mitochondrial DNA analysis weakly supported two phylogeographic groups of jaguars, one north and one south of the Amazon River, South America, although there was evidence of continued gene flow between the two groups. Ruiz-Garcia and others (2006) reported that DNA microsatellite analysis indicated the jaguar population in Colombia (South America) included individuals from two subspecies (*P.o. centralis* and *P.o. onca*). Wozencraft (2005) recognized nine subspecies of jaguar rangewide, including *P. o. arizonensis*. As investigative techniques evolve, work will continue on jaguar systematics and taxonomy and perhaps produce a definitive decision on which (if any) subspecies should be recognized within *Panthera onca*.

2.2. Description

The jaguar, a member of the cat family (Felidae), is allied with the "roaring" cats and is most closely related to the African lion (*P. leo*), leopard (*P. pardus*), tiger (*P. tigris*), snow leopard (*P. uncia*), and clouded leopard (*Neofelis nebulosa*) (Johnson and others 2006; Nowak 1999). It is the largest species of cat native to the Western Hemisphere and the third largest in the world (Nowak 1999; Seymour 1989). It is also the only "roaring" cat in the New World (Nowell and Jackson 1996; Tewes and Schmidly 1987).

Linnaeus (1758) originally described the jaguar as *Felis onca* (see also Nelson and Goldman 1933). However, *Panthera onca*, first used in 1869, is now the accepted scientific name (Nowak 1999; Pocock 1939; Seymour 1989). The predominant English common name, "jaguar," is possibly derived from a Tupiguaraní (Amazon Basin Indian) word meaning "carnivore that overcomes its prey at a single bound" (Liais 1872) or "wild beast that dominates its prey in one jump" (Rosa and Nocke 2000). Another derivation is offered by Merriam-Webster (2007): jaguar etymology – Portuguese, from Tupi *jawará* large carnivore. However, the origin and meaning of "jaguar" have been challenged online. A non-refereed and independently-operated etymological Web site (http://www.takeourword.com/tow198/page2.html) asserts: "Tupi-Guarani…scholars indicate…*jaguara* was originally a word that referred to all carnivorous animals….The Tupi-Guarani word for *Felis onca* is *jaguareté*, where *eté* means 'true'." The origin of the predominant Spanish common name, "el tigre," is obvious: it is a direct reference to the largest and fiercest cat of all, the tiger. While describing his travels in Sonora, Mexico, from 1756 to 1767, Father Ignaz Pfefferkorn (1795), a Jesuit missionary, mentioned the "tigers" (jaguars) of the area. "El tigre" is still commonly used by Spanish-speaking peoples in Mexico when referring to the jaguar. Regardless, by any name or derivation the jaguar is a big, fierce cat.

Rangewide, jaguars measure about five to eight feet from nose to tip of tail and weigh from 80 to 348 lb, although the 80 and 348 lb weights are exceptional (Nowak 1999; Nowell and Jackson 1996; Seymour 1989). Males are typically 10 to 25 percent larger than females (Emmons 1999; Rich 1976; WCS 2007), or perhaps 20 to 30 percent larger (Sunquist and Sunquist 2002; Sunquist and Sunquist 2007). In the southern part of the range, females tend toward 100 to 150 lb and males toward 170 to 220 lb. In Central America and southern Mexico, both sexes trend

slightly larger than they do to the north or south. Leopold (1959) listed a weight range in Mexico of 140 to 250 lb for males and 100 to 180 lb for females. Reliable data are still scarce (many published weights are estimates), but jaguars from northern Mexico and the southern United States tend to weigh about as much as mountain lions (*Puma concolor*): males average about 120 lb and females about 80 lb (see Brown and López-González 2001).

Jaguars have a relatively robust head, compact but muscular body, short limbs and tail, and powerfully-built chest and forelegs (Rosa and Nocke 2000; Leopold 1959; Nowak 1999; Tewes and Schmidly 1987; WSC 2007). Their short, muscular limbs are well suited to climbing, swimming, and crawling (Nowell and Jackson 1996; WCS 2007). They have the strongest teeth and jaws of any New World cat and their skull is more massive than a mountain lion's (Brown and López-González 2001). Their canines are well developed (Seymour 1989).

The overall coat of a jaguar is typically pale yellow, tan, or reddish yellow above, and generally whitish on the throat, belly, insides of the limbs, and underside of the tail, with prominent dark spots or blotches throughout (Seymour 1989). Jaguars are easily distinguished from adult mountain lions, the only other large cats native within their range, by the former's distinctive dark spots, which have small dots or irregular shapes within larger rosette markings (Nowak 1999). Young mountain lions also have black-spotted coats, which persist up to their third year of life, but their spots occur in three irregular dorsal lines and transverse rows (Currier 1983), while those of jaguars persist throughout life and in juveniles look like those of adults.

The black or blackish-spotted rosette pattern of a jaguar might act as camouflage, and no two jaguars have the same coloration or are marked exactly alike (Brown and López-González 2001). Color and spotting patterns differ even from one side of a jaguar to the other (Nelson and Goldman 1933) and can be used to identify individuals (Maffei and others 2004; McCain and Childs 2008; Silver 2004; Silver and others 2004; Wallace and others 2003).

Black or blackish (melanistic) jaguars also occur naturally – but not in the United States. Jaguars are among the few species of wild cats in which melanism occurs (the leopard is another), but even in melanistic jaguars the underlying rosettes are evident. Melanism in jaguars is caused by a dominant mutation of a single gene (Eizirik and others 2003; Kitchener 1991; Sunquist and Sunquist 2002). Melanistic jaguars occur naturally in the Amazon Basin, comprising about six percent of the population (Brown and López-González 2001). There are unsubstantiated reports from Central America, north to Belize (see Meyer 1994). Brown and López-González (2001) asserted that no naturally occurring black jaguars have been confirmed north of Mexico's Isthmus of Tehuantepec. Dinets and Polechla, Jr. (2005) published a photograph of a melanistic jaguar from northwestern Mexico, but the publication was not peer reviewed and jaguar experts in Mexico question validity of the photograph (B. Van Pelt personal communication).

Although the best available science does not support occurrence of a black jaguar in Arizona or New Mexico or black mountain lions anywhere (see below), black jaguars and other "big black cats" have been and continue to be reported (AGFD and NMDGF unpublished data). These reports, particularly one in 1910 near Silver City in southwestern New Mexico (McKenna 1969), typically generate considerable discussion in JAGCT meetings, so we will address the possible explanations fairly thoroughly in hopes of putting the subject to rest.

As with sightings of "typical" jaguars, those of black jaguars are often too old or the sighting location is too poorly described to warrant follow-up by AGFD or NMDGF. When they are investigated, they most often are attributed to anything from a black dog to a bobcat to a feral housecat. Escape of a captive black jaguar (or leopard) and subsequent observation by the public is another possible explanation for such sightings, but this seems unlikely to occur repeatedly and in widely separate areas. Moreover, if such an escape occurred one might reasonably expect considerable media coverage and a spate of sightings before the animal was captured, died, or disappeared. Most reports received by AGFD and NMDGF are of single animals seen once by one person. An exception recently occurred in southern Arizona: multiple people, including local government employees, reported with great certainty that a big black cat was leaving very large tracks in and around a relatively rural residential area south of Tucson. Investigation found it to be a large black Labrador retriever (AGFD unpublished data).

What then is the origin of reports of black jaguars in the AZ-NM borderlands? Perhaps it is the power of suggestion. A jaguar was illegally killed in southern Arizona in 1971 (Brown 1991, 1997) and for nearly 30 years jaguar news stories in the Southwest tended to be illustrated by file photos of live captives. Apparently the most readily available file photos were of melanistic animals, perhaps because they are prevalent in zoos, easily photographed, and striking in appearance. Sighting reports in Arizona often follow close behind any jaguar media coverage, and when a photo of a black jaguar appears in the coverage experience tells us to expect a spate of reported sightings of big black cats. Fortunately, remote-camera work by Emil McCain and Jack Childs in southern Arizona since 1997 has yielded photographs of "typical" Arizona jaguars that seem to have replaced black jaguars of unknown origin in recent media coverage.

Bad lighting is another possible explanation. In low light and when they are facing or quartering away, "typical" jaguars appear very dark, if not black (E. McCain personal communication). However, both the number and the widespread locations of "black jaguar" sightings in AZ-NM suggest another explanation, one that is not unique to AZ-Nm. Jaguars once occurred in Texas, but none have been documented there since two were killed in 1946 and 1948 (USFWS 1993). Texas does have an abundance of mountain lions and a corresponding abundance of "black panther" sightings. Texas Parks and Wildlife Department (TPWD 2007) offers a simple, logical explanation for these sightings on its Web site: "[mountain lion] fur is a light, tawny brown color which can appear gray or almost black, depending on light conditions. Contrary to popular belief, there are no black panthers in North America; no one has ever captured or killed a black Mountain Lion." Indeed, melanism has not been documented in the mountain lion. Currier's (1983) exhaustive species account for The American Society of Mammalogists (TASM) does not list melanism as occurring in mountain lions. When it occurs in other species covered in the TASM series, the species account addresses it (e.g. the jaguar; Seymour 1989).

So, a mountain lion, seen by a casual observer, perhaps even a skilled observer, especially if seen briefly and unexpectedly in poor lighting (as might occur at dawn or dusk), could easily become a "black jaguar" report. Most people would be thrilled to see a wild mountain lion, and a wild jaguar would likely be even more exciting. If a "black jaguar" is what they have seen in the media or in a zoo, it seems all the more likely that is what they will "see" in the field. As George (1995) succinctly stated: "People surely perceive what they want to, whether they're reading

patterns in inkblots, seeing 'the man in the moon,' or hearing messages in shower spray hitting against the curtain." Or seeing black jaguars where none occur.

2.3. Distribution and Abundance

The distribution and abundance of any species of wildlife should be straightforward, a matter of verifiable fact, but often they are not, especially when the animal is secretive, rare, nocturnal, or another species can be mistaken for it. Reports and records, whether historical or recent, often vary considerably in quality (and accuracy). So do observers. Also, humans can affect distribution and abundance in many ways, some intentional and some not. These factors can give rise to doubts. For example, some JAGCT stakeholders still question whether jaguars are even native to the Southwest, speculating that perhaps early European explorers brought them here. Such speculation, however, seems to be definitively refuted by both cultural and fossil records.

The jaguar was prominent in New World art, myth, folklore, and religion long before Hernán Cortés' conquistadores arrived on Mexico's east coast in 1519 and completed the Spanish conquest in 1521 (see: Baldwin 1998; Carmony 1995; Coe 1992; Covarrubias 1954, 1957; Daggett and Henning 1984; Plotkin 1993; Shele and Miller 1986; Smith 2003; Weaver 1993).

The jaguar's "most honored status…was achieved during the reign of the great Native American civilizations that formerly [i.e. before Cortés] occupied Mesoamerica[5]" (Brown and López-González 2001). For 2000 to perhaps more than 3000 years, jaguars served Mesoamerican cultures as icons of great importance, symbols of power and ferocity. They were prominent in ancient architecture and the costumes of royalty and warriors. Alive they were thought to possess the ability to move between the living world and the spirit world, which was probably important for cultures that featured were-jaguars, rebirthing of royalty as a means of immortality, and human sacrifice. The Maya word "balam" held two meanings: jaguar and priest. The Jaguar Knight (*Ocelotl*) was one of the Aztec Empire's two highest military ranks of professional soldiers. Popocatepetl, Jaguar Knight hero of an ancient Aztec legend (a tragedy that unfolds like Shakespeare's *Romeo-and Juliet*), lives on today 45 mi southeast of Mexico City, in the form of Mexico's most active volcano, the smoke from which drifts across his lover, Iztaccihuatl, now a nearby volcano.

Linkage of jaguars and humans continues throughout Mesoamerica today, where the Maya and other components of the Aztec Empire still live. Jaguar icons are still culturally prominent, as witnessed in almost any *mercado* or artisan store in Mexico that sells masks for decorative, festive, or ceremonial use, and in the fabulous collections in the Museo Rafael Coronel (Zacatecas, Zacatecas), Museo Nacional de la Máscara (San Luis Potosi, San Luis Potosi), and Museo Nacional de Antropología (Mexico City, Distrito Federal). Jaguar masks are well represented in Mauldin's (1999) *Masks of Mexico: tigers, devils, and the dance of life*.

The jaguar's relative but not complete absence as a cultural icon in the American Southwest suggests it was less common in that area than it was in Mesoamerica in recent history (B. Miller, A.

[5] In this context, ancient Mesoamerica = roughly central Mexico, Belize, Guatemala, and western Honduras and El Salvador.

Rabinowitz, and C. López personal communication). However, "less common" is not at all the same as "absent" (E. McCain personal communication).

Small wonder that jaguars were well known to natives in what is now Mexico, and the surrounding region (including the American Southwest), long before conquistadores arrived; they had been there for millennia. Ancestors of the modern jaguar arrived in North America from the Old World, presumably via the Bering Strait land bridge, in the early Pleistocene Epoch (Arroyo-Cabrales 2002). The Pleistocene extended from about 1.8 million to 10,000 years Before Present (BP) (GSA 1999). The epoch included cycles of continental glaciation world-wide, the last glacial maximum occurring about 18,000 radiocarbon years BP (Thompson and Anderson 2005). The glacial and interglacial periods were accompanied by great changes in climate and floral and faunal composition (Betancourt and others 1990; Martin 2005; Martin and Klein 1984; Ramamoorthy and others 1993). The jaguar was among the many species affected.

The fossil record documents pre-historical distribution of the jaguar throughout much of what is now the United States, although most of the remains belong to an extinct race (Daggett and Henning 1984; Simpson 1941). After the Pleistocene ended, another interglacial period began (it continues today) and the climate trended warmer and drier. As with other cool-adapted species, the jaguar's range retracted to the south (Kurtén and Anderson 1980; Seymour 1989). Today, the jaguar occurs locally from the southwestern United States (Arizona and New Mexico) to Brazil and Argentina (Chávez and Ceballos 2006; McCain and Childs 2008; Nowak 1999; Nowell and Jackson 1996; Seymour 1989).

As for abundance, nowhere is the jaguar common. It is, however, relatively more common in parts of South America, Central America, and central to southern Mexico than it is in northern Mexico or in the borderlands the United States shares with Mexico. C. Miller and M. Kelly (personal communication referenced in Meerman 2005) provided Wildlife Conservation Society survey data indicating that jaguar densities in three discrete study areas in Belize were as follows: 6.8[6] in Chiquibul; 8.8 in Cockscomb Basin; and 11.3 in Gallon Jug. "Camera-trapping"[7] in two reserves in Belize (Central America) and three reserves in Bolivia (South America) yielded density estimates ranging from 2.84 in Bolivia to a high of 8.8 in Belize (Silver and others 2004). On a cattle ranch in the southern Pantanal of Brazil, Soisalo and Cavalcanti (2006) estimated jaguar density ranged from 6.6 to 10.3 jaguars/100 km^2, using camera trapping and GPS telemetry. Ceballos and others (2002) reported that jaguar density in the Calakmul Biosphere Reserve of southern Mexico was 6.67 (Note: converted from the authors' 1 per 15 km^2). Grigione and others (2001) reported that preliminary evidence indicated jaguar density in three **metapopulation**s in northern Mexico was 1.3 to 1.5. Rosas-Rosas (2006) reported a conservative approximation of jaguar density of 1 in the Nácori Chico area of northern Sonora (Mexico). Due to the scant information available and vast areas lacking any organized survey or monitoring effort (and perhaps due the low numbers of jaguars), no density estimate is possible for the AZ-NM borderlands north of the U.S.-Mexico International Border.

[6] All densities reported herein are presented as jaguars per 39 mi^2 (100 km^2).
[7] See: Gese 2001; Rosas-Rosas 2006; Soisalo and Cavalcanti 2006; Wallace and others 2003).

United States – The jaguar's recent historical range in the United States includes portions of Arizona, New Mexico, and Texas, and perhaps California and Louisiana (Bailey 1905; Brown 1983; Davis 1982; Goldman 1932; Hall 1981; Hoffmeister 1986; Lowery 1974; Swank and Teer 1987, 1989; USFWS 1980, 1994, 1997). Nelson and Goldman (1933) described the distribution of the *arizonensis* subspecies as: the mountainous parts of eastern Arizona north to the Grand Canyon; southwestern New Mexico; northeastern Sonora; and southeastern California.

The jaguar was probably an uncommon resident in the southwestern United States in recent history (e.g. Rabinowitz 1999; Seymour 1989). Brown and López-González (2000, 2001) published the most comprehensive occurrence information for the U.S. portion of the range, noting that virtually every published jaguar distribution map includes portions of New Mexico and Arizona in the historical range. Records from Arizona and New Mexico for 1900 to 2000 ranged from the Grand Canyon (AZ) and the Datil Mountains (NM) to the U.S.-Mexico border (Brown and López-González 2000, 2001). Hill (1942) also cited a report from near Springer, northeastern New Mexico.

Goldman (1932) and Hoffmeister (1986) believed the jaguar was once a regular, but not abundant, resident in southeastern Arizona. Although lone jaguars were known to have been killed in Arizona in 1971 and 1986 (see: Brown 1991, 1997; Brown and López-González 2000, 2001; Valdez 2000), the species was widely considered extirpated from the United States by the mid-1900s (Brown and Davis 1995; Nowak 1999). However, in 1996, two mountain lion hunters independently confirmed that jaguars were still, or were again, present in the AZ-NM borderlands. The first man, rancher Warner Glenn, and his daughter Kelly Glenn-Kimbro, took photographs of an adult male jaguar running before hounds on March 7, 1996, in the Peloncillo Mountains, in southwestern New Mexico near the Arizona border (Glenn 1996). The Peloncillos run approximately north-south to the Mexican border, where they join the foothills of the Sierra San Luis and other mountain ranges connecting to the Sierra Madre Occidental. The second man, Jack Childs, was in the Baboquivari Mountains of southcentral Arizona when, on August 31, 1996, he and colleague Matt Colvin photographed and videotaped a male jaguar treed by their hounds (Childs 1998; Childs and Childs 2008). In contrast to the 1971 and 1986 incidents, neither Glenn nor Childs killed the jaguars they observed.

Jaguars have also been photographed in the AZ-NM borderlands since 1996, including the one that Child and Colvin photographed in 1996. In southcentral Arizona, near the Mexico border, McCain and Childs (2008) documented repeat occurrences of at least two different individuals from 2001 through March 2007; one of these animals was also documented in August 2008 and January 2009 (McCain and Childs 2009) and February 18 through March 2, 2009 (Johnson and Van Pelt, unpublished data). In New Mexico, Warner Glenn observed and photographed another adult male jaguar on February 2006 in Hidalgo County; it was not the same one that Glenn saw and photographed in 1996 (W. Glenn personal communication).

For some, the accumulating information began to suggest persistence, if not residency. McCain and Childs (2008) make a compelling case that adult jaguars might be resident (albeit in very low numbers) in the AZ-NM borderlands shared with Mexico. Four and perhaps five individual jaguars have been documented north of the International Border since March 1996, and at least one of them ("Macho B"), estimated to be 2-3 years old when first seen, occurred there over a

period of almost 13 years (August 1996 – March 2009) (Childs and others 2007; McCain and Childs 2008, 2009; Johnson and Van Pelt unpublished data).

Contrary to some inferences, McCain and Childs (2008) did not make a case for occurrence of a jaguar population in the borderlands. Their focus was on persistence and possible residency of individual. As noted by A. Rabinowitz (personal communication) after considering McCain and Childs (2008), one persistent (perhaps even resident) individual or a few individuals does not constitute a resident (viable) population. Rabinowitz (1997, 1999, personal communication) also suggests that the evidence does not support a conclusion that **suitable habitat** for establishing a persistent population (i.e. one that is continually present) exists in the United States.

Northern Mexico - Swank and Teer (1987, 1989) described jaguar distribution in Mexico as a broad belt from central Mexico to Central America, the most northerly established populations occurring in southern Sinaloa and southern Tamaulipas. Anderson (1972) considered the jaguar a "species of postulated occurrence" in Chihuahua, Mexico, referencing "infrequent reports of wandering" individuals that "enter the state from the west [Sonora] and presumably do not remain long." Although jaguars had been considered relatively common in Sonora in the 1930s and 1940s, Brown (1991) and Swank and Teer (1987, 1989) stated that a population in southern Sinaloa and Tamaulipas, about 800 miles south of the U.S.-Mexico border, was the most northern population reported by Mexican officials. However, Brown (1991), based on discussions with back-country residents in Mexico during the 1980s, also speculated that jaguars had not been extirpated from northern Mexico and might be more persistent in Sonora than had been reported officially. He mentioned hearing about two jaguars killed in central Sonora around 1970, and assertions by local Indians that male and female jaguars still occurred in the Sierra Bacatete of Sonora, 200 miles south of Arizona. Brown speculated a resident population of jaguars in those mountains could be the **source population** for individuals that travel northward through the Sierra Libre and Sierra Madera until they reach Arizona.

Chávez and Ceballos (2006), drawing on Aranda (1998), Chávez and others (2005), and Monroy-Vilchis and others (2005; see also Monroy-Vilchis and others 2008), depicted the distribution of jaguars in Mexico as continuous from north of the Isthmus of Tehuantepec along both the east and west coasts north to the United States. However, the northernmost breeding population in Mexico is now known to be centered in (but not restricted to) east-central Sonora, around Huasabas, Sahuaripa, and Nácori Chico, about 140 miles south of the U.S.-Mexico border (Brown and López-González 2001; López-González and Brown 2002; Rosas-Rosas and others 2008; Valdez 2000; see also Rosas-Rosas 2006). The Huasabas-Sahuaripa area was well known to American sport hunters decades ago; legendary houndsmen-guides Dale and Clell Lee helped clients kill eight jaguars there between 1935 and 1937 (Brown and López-González 2001). The Huasabas-Sahuaripa population is the northernmost of three extant metapopulations in Sonora that were identified by Grigione and others (2001) and López-González and Brown (2001), the more southerly two being the Sierra Bacatete and Quiriego-Sinaloa.

The Arizona and New Mexico jaguars reported from 1996 through 2009 (Childs 1998; Glenn 1996; Childs and Childs 2008; McCain and Childs 2008, 2009) almost certainly belong to the northernmost (Huasabas-Sahuaripa) population known in Mexico (Rosas-Rosas 2006). No physical evidence of this linkage (e.g. DNA, spot-pattern matches) has been obtained to date, but

the logic seems compelling. Thus, for purposes of JAGCT and this document, the range of the "northern jaguar population" is considered to extend from Alamos (Sonora, Mexico) north through the Sierra Madre Occidental of Chihuahua and Sonora and the river valleys, foothills, and scrublands of central Sonora into southcentral and southeastern Arizona and southwestern New Mexico. Jaguars are no doubt distributed unevenly (in a temporal as well as a spatial sense) across that region, reflecting their territorial nature and the variety of conditions present. Some **habitat patches** in that region are clearly suitable for (occupied by) jaguars, others are not, others are marginal, and the nature or suitability and occupancy of any given habitat patch might change seasonally or from year to year in response to prey base dynamics or other factors (e.g. temperature and availability of water; see Section 2.5).

2.4. Reproduction, Lifespan, and Mortality.

Jaguar breeding has been documented year-round both in the tropics and captivity, but individual females breed only every two or three years if they have cubs (Ewer 1973; Gomes de Oliveira 1994). In Belize, jaguars usually bear young during the rainy season, when native prey are more abundant (Rabinowitz 1986b; Rabinowitz and Nottingham 1986). In northerly and southerly parts of the range (i.e. temperate zones), breeding tends to occur in spring (Nowak 1999). Cavalcanti (2008) reported that radiotelemetry-monitored jaguars in the southern Pantanal (Brazil) lacked an established breeding season and that 64.4 percent of a female's home ranges overlapped with a male's. This suggested that, contrary to previous findings (Rabinowitz and Nottingham 1986; Schaller and Crawshaw 1980), individual females did not restrict their movement to within the home range of individual males. Cavalcanti concluded that "the mating system in jaguars may be one of a polygynous and promiscuous nature; a male likely mates with several females and a female likely mates with several males." We speculate that such a system might be particularly advantageous in the periphery of the range, where co-occurrence of males and females might be highly sporadic.

Male and female jaguars might only come into contact during the breeding season (Crawshaw and Quigley 1984). Copulation lasts an average of nine seconds (range 2-35 s) (Stehlik 1971), but occurs as many as 100 times per day over a few days (Eaton 1978). Gestation lasts about 93-105 days and litters average 1-4 young (Nowak 1999). The offspring are born in sheltered sites, such as caves, under fallen trees, and among rocks (Mondolfi and Hoogesteijn 1986). They suckle for 5-6 months but stay with the mother for up to two years (Nowak 1999). Sexual maturity is reached at about 2-3 (females) or 3-4 (males) years of age (Mondolfi and Hoogesteijn 1986; Tewes and Schmidly 1987).

Although young and other jaguars succumb to a variety of natural causes, rangewide the major cause of adult jaguar mortality is killing by humans (see: Chávez and Ceballos 2006; Rabinowitz 2006; Seymour 1989; Sunquist and Sunquist 2002; Sunquist and Sunquist 2007; Tewes and Schmidly 1987). The maximum known longevity for jaguars in the wild is no more than 11 years (Rabinowitz cited in Tewes and Schmidly 1987). However, that appears to have been surpassed by a possibly 15-16 year-old jaguar that was photographed in southern Arizona at an estimated 2-3 years of age in August 1996 and which has repeatedly been observed in the same general area through January 2009 (McCain and Childs 2008, 2009).

2.5. Food Habits.

Jaguars are true "top carnivores," capable of killing almost anything they encounter (see: Rabinowitz and Nottingham 1986; Sunquist and Sunquist 2002). They also scavenge (Cavalcanti 2008; López-González and Piña 2002). They may hunt any time day or night (Cavalcanti 2008; Emmons 1990). They take live prey by ambush or by stalking and then making a short rush-attack. They swim well and readily take to water to capture prey (e.g. turtles and caimen). Their kill technique apparently varies with the prey. Jaguars kill capybaras by biting the throat or puncturing the back of the skull (Tewes and Schmidly 1987). They kill caimen by pouncing on them and biting through the back of the neck to sever the cervical vertebrae (Almeida 1976). According to Rosa and Nocke (2000), jaguars are the only American cats that routinely kill prey with a single piercing bite to the skull. Jaguars typically do not cover kills as mountain lions do, but often drag a carcass (sometimes 100 yd or more) to dense cover in a more secluded spot to feed on it over several days (Sunquist and Sunquist 2002; Tewes and Schmidly 1987).

Rabinowitz (1986a, 1986b) and Rabinowitz and Nottingham (1986) considered the jaguar an opportunistic predator, taking a wide variety of primarily medium and large-sized prey, generally in relation to prey density and ease of capture. The list of jaguar prey rangewide underscores their opportunistic tendencies. It includes more than 85 species of native wildlife and livestock (Seymour 1989; see also: Aranda 1994; Garla and others 2001; Núñez and others 2000; Reyna-Hurtado 2002; Rosas-Rosas 2006; Rosas-Rosas and others 2008; Tewes and Schmidly 1987). Known prey include collared peccaries (javelina), capybara, paca, armadillos, caimen, turtles, cattle, and various birds and fish.

López-González and Miller (2002) concluded that "jaguars are equally using medium- and large-sized prey, with a trend toward use of larger prey as distance increases from the equator." Cavalcanti (2008), using Global Positioning System (GPS) technology with radiocollars on 10 jaguars, documented 438 prey items at 415 kill sites in the southern Pantanal of Brazil. Cavalcanti found that individual jaguars differed in selection of species they killed (and in the proportion of native prey vs. cattle), but cattle (31.7%), caimen (24.4%), and peccaries (21.0%) were the most frequent prey items.

Iriarte and others (1990) and others (e.g. Emmons 1987; Haemig 2006; Rabinowitz and Nottingham 1986; Schaller and Crawshaw 1980; Taber and others 1997) discussed dietary overlap and possible effects of dietary competition between jaguars and mountain lions occurring in the same in area. However, Aranda and Sánchez-Cordero (1996) concluded that jaguars and pumas coexist in Calakmul Biosphere Reserve (Campeche, Mexico) by consuming different prey.

Although javelina and deer are likely mainstays in jaguar diets in the U.S.-Mexico borderlands, other available prey, including livestock, are no doubt also taken. A single event of jaguar depredation on livestock was confirmed in southcentral Arizona in 2007 (McCain and Childs 2008; E. McCain personal communication). However, that was not likely a solitary occurrence, since jaguars take livestock in virtually all parts of their range (e.g. Crawshaw and Quigley 2002; Hoogesteijn and others 2002; Núñez and others 2000; Quigley 1987; Rabinowitz 1986a, 1986b; Renata and others 2002; Rosas-Rosas 2006; Rosas-Rosas and others 2008; Schaller and Crawshaw 1980; Valdez and others 2002; Wittmer and others 1995). Jaguars in the Pantanal

(Brazil) probably take about three head of cattle for every carcass found (E. Gese personal communication). Jaguar predation on livestock is a learned behavior and injury, lack of natural prey, livestock husbandry practices, and other factors can exacerbate it (Rabinowitz 1986a, 1986b; Rabinowitz and Nottingham 1986).

Cavalcanti (2008) reported that in the southern Pantanal (Brazil) GPS-collared jaguars showed individual preferences for (or against) preying on cattle. While a few jaguars had >50% of their kills consisting of cattle, others had <10% of their kills consisting of cattle. Much of the annual variability in predation on cattle was driven by climate (rainfall) and the subsequent exposure (encounter rates) of cattle to jaguars on the landscape. All 10 jaguars were in excellent physical condition when captured for collaring. Cavalcanti also noted that "older and more debilitated individuals seemed to have no problem killing 'dangerous' native prey. However, Cavalcanti (2008) found that during an intense drought period, "climatic conditions played a stronger role in jaguar prey selection than individual preference or propensity to kill livestock and that prey switching was common." Nevertheless, when jaguars are known to occur in an area, they tend to be credited with causing more of the livestock losses that occur in that area than studies indicate they should (see: Rabinowitz 1986b; Rabinowitz and Nottingham 1986; Rosas-Rosas 2006; Rosas-Rosas and others 2008). Leopold (1959) noted that a local resident in Mexico advised him that "only certain animals form the habit of killing stock, and when these individuals are killed, losses cease even though there are other jaguars in the area." No such "certain animals" were found by Cavalcanti (2008) in the southern Pantanal (Brazil); all 10 jaguars that were monitored with GPS telemetry over a 30-month period killed cattle, but at varying levels of predation seasonally, annually, and individually.

2.6. Home Range.

Like most large carnivores, jaguars have relatively large home ranges that are highly variable, depending on topography, available prey, and population dynamics (Brown and López-González 2001). However, little information is available on this subject outside tropical America, where several studies of jaguar ecology have been conducted. Quigley and Crawshaw (1992) estimated that in Brazil a minimum of 772 to 1160 mi^2 was needed to support 30 to 50 adult jaguars; the actual area depended on prey density, habitat composition, and the amount of human exploitation. Individual jaguar home ranges varied from 11 to 16 mi^2 in Belize (Rabinowitz and Nottingham 1986) and 10 to 20 mi^2 in Jalisco, Mexico (B. Miller personal communication). In Jalisco, home ranges tended to be smaller in the dry season than in the wet season and females with young kittens tended to have smaller home ranges than those with older kittens (Nuñez and others 2002). However, B. Miller (personal communication) noted that individual jaguars recorded at the same location on consecutive days traveled up to nine miles overnight before returning to that location.

Relationships between home ranges of males and females in the same general area are not well understood, but radiotelemetry is providing new insights. Cascelli de Azevedo and Murray (2007) reported that in a floodplain jaguar population in the southern Pantanal (Brazil), home range sizes were comparable between sexes and overlapped little at the core area. They used ground and fixed-wing radiotelemetry to monitor eight collared jaguars (3 males, 5 females). They concluded that spacing patterns in local jaguar populations were likely based on exclusion through territoriality rather than food limitation. Cavalcanti (2008), also working in the southern Pantanal, used GPS

radiocollars to monitor 10 jaguars (6 males, 4 females), monitoring from three to five simultaneously and independent of weather, time of day, or season. Cavalcanti concluded that home ranges varied among animals and seasons from 34.1 to 262.9 km^2. The size of core areas for both sexes did not vary seasonally, but their home ranges were generally larger in dry seasons than in wet seasons. Cavalcanti noted apparent spatial avoidance among females during the wet season, but extensive overlap among males in dry and wet seasons. Two adult males were found sharing a feral hog carcass. On three occasions, two male jaguars were less than 200 m from each other; Cavalcanti was unable to find any prey carcasses in the area. Twice two males occurred within 30 m of each other; one of them was monitored for three months before being found dead, apparently due to an aggressive encounter with another male (or more than one). Cavalcanti (2008) concluded that jaguars appeared to be more social than previously believed, with males and females interacting at higher frequency than anticipated based upon past literature.

2.7. Habitat[8].

"Habitat" is often a contentious discussion topic in JAGCT. Mere mention of the word invites debate over what "habitat" is and whether delineation of jaguar habitat should or will inevitably lead to critical habitat designation under the Endangered Species Act (ESA) of 1973, as amended (Public Law 93-205, 7 U.S.C. §136, 16 U.S.C. §1531-1544, 87 Stat. 884). Little if anything about the ESA is as contentious to some stakeholders as critical habitat[9], even though USFWS has determined that designation for the jaguar would not be prudent (USFWS 2006; see Section 3.2 below) and AGFD and NMDGF are committed to emphasizing non-regulatory approaches to jaguar conservation (AGFD and NMDGF 2007). Nevertheless, jaguar habitat must be dealt with to assess the status of borderlands jaguars from a conservation perspective.

In considering jaguar habitat attributes, it is particularly important to remember that vegetation is only one component of habitat for this species (indeed, for any species). A. Rabinowitz (personal communication) remarked about the jaguar that:

> "the term 'habitat' is defined by all those factors that make an area livable to a species, and I am completely convinced that the one overwhelming determinant of where big cats reside is prey availability and [abundance]."

Elsewhere, Rabinowitz (1999) stated "the more open, dry habitats of the southwest are marginal for the jaguar in terms of water, cover, and prey density." Rabinowitz (2006) later identified the following landscape features as those that most affect jaguar presence and movement rangewide: (1) habitat type [vegetation and topography], (2) percent of tree and shrub cover, (3) elevation, (4) human densities, (5) human settlements, and (6) roads. He also commented, "We know what jaguars need: occasional access to water, some degree of forest cover, and prey species that can

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[8] See Brown (1994) for a comprehensive discussion, including descriptions and illustrations of examples, of the major biotic communities and vegetation types of northwestern Mexico and the southwestern United States that are mentioned in this section.

[9] For examples of perspectives on critical habitat and its relevance to recovery, see: USFWS 2003; USFWS 2005; Taylor and others 2005.

range from peccaries to armadillos. We also know that jaguars can live close to people, but they generally avoid large open areas and sites of high human density."

In Central and South America, jaguars show a high affinity for lowland wet communities (jungles), typically mangrove swamps, swampy savannas, and tropical rain forests, but they also occur in upland habitats with temperate climates (Cavalcanti 2008; Sanderson and others 2002a, 2002b; Seymour 1989; Tewes and Schmidly 1987). Leopold (1959) reported the highest densities he noted in Mexico were in "heavily forested flatlands and foothills of southern Sinaloa, the swamps of coastal Nayarit, the remaining uncut forests along the Gulf coast as far east as central Campeche, and the great rain forests of northern Chiapas." Swank and Teer (1987, 1989) stated that jaguars prefer a warm, tropical climate, usually associated with water, and are rarely found in extensive arid areas. However, jaguars occur in dry tropical forest in Jalisco, Mexico (Nuñez and others 2002) and were reported by local residents as recently as 1991 to be not unusual (and still hunted) in the arid thornscrub-covered Sierra del Bacatete of Sonora, Mexico (D.E. Brown and T.B. Johnson personal communication; see also Grigione and others [2001] and Brown and López-González [2001]). Also, Sheldon (1921) reported that when he visited Tiburón Island (off the coast of Sonora), the Seri Indians told him jaguars were rare residents of the scrub and chaparral covered, mountainous island.

Jaguars reach their northernmost distribution in relatively arid habitats in northwestern Mexico and the southwestern United States, across a broad elevational belt (Brown and López-González 2000, 2001; Chávez and Ceballos 2006; Nowak 1994, 1999; Sanderson and others 2002a; Seymour 1989; Valdez and others 2002). Brown and López-González (2000) noted that kill-location elevations for 62 jaguars killed in the American Southwest since 1900 ranged from 500 m (1649 ft) to more than 3000 m (9843 ft); most were above 1500 m (4921 ft) in mountains. Brown (1991) stated that kill records from Arizona, New Mexico, and Texas indicated jaguars had occurred there in habitats ranging from low-elevation thornscrub and desertscrub to montane conifer forests. Most Arizona records to date have been from Madrean evergreen-woodland, shrub-invaded semidesert grassland, and along rivers (Hatten and others 2003, 2005). Notably, the same jaguar that Childs (1998) observed in southern Arizona woodlands in 1996 was repeatedly documented in arid scrub and desert grasslands in southcentral Arizona from September 2006 through January 2009 (McCain and Childs 2008, 2009).

As Rabinowitz (1999) stated, "The fact that the southwestern United States is the northern limit of the modern jaguar's range is not by chance. The more open, dry habitats of the southwest are marginal for the jaguar in terms of water, cover, and prey density." A. Rabinowitz (personal communication) also commented, regarding habitat aspects of jaguar conservation in the AZ-NM borderlands, that prey availability and abundance are "the one overwhelming determinant of where big cats reside," and cautioned that "if you take this out of the equation [in describing jaguar habitat], then you are not looking at jaguar habitat or potential habitat. You are simply looking at land suitability characteristics for jaguars." Rabinowitz added that concerns about prey base in the presumed core area of the northern jaguar population (in Mexico) are sufficient to warrant concern about long-term viability of the population. When native prey have been depleted, or jaguars are old or disabled, jaguars tend to turn to livestock as prey (B. Hassan personal communication cited in Brown 1991; Rabinowitz 1986b; Rabinowitz and Nottingham 1986). The switch to livestock inevitably leads to killing of jaguars (see Section 3.1). Notably,

Rosas-Rosas (2006) and Rosas-Rosas and others (2008) recently documented that cattle are now the major food item for the northern jaguar population in Mexico.

Several recent studies have helped refine understanding of habitats that have been or might be used by jaguars in Arizona and New Mexico: Boydston and López-González (2005); Hatten and others (2003, 2005); Menke 2004; Menke and Hayes (2003); Robinson (2006); and Sierra Institute (2000). The habitat types (dominant plant communities) named in those studies range from thornscrub and desertscrub to woodland communities, including riparian and montane settings (for biotic community nomenclature, see Brown 1994). However, conclusions about the conservation importance of the plant communities/habitat types in which jaguars have occurred or might occur in Arizona and New Mexico are preliminary and can vary widely, depending on the assumptions factored into the analyses, including number and reliability of jaguar occurrence records and their significance as predictors of habitat quality and value and use by jaguars.

Rangewide, jaguars occupy a variety of habitats but generally occur in well vegetated areas (Seymour 1989). Habitat "generalism" is typical of wide-ranging "top carnivores," which tend to have broader habitat tolerances than many other species and which have considerable effect on the ecosystems of which they are a part (see: Foreman 2004; Gittleman 1996; Mayr 1970; Miller and others 2001; Soulé and Terborgh 1999; Terborgh and others 1999).

3. Species Status

3.1. Threats.

Relevant Types of Threats. Two kinds of threats are relevant to assessing status of borderlands jaguars: those that contributed historically and which, in some areas, perhaps continue to contribute to rangewide imperilment of the jaguar; and those that are relevant to current and future jaguar occupancy of the AZ-NM borderlands. The former must be addressed on a rangewide basis, which is beyond the scope of authorities for AGFD and NMDGF. Only the latter threats are within the scope of the AZ-NM conservation effort.

In listing determinations, the ESA obligates USFWS to analyze five factors in terms of their effects on (i.e. threats to) species: (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; and (E) other natural or manmade factors affecting its continued existence. The USFWS (1997) notice extending endangered status to the jaguar throughout its range (i.e. adding the United States portion of the historical range to the previously listed portion from Mexico south to Argentina) summarizes the five factors analysis. It indicates the primary reasons for listing were: loss and modification of habitat; historical [ca. 1880-1970] legal or illegal killing and recent illegal shooting [i.e. 1971 and 1986 in Arizona] and commercial trade; insufficiency of state regulations protecting free-ranging borderlands jaguars from harm; and possible harm from M-44 ejector devices (with cyanide capsules) that are sometimes used by U.S.D.A.-APHIS Wildlife Services in predator control actions. Collectively, these four areas thus frame the "threat" that USFWS found sufficient to warrant extending endangered status to the U.S.-portion of the range (i.e. neither disease nor predation was considered a threat to the jaguar).

USFWS (1997) also stipulated that, based on the best available information, the following actions (potentially perceived as threats) will not result in a violation of Section 9 (Prohibited Acts) of the ESA, provided these activities are carried out in accordance with any existing regulations and permit requirements:

a. Normal ranching activities, except predator control targeting large cats that result in inadvertent trapping or mortality of a jaguar.
b. Habitat clearing, except in areas where jaguars are known to exist or have been known to exist.
c. Fencing or other property delineation.
d. If, when using dogs, a jaguar is inadvertently chased and/or treed by the dogs, so long as the dogs are called off upon realization that a jaguar is being chased.

USFWS (1997) also noted that take by any of the following activities would likely violate Section 9 of ESA (i.e. they might cause harm to jaguars):

1) Any activity specifically prohibited by ESA (e.g. shooting, hunting, trapping, etc.).
2) Intentional clearing or destruction of habitat known to be occupied by jaguars.
3) Any activities that fall within the definition of harass and harm. USFWS defines the terms harass and harm as follows: Harass means an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Harm has been defined as an act which actually kills or injures wildlife. Such acts may include significant habitat modifications or degradation when it actually kills or injures wildlife by significantly impairing essential behavioral patterns including breeding, feeding or sheltering.
4) Predator control activities targeting large cats that trap, kill, or otherwise injure jaguars.

Although USFWS (1997) did not identify disease as a threat to the jaguar, Furtado and Filoni (2008) reported that "it is widely accepted that surveillances and monitoring programs are required for an adequate understanding of disease dynamics in wild jaguar…Diseases should always be considered as an important factor in **conservation biology**."

Threats Within vs. Outside the United States. In assessing conservation progress in the AZ-NM/Mexico borderlands, it seems that the identified threats are of quite different significance within versus outside the United States. South of the United States, jaguar population declines since the late 1800s have been attributed primarily to causes that still affect such areas today: habitat destruction, modification, and fragmentation (especially forests and grasslands and savannahs); unregulated or insufficiently regulated hunting (or lack of enforcement of regulations); illegal and legal killing to obtain skins, skulls, teeth, and other parts or to prevent or control depredation on livestock; and, in some areas, population declines in prey species (see: Chávez and Ceballos 2006; Seymour 1989; Swank and Teer 1987, 1989; Valdez 2000, 2002). In

Mexico, habitat destruction remains a significant threat (Chávez and Ceballos 2006; Sanderson and others 2002a, 2002b; Sanderson and others 2002c; Valdez 2000; Valdez and others 2002) and illegal killing of jaguars also still occurs, principally because of conflicts with the livestock industry (Ceballos and Navarro-L. 1991; López-González 2004; Martinez-Mendoza 2000; Rosas-Rosas 2006; Rosas-Rosas and others 2008; R. Thompson personal communication). These rangewide threats are clearly primary reasons why jaguars may not be as abundant or as widely distributed today as they once were. Sanderson and others (2002b) reported that jaguars now occupy only 46 percent of their historical (pre-1900) range. Woodroffe (2001) and Hoogesteijn and others (2002) stated that most extant jaguar populations occur in isolated protected areas or in remote areas that are inhospitable to humans. But, are these threats operant in the United States, and if so can they be reduced or mitigated here?

The jaguar's historical decline in the United States (see Fig. 1), was concurrent with widespread predator control that was primarily associated with emergence of the cattle industry (Brown 1983; USFWS 1990). Shooting unquestionably accounted for the vast majority of documented jaguar mortalities in the United States before the species was protected by state or federal law in the late 1960s and early 1970s (see: Brown 1983; Brown 1991; Brown and López-González 2001). Moreover, the only two jaguars documented in the United States from 1969 through 1995 were in southern Arizona in 1971 and 1986 (Brown 1991); both were killed by shooting and neither incident resulted in conviction for unlawful take (Brown 1991, 1997; Brown and López-González 2001). However, both of these jaguar killings generated considerable media coverage for several years, and to some extent heightened public awareness that jaguars still roam the borderlands and are protected by law. In any case, none of the jaguars documented in the United States from 1996 through 2009 was killed in the United States.[10]

Another element of predator control programs that could result in jaguar mortality is use of sodium fluoride in M-44 devices[11]. Pursuant to the 2007 Jaguar Conservation Assessment and Strategy (Johnson and Van Pelt 2007), JAGCT asked USDA-APHIS Animal Damage Control (now known as USDA-APHIS Wildlife Services) to assess the risk of accidental killing of a jaguar in Arizona and New Mexico by use of M-44 devices (see Van Pelt 2004). These devices are used routinely to take coyotes suspected of preying on livestock and are registered for use by ADC personnel in Arizona and New Mexico and by private applicators in New Mexico. Private applicator use in New Mexico is regulated by the New Mexico Department of Agriculture. M-44s have not been nor are they currently registered for private applicator use in Arizona. Since Arizona Proposition 201 became effective July 1, 1995, M-44 use in Arizona has been prohibited on public land.

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[10] It is almost certain that the jaguar Warner Glenn documented in Arizona in March 1996 was subsequently killed in Mexico, given that a hide that matches its spot pattern was displayed there (PROFEPA unpublished data).

[11] The M-44 device is a spring-loaded cyanide ejector mechanism that is anchored in the ground and which uses a fetid bait to attract coyotes. When a coyote pulls up on the baited top of the device, the spring-loaded plunger is triggered so it pops upward, through a small plastic capsule containing a small (0.8 g) amount of powdered/granular sodium cyanide, into the coyote's mouth. The coyote is generally killed within seconds.

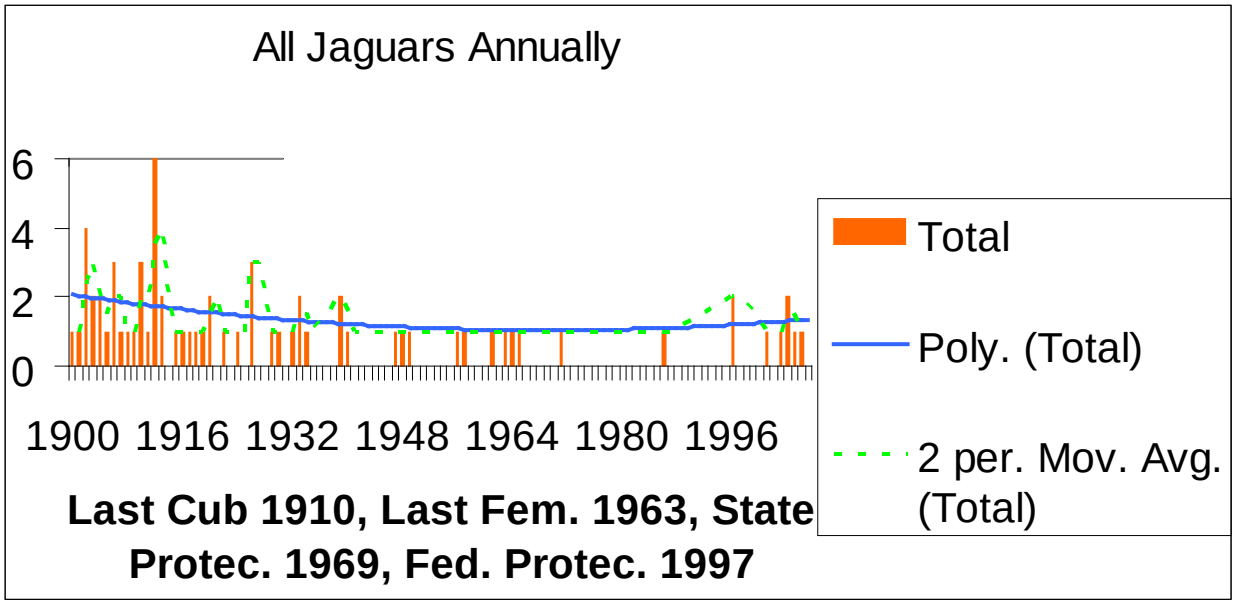

Figure 1. Historic sightings in the United States indicate a declining resident jaguar population from the late 1800s into the 1940s, after which only an occasional jaguar was reported every five to ten years until the present date. Figure adapted from McCain and Childs (2008) and used with permission of the authors.

In accordance with the 1997 Jaguar Conservation Assessment and Strategy, JAGCT asked Wildlife Services to analyze M-44 use in Cochise, Pima, and Santa Cruz Counties in Arizona and Hidalgo County in New Mexico for the previous five years, including determination of: (1) the number and species of felids taken by such methods; (2) the amount of area worked in the above counties; and (3) expert opinion on baits that would be least likely to attract jaguars while still allowing for effective M-44 use.

Wildlife Services completed the M-44 risk assessment for JAGCT in 1997, concluding that (see Van Pelt 2004):

> M-44 devices have not resulted in the mortality of any felids in the affected area in the last five years despite use of these devices by ADC personnel in Arizona and New Mexico and by private applicators in Hidalgo County, New Mexico. ADC M-44 use has not been widespread in the area. It is estimated the areas with M-44 use totaled no more than about one-half of 1% of the area of the four counties in any one year. No use has occurred on National Forest lands which are presumed to encompass the majority of the habitat most likely to be used by jaguars. Although M-44 use on the New Mexico portion of the Coronado National Forest could occur, it is expected to be relatively infrequent and of low intensity. M-44 use in Arizona is only allowed on private land. In general, M-44 devices are not attractive to felids because fetid or rotten scented bait materials and, in many cases, canid-specific gland lures, are used as the attractive agents. Cats generally

> prefer fresh meat and are not generally attracted to bait materials that are composed of animal flesh that is in an advanced state of decomposition, and are not generally attracted to coyote pheromone. This assessment indicates accidental or incidental take of a jaguar by M-44 use is highly unlikely to occur.

The 2007 AGFD-NMDGF Jaguar Conservation Framework addresses the M-44 issue at Section 4.5.1, which states that: "Predator control activities by signatories to the MOU will not be purposefully directed at jaguars. Such activities are subject to a variety of federal, state, and tribal laws, local ordinances, and oversight by various federal, state, and tribal land management, wildlife management, and agricultural agencies or programs. Thus, any JAGCT discussions or recommendations regarding possible effects of area-specific predator control activities on jaguars, and measures to avoid harm to jaguars in such areas, will be carefully coordinated with the appropriate entities." In accordance with that guidance, Wildlife Services will, at JAGCT request, instruct its personnel who are working in areas suspected to be **inhabit**ed by one or more jaguars to avoid using M-44 baits that have fresh meat or fish or anise oil as ingredients (D. Bergman personal communication).

As summarized by EPA (2009), in January 2007 Sinapu (now known as WildEarth Guardians (http://www.wildearthguardians.org) and 10 other groups petitioned EPA to (among other things) cancel registrations for use of sodium cyanide and Compound 1080 (sodium fluoroacetate) in predator control and to cancel registrations for all pesticide products used in predator control that contain either compound. The petitioned actions would, if granted, terminate use of sodium cyanide in M-44 devices and sodium fluoroacetate in predator-attractant baits and in livestock protection collars. The petition (and three addenda filed in 1997) alleged that the compounds cause unreasonable adverse effects on public health, the environment, and species' populations (including those that are threatened or endangered). EPA (2009) responded as follows: "For the reasons set forth in the attached response, EPA is denying the first five elements of the petition. In regards to the sixth element (a request for EPA to reinitiate consultation with USFWS on the two compounds when used for registered lethal predator control so that more threatened and endangered species are not harmed), EPA is granting the petition inasmuch as the Agency plans to reinitiate consultation with FWS on these pesticides." As EPA and USFWS re-consult on this issue, JAGCT will need to keep apprised of the findings with regard to possible effects on or implications for jaguar conservation in the borderlands.

Commercial trade as a threat to jaguars is clearly evident historically but less clear cut today. Killing of jaguars for commercial sale of their fur was a factor in exterminating a substantial resident population in central Texas in the late 1800s (Nowak 1975). Prior to the 1980s, commercial trade in jaguar hides was substantial, and unsustainable in the long term, as discussed by Nowell and Jackson (1996; Part II, Chapter 4), Payán and Trujillo (2006); Redford and Robinson (1991), and Swank and Teer (1987, 1989). According to Chadwick (2001): Iquitos (Peru) shipped 12,700 jaguar pelts between 1946 and 1966; Brazil sold more than 6000 hides each year through the latter 1960s; and between 1968 and 1970 the United States alone imported 31,104 jaguar hides. However, Nowell and Jackson (1996) stated that killing of jaguars for their pelts declined drastically after the mid-1970s, when anti-fur campaigns gathered momentum and

CITES[12] progressively shut down international markets. Similarly, Swank and Teer (1989) commented that, by the time they conducted a rangewide jaguar status assessment in 1987, organized poaching rings supporting the pelt trade had already disappeared. Koford (1973) noted that, in addition to the new conservation regulations, depletion of accessible populations probably contributed to the end of the boom years in hide traffic. In short, although illegal trade in jaguar hides and other parts no doubt still exists and might at times involve jaguars (see: Roe and others 2002; Rosenberg 2009; TRAFFIC at http://www.traffic.org/home.action), CITES and other factors (e.g. social pressure) appear to be sufficient to ensure that commercial trade is not now and will not again become a significant threat to rangewide existence of the jaguar, and is certainly not a significant threat to jaguars in the United States.

The primary concern now with regard to jaguar conservation in the U.S.-Mexico borderlands is clearly potential for future loss, fragmentation, and modification of habitat. These factors have already contributed to population declines throughout much of the historical range, including northern Mexico (see: Medellin and others 2002; Swank and Teer 1987, 1989; Valdez 2000). Although jaguars in east-central Sonora occur in a very rugged area, habitat loss and road development are potential threats (López-González 2004). In contrast, with the possible exception of "Border Security" projects and effects of large-scale "back-country" human traffic across the International Border (see below), habitats within the primary emphasis area for jaguar conservation in the United States are managed in ways that are largely conducive to supporting jaguars. They have healthy populations of native prey, relatively dispersed human occupancy, and occur largely on public lands that are used primarily for outdoor recreation and/or ranching.

As noted above, illegal human traffic across the U.S.-Mexico border and resulting law enforcement and other "Border Security" activities are a substantial concern with regard to borderlands jaguar conservation. From the 1980s through today, drug trafficking and illegal immigration have increased tremendously along the border, with consequent impacts on wildlife and habitat. In 1971, the U.S. government spent less than $71 million on Southwest border enforcement, but in 1997 spending on drug enforcement alone reached $1.7 billion (Andreas 1999). According to the Public Lands Foundation (PLF 2005), Arizona's 374 miles of International Border comprise only about 19 percent of the 1952-mile U.S.-Mexico border. However, PLF (2005) reports that: in FY2004, more than 52 percent of all arrests of illegal immigrants along the Southwest border were in Arizona; and in FY2005, the U.S. Border Patrol in Arizona made more than 575,000 arrests of illegal immigrants, seized more than 500,000 pounds of marijuana with an estimated value of more than $400 million, and seized 8750 vehicles (many of which were stolen).

The impacts of such massive problems on wildlife and wildlife habitat are inevitable, and potentially significant. A decade ago, Operation Gatekeeper on the U.S. side of the California-Mexico border was already pushing illegal immigration operations from traditional entry points into "the most inaccessible zones where the danger is greatest," even though such areas are also

[12] Although the United States signed CITES (Convention for International Trade in Endangered Species of Wild Fauna and Flora) on March 3, 1973, the convention was not ratified by Congress until September 13, 1973 and it did not "enter into force" (take effect) until July 1, 1975 (see: CITES 2007 and http://www.cites.org/).

less accessible for law enforcement officers (Ackerman 1998). The plan worked, for California. Ackerman noted apprehensions of undocumented migrants had fallen 46 percent in San Diego (to an 18-year low) since Gatekeeper started in 1994, but they had risen 88 percent along the Texas and Arizona borders. The increase in the Tucson sector was actually 194 percent from FY1993 to FY1997.

Today, it seems as though no area along the Arizona-Sonora border, no matter how isolated, rugged, or devoid of water, is untouched by illegal immigration, drug traffic, and law enforcement activities. The affected area includes habitats occupied and possibly occupied by jaguars since 1996, and the impacts of illegal activities have become increasingly conspicuous in recent years. In addition to habitat impacts such as widening existing trails and creating new ones (both of which exacerbate erosion problems and loss of vegetation; see BLM 2006a, 2006b, 2006c), illegal border crossers obtain subsistence food by poaching wildlife, including animals that are commonly known prey of jaguars (e.g. deer and javelina) and destroy wildlife habitat as they build primitive camps and fuel campfires with trees and shrubs (G. Perry personal communication). As law enforcement impedes illegal human traffic in one area, the traffic shifts to others that are typically more isolated and in which access for law enforcement purposes is more difficult. Until recently, many of these areas have had relatively little human disturbance and some are the same areas in which jaguars have occurred from 1996 through 2009. The nocturnal movements of illegal immigrants and smugglers, and of those who are trying to intercept them, are much more likely to affect the jaguar, which in this arid environment is almost exclusively nocturnal, than are daytime activities by hikers, ranchers, and hunters (E. McCain personal communication). More than two dozen Borderlands Jaguar Detection Project trap-cameras set in remote settings have been destroyed or taken, and it has become unsafe for biologists to work (especially at night) in many key areas along the AZ-NM/Mexico borderlands (E. McCain personal communication).

The scale of impact by illegal immigrants and smugglers in the borderlands is both astounding and costly. Since FY2003, the Bureau of Land Management (BLM) has been implementing a project to mitigate damages in southern Arizona from illegal immigration and smuggling (BLM 2006a, 2006b, 2006c). Funding for the project has been taken from base annual appropriations, totaling $4,404,000 as of FY2006 (BLM 2006c). These funds have been used by BLM across jurisdictional boundaries to cooperate with various governmental agencies (at all levels), private organizations, youth groups, and the Tohono O'odham Nation to, among other things: remove more than 590 tons of trash and human waste; remove 130 abandoned vehicles and 1937 abandoned bicycles; repair or rehabilitate hundreds of miles of illegal roads and trails and damaged washes; repair cut fences; replace destroyed gates with cattle guards; install vehicle barriers; clean up graffiti; and plant native trees and re-seed ground cover. Notably, the Malpai Borderlands Group (MBG), a JAGCT participant, has been among the BLM cooperators, traveling 19,744 miles and working virtually year-round to repair damaged roads, remove trash, repair fences, etc.

A new and significant threat to borderlands jaguar conservation emerged after the tragic events of September 11, 2001, when the United States recognized a much-heightened need for terrorist detection and interdiction at its borders and beyond. The Homeland Security Act (HSA) of 2002 (Public Law No. 107-296, 116 Stat.2135), enacted on November 25, 2002, created a Department

of Homeland Security (DHS), which includes the U.S. Customs and Border Protection Agency (USCBP). On March 16, 2004, DHS announced the Arizona Border Control Initiative, a multi-agency effort to provide additional resources to "detect and deter terrorist activities and cross-border illegal trafficking of people and drugs" (DHS 2004).

Long-term plans for securing the border were addressed in the USCBP 2005-2010 Strategic Plan (USCBP 2005; see also USCBP 2006). Security measures identified for the U.S.-Mexico border that might influence jaguar presence and conservation include: lighting; fencing and other physical barriers, road and bridge construction and maintenance; surveillance of pedestrian and vehicle traffic; other security activities, and habitat alteration to facilitate law enforcement (Segee and Neeley 2006).

Bies (2007) summarized, largely from a wildlife perspective, the current border security situation in the Southwest and the possible impacts of fencing and barriers[13,14], as follows: In 2005 and early 2006, Congress failed to find common ground between the Senate and House on comprehensive immigration law reform to address, among other things, national security concerns about the U.S.-Mexico International Border. However, Congress subsequently passed the Secure Fence Act of 2006 (SFA; Public Law 109-367), which President Bush signed into law on October 26, 2006. The intent of the law is to "establish operational control over the international land and maritime borders of the United States," through surveillance (e.g. unmanned aerial vehicles, ground-based sensors, satellites, radar coverage, and cameras) and physical infrastructure enhancements (e.g. additional checkpoints, all weather access roads, and vehicle barriers). The SFA includes southern border fencing provisions from the December 2005 House version of comprehensive immigration reform legislation, including "at least 2 layers of reinforced fencing…from 10 miles west of Calexico [CA] to 5 miles east of Douglas [AZ)]." Notably, the SFA did not provide funds for the fencing.

Uncertainties about what might or might not be done to secure the U.S.-Mexico International Border, where and how construction might occur, and the impacts of such actions on humans and wildlife continued to generate public concern. During workshops in 2005 and 2006, a broad coalition of stakeholders in Arizona identified a suite of recommendations for addressing impacts (particularly those of physical barriers and fences) to wildlife and wildlife habitat along the AZ/Mexico border (Defenders and Wildlands Project 2007). AGFD and USFWS were among the workshop participants. In New Mexico, a gathering of stakeholders similar to the workshops in Arizona was convened on July 8, 2008 to discuss concerns about the NM/Mexico borderlands (R. Held personal communication). The workshop was sponsored by the New Mexico Chapter of the Wildlife Society and the New Mexico Farm and Ranch Heritage Museum in Las Cruces. NMDGF and USFWS were among the participants.

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[13] For a binational perspective on potential environmental consequences of the border fence, see Córdova and Vásquez (2007).

[14] "Fence" is typically used alone hereafter when referring to border security measures that DHS will use to establish "operational control. However, in such use "fence" will always include, in addition to actual fencing of various dimensions, the full suite of physical and electronic security measures and activities that DHS has been authorized to implement.

In 2007, the Good Neighbor Environmental Board (GNEB) provided an objective, border-long perspective in its 10th Annual Report (GNEB 2007). GNEB is an independent U.S. Presidential advisory committee that was established to advise the President and Congress of the United States on "good neighbor" environmental and infrastructure practices along the U.S. border with Mexico (see http://www.epa.gov/ocem/gneb/index.html). In its 2007 report to the President and Congress, the Board reported (in part):

> **Undocumented Human Crossings.** To address problems associated with unauthorized flows of people across rural areas of the U.S.-Mexico border, and also continue to protect the environmental quality of the region…the [GNEB] recommends:
>
> > **Strengthen communication and collaboration between security agencies and environmental protection agencies, including land management agencies, on both sides of the border.** Early and ongoing cooperation and participation in the cross-agency dialogue will contribute to effective solutions that serve the core agency missions of homeland security and environmental protection, while also addressing quality of life concerns of border communities.
> >
> > **Strategically employ a mix of technology and personnel to meet the security and environmental need of the border region.** Vehicle barriers and sensor technology along the boundary that permit habitat connectivity and migration of important species can serve well in rural areas characterized by fragile habitats.

In the same report, GNEB noted that:

> *Impenetrable fences may present significant negative consequences to wildlife and the environment*. Fences may disrupt hydrologic patterns, causing flooding and erosion. Wildlife migration routes and territories for some species may be truncated, fragmenting habitats and causing declines in regional populations of large animals such as deer, black bear, pronghorn antelope, mountain lions, and jaguar, and small animals such as snakes, lizards, turtles, and foxes. Migratory birds, as well as bird and mammal breeding behavior, will be affected by lights associated with fences in some areas. Border lighting projects associated with fencing also have been criticized for potential harm to species such as the jaguarundi and ocelot in the Lower Rio Grande Valley. A fence running along large sections of U.S.-Mexico border, with its accompanying roads, would permanently eliminate hundreds of thousands of acres of transboundary wildlife habitat.

Despite the impacts evaluation and cross-jurisdictional collaboration needs that were so obvious to so many and a variety of initial DHS consultations with USFWS on border fence issues (e.g. USFWS 2007), Congress and the Bush Administration foreclosed requirements for consultation. With regard to construction of barriers and roads for border security, under the HSA the DHS Secretary is exempt, on a case-by-case basis, from compliance with the ESA and the National Environmental Policy Act of 1969 (Public Law 91-190, 42 U.S.C. 4321-4347, January 1, 1970, as amended) (see also the REAL ID Act of 2005, Division B of Public Law 109-13, 119 Stat.231, enacted May 11, 2005). On April 1, 2008, after withstanding a variety of protests and legal challenges regarding lack of environmental review of border security measures, DHS

Secretary Michael Chertoff invoked his authority under the REAL ID Act to waive 37 applicable federal laws and all state, local, and tribal laws to expedite construction of the border fence and related infrastructure (CNN 2008).

Despite DHS Secretary Chertoff's April 2008 waiver, USFWS and DHS have continued to engage in discussions regarding conservation of jaguars and other borderlands species protected under the ESA (S. Spangle and S. Barrett personal communication). Such discussions appear to be producing substantive, if ex post facto, results at a national level. In January 2009, DHS and the Department of Interior (DOI) signed an agreement committing $50 million from the DHS Fiscal Year 2009 budget for projects intended to mitigate the effects on listed species of barriers and fencing constructed along the International Border (Reese 2009). Final proposals from DOI for these DHS funds must be submitted by June 1, 2009. USFWS expects to complete a list of eligible projects by March 16, 2009 (J. Avey personal communication).

The ESA Section 9 "violations" noted above have particular relevance to DHS fencing, barrier, and related national security work along the AZ-NM/Mexico border. A Customs and Border Inspection spokesperson noted in mid-January 2009 that 601 miles of fencing had already been completed, leaving only 69 miles in Texas to be constructed (Sullivan 2009). However, Reese (2009) and Simon (2009) noted that construction of the final segment is being challenged by legal appeal to the Supreme Court and by petition to President Barack Obama. Regardless, the extent to which projects carried out under the DOI-DHS agreement will mitigate impacts on borderlands jaguars is yet to be determined but the impacts are already being witnessed. During remote-camera jaguar monitoring fieldwork in 2007, the Borderlands Jaguar Detection Project documented DHS emplacement of steel reinforced barriers at the exact location where a jaguar had been tracked through southcentral Arizona to its crossing the International Border (E. McCain personal communication). Since then, considerably more border-security fencing and barriers have been constructed in areas likely to have value as movement corridors for jaguars.

Other threats might include introduction of exotic diseases from invasive wildlife or pets (e.g., feline leukemia), reduction in the native prey base, climate change, and shifts in corridors used by humans moving along the border. Essentially as the border fence is implemented, humans crossing the border will likely shift their movements to mountainous corridors putting them in direct conflict and impacts to the native prey populations, but also the endemic carnivores in those mountain ranges.

3.2. Conventions and Regulatory Protections.

International. The World Conservation Union (IUCN) considers the jaguar "near threatened" rangewide (IUCN 2006). The jaguar has been listed under CITES as an Appendix 1 species since 1973 (CITES 2007). CITES prohibits international trade among member nations in Appendix 1 species, including trophies, skins, and products. The United States and Mexico are both CITES signatory nations.

Mexico. The jaguar was protected by Mexico in 1986 and hunting was banned in 1987 (SEDUE 1987). It was listed as threatened on May 17, 1991 (SEDUE 1991) and uplisted to endangered on May 16, 1994 (SEDESOL 1994). The jaguar now falls under protection of Mexico's Ley General

de Vida Silvestre (General Wildlife Law), enacted in 2000 (SEMARNAT 2000) to provide for wildlife conservation and management, and jurisdiction of Mexico's Secretariat of Environment and Natural Resources (Secretaría de Medio Ambiente y Recursos Naturales; SEMARNAT, by its Spanish acronym; see http://www.semarnat.gob.mx/pages/inicio.aspx). Mexico now considers the jaguar a priority species (DOF 1999, INE 2000) and an endangered species in accordance with Norma Oficial Mexicana NOM-059-SEMARNAT-2001 (Ceballos and others 2006). Under current Mexican law, specimens and parts of endangered species cannot be used for commercial purposes. Endangered and threatened species (or any parts thereof) can only be taken for scientific or recovery (e.g. captive propagation) purposes, and then only with prior authorization from SEMARNAT. Jaguars may not lawfully be killed simply because they depredate on livestock.

Note: see Simonian (1995) and Valdez and others (2006) for discussion of the evolution and current status of wildlife conservation and management in Mexico, including information on laws and regulatory processes referenced or alluded to above.

United States of America. The jaguar was listed by the United States as an endangered species in 1972, under the Endangered Species Conservation Act of 1969 (ESCA; USFWS 1972). Two lists of endangered wildlife were maintained under ESCA: foreign species; and species native to the United States; the jaguar appeared only on the list of foreign wildlife. The ESCA was superseded by the Endangered Species Act of 1973 (ESA; 7 U.S.C. §136, U.S.C. §1531 et seq.) and on September 26, 1975 the two ESCA lists were replaced by a single ESA "List of Endangered and Threatened Wildlife" (Federal Register 40:44412-44429). The jaguar was included in the 1975 ESA list, but only for its historical range in Mexico and Central and South America. USFWS (1979) considered its failure to include historical range in the United States an administrative error that would be rectified "as soon as possible." USFWS (1980) soon proposed the corrective listing but then (USFWS 1982) withdrew it. Listing was proposed again on July 13, 1994 (USFWS (1994) and on July 22, 1997 (USFWS 1997) endangered status was extended to the jaguar throughout its historical range, from the southern United States (i.e. Arizona, California, Louisiana, New Mexico, and Texas) through Mexico, Central America, and South America Subsequently, USFWS (2006) determined that it was not prudent to designate "critical habitat" for the jaguar in the United States and, on January 7, 2008, USFWS Director H. Dale Hall approved a "determination under 16 USC §1533(f)(1) that development of a formal recovery plan at this time would not promote the conservation of the jaguar (see Tuggle 2007).

State of Arizona – The Arizona Game and Fish Commission protected the jaguar in 1969, closing the open season that had previously allowed the species to be taken by licensed hunters. Jaguars are now listed as nongame mammals under Arizona Game and Fish Department (AGFD) Commission Order 14, with no open season for legal take by hunting. Violation of this order is a Class 2 misdemeanor. On May 7, 1998, state legislation (Senate Bill 1106) was signed into law that provides, when the jaguar is delisted federally, for imposing a $2500 criminal penalty (Class 2 Misdemeanor) and up to $72,500 in civil penalties for unlawful take of a jaguar. The civil fine is commensurate with the current federal fine under the ESA but the criminal penalty is considerably lower than the companion federal fine. The legislature's intent was to ensure that state penalties would not be additive to current federal penalties, and could serve as an inducement to federal delisting.

State of New Mexico - The State of New Mexico classifies the jaguar as a Restricted species (19.33.6.9 NMAC) because of its status as a CITES Appendix 1 species. In 1999, during the 44th New Mexican Legislative Session, Senate Bill 252 was signed into law, establishing new regulations and penalties for illegally killing a jaguar. The penalties would take effect only if the jaguar were removed from the federal endangered species list. Although this law provided state penalties as high as those for any animal protected by New Mexico, the penalties are not as high as those under the ESA. In the 2006 New Mexico legislative session, House Bill 536 ("Unlawful Trophy Animal Disposition") was passed and signed into law. It allows the New Mexico Game Commission to establish regulations authorizing higher civil damages than previously allowable for wildlife designated as trophy animals, and establishes a minimum $2000 in civil penalties (without requiring removal from ESA listing to take effect). Thus, higher penalties for illegal jaguar killing may be established through Commission action. As of December 2008, no such action has been initiated.

3.3. Biological and Ecological Considerations.

Habitat Distribution Potential. Boydston and López-González (2005) used Geographic Information Systems technology to assess sexual differentiation in distribution potential of northern jaguars, by modeling distributions of males and females (records of occurrence were derived primarily from killed animals). They suggested that eastern Sonora appeared capable of supporting male and female jaguars, with potential range expansion into southeastern Arizona. However, New Mexico and Chihuahua had environmental characteristics primarily limited to the "male **niche**," thus they might be areas into which only males occasionally disperse. Boydston and López-González further suggested that environmental requirements for females might be limiting distribution of northern jaguars. These theories merit further investigation.

Shifts in Distribution. There is little reason to think that jaguar distribution in the Southwest is static. Over the past 100 years, vegetation in the Southwest has changed appreciably (i.e. from more open grassland and woodland to scrub and shrub-invaded grassland and more closed forest) in response to a variety of factors (Hastings and Turner 1965; Turner and others 2003).

EPA (1998) provides relevant information on climate shifts and projects changes for the near-term future: (a) global mean surface temperatures have increased 0.6-1.2°F between 1890 and 1996; (b) the nine warmest years in the 1900s – 1995 was the warmest year on record – occurred after 1984; (c) the average temperature in Tucson, Arizona has increased 3.6°F and rainfall has increased by up to 20 percent in many areas over the past century; and (d) by 2100, temperatures in Arizona could increase by 3-4°F in spring and fall and by 5°F in winter and summer, while precipitation could decrease slightly in summer, increase by 30 percent in fall, increase by 60 percent in winter, and increase by 20 percent in spring. [Note: see Thompson and Anderson (2005) for concise insight into primary factors involved in climate and vegetation shifts in the southwestern United States. Also see Karl and others (1996) regarding indices of climate change for the United States; the document was written expressly for use by comprehension and use by "non-specialists in the field." For information on the biotic effects of climate in the Southwest, see: http://www.cpluhna.nau.edu/change/climate.htm.]

The effects and importance of such climate changes on historical and future jaguar habitat and distribution here at the northern periphery of the range are unknown (although see: Abbitt and others 2000; Brown and Davis 1995), but the indirect effects (e.g. changes in prey base abundance and vegetation) might be important. Also, the human footprint on the landscape has become much more evident over the past 100 years and seems likely to become even more pronounced. There are far more people here now than there were 100 years ago and far fewer places without people. This pattern is not likely to change in the foreseeable future and consequent effects on the dynamics of jaguar presence seem inevitable.

Importance of Periphery. Arizona and New Mexico are at the northern edge of the northernmost jaguar population known today. Miller and others (1996) established the value of peripheral populations in recovery of the black-footed ferret, as did Schaller (1993) for the giant panda. Ehrlich and Ehrlich (1992) and Garcia-Ramos and Kirkpatrick (1997) affirmed the conservation value of populations at the fringe of the range in a more general sense.

Channell and Lomolino (2000) assessed the importance of populations at the periphery of a species' range, in a study of dynamic biogeography and conservation of endangered species. Their analysis suggested populations persist longest at the extremes of their range, when they undergo dramatic reductions in their range, and accordingly they postulated that such populations might deserve even greater conservation focus than do "core" populations. Peterson (2001) discounted the conservation value of peripheral populations, asserting they are often not viable and can be "**sink**" **population**s (see: Brown and Kodric-Brown 1977; Pulliam 1988). Nielsen and others (2001) contested Peterson's findings, claiming that such populations are "vitally important to a species' past, present, and future existence." The "importance of periphery" is an intriguing concept that needs scrutiny to determine how, if at all, it relates to northern jaguar conservation (see also below).

Habitat and Population Fragmentation and Connectivity. Habitat and population fragmentation and connectivity are probably the most important factors to consider in assessing jaguar conservation. The importance of individual (e.g. peripheral) populations, connectivity, and the effects of fragmentation is inherent in the metapopulation concept (see: Begon and others 1996; Hanski 1991; Hanski and Gilpin 1991; Levins 1969; McCullough 1996; Meffe and others 1997; Ricklefs and Miller 1999). A metapopulation consists of a group or network of spatially-separated (i.e. semi-isolated) populations of the same species, together with areas of suitable habitat that are currently unoccupied. The overall dynamic for a non-declining metapopulation is a balance of local loss (extinction or extirpation) and local re**colonization**. A crucial element of the metapopulation concept is linkage of the semi-isolated populations through **dispersal**, providing for demographically significant genetic exchange (see: Gutierrez and Harrison 1996; Harrison 1991, 1994). In the absence of linkage, an insular (isolated) population, as can result from habitat fragmentation, may represent a nonequillibrium metapopulation (Harrison and Taylor 1997) in which extinction probability increases (see Brown and Kodrick-Brown 1977).

In a metapopulation, each "linked" individual population cycles (trends up or down) in relative independence of the other populations and eventually is lost (i.e. disappears) due to fluctuations caused by random demographic events. The smaller the population, the more prone it is to being lost. As Andrewartha and Birch (1954) stated, "in different localities the [demographic] trends

may be going in different directions at the same time…spots [habitat patches] that are occupied today may become vacant tomorrow and reoccupied next week or next year." Although the individual populations have finite life-spans, the population as a whole (i.e. the metapopulation) tends to be more persistent over time because immigrants from one population (which might be experiencing an increase) are likely to re-colonize habitat that has been left open by loss of another population. They may also immigrate into another small population and in doing so rescue it from extinction (i.e. the "rescue effect;" Brown and Kodric-Brown 1977).

Although no single population may be able to guarantee the long-term survival of a given species, the combined effect of many populations may be able to do this (thus the ecological importance of both "core" and "peripheral" populations). The ecological relationships inherent to metapopulation theory are complex, however, and there is "no single 'magic' population size that guarantees the persistence of populations" (Thomas 1990). Nor is there a magic number of peripheral populations interacting with the core. Given the extent to which habitat fragmentation has occurred and continues to occur, it is particularly important that metapopulation models consider spatial dynamics such as patch area size and extent of isolation. For a review of this subject, see Hanski and Ovaskainen (2003).

Rangewide, jaguar habitat is increasingly fragmented and if jaguars are unable to move from one isolated population to another, at least occasionally, gene flow will eventually cease and jaguar population viability will be threatened (see: Rabinowitz 2006; Sanderson and others 2002a, 2002b). This concern is consistent with the contention that, in general, connectivity (e.g. linkages or corridors) among large core areas and peripheral habitats is essential to maintaining biological diversity (see: Beatley 1994; Beier and Noss 1998; Bennett 1999; Cody and Diamond 1975; Damschen and others 2006; Groves 2003; Hudson 1991 (especially Part II, Conservation Corridors: Countering Habitat Fragmentation); Simberloff and others 1992). The literature on conservation-oriented corridors is rapidly expanding, perhaps in part because the global landscape becomes ever more fragmented each year. Practical applications and the benefits thereof are capably and appropriately advocated, but limitations are also being identified (e.g. Chetkiewicz and others 2006; Hilty and others 2006). Regardless, the current understanding is that connectivity of large areas is essential to conserving biological diversity at a landscape-level and (see: Foreman 2004; Soulé and Noss 1998; Weber and Rabinowitz 1996)[15,16] particularly important to long-term viability of large-carnivore populations.

Meaningful corridors are, however, neither a panacea nor simple to design and easy to secure. In some cases, the landscape-level concept of connectivity is so sweeping that it becomes as

[15] Whether such areas must be devoid of human habitation (e.g. legally-established "wilderness") or merely be hospitable to presence of carnivores (i.e. no illegal killing) is widely debated, including within JAGCT. Debate over effects of human presence is largely values-based, a reflection of land-use preferences. Disparities in philosophy do not change the ecological facts regarding the need of wide-ranging carnivores such as jaguars for large areas of suitable habitat, movement corridors between core and peripheral populations, and protection from illegal killing.

[16] Simberloff and others (1992) discuss potential and realized situations in which restoration of connectivity through terrestrial or aquatic linkages or corridors might be or is detrimental to conservation objectives.

threatening to some interests as it is essential to others. This is evident in borderlands jaguar conservation. Some participants in JAGCT are staunch advocates of a connected network of wild, protected places (e.g. Sky Island Alliance and Wildlands Project; see Section 3.5.1). Often, but not always, such advocates are urbanites who value wildlands and connectivity corridors for conservation and recreation purposes but who typically do not derive a livelihood from them. Other stakeholders, often rural residents with several generations invested in the land and in their livelihoods, are staunchly opposed to wildlands protections that restrict access to or multiple-use of such areas. Neither set of values is "better" than the other (in fact, there is substantial overlap between them, e.g. maintaining connectivity and relatively low-levels of human occupancy), but change, or even the possibility of change, is almost always threatening and it seems that the bigger the perceived change the bigger the perceived threat.

Increasingly, landscape-level conservation proponents within the more traditional conservation community have also taken note of the need to address fear of change by directly involving local people who see the potential for being significantly affected by the proposed actions. The Wildlife Conservation Society's "Living Landscapes Program" (WCS 2009) is an excellent example:

> The...Living Landscapes Program is based on a simple reality: animals do not recognize park boundaries, particularly wide-ranging species such as elephants, bears and jaguars. Indeed, while parks are essential for conservation, the larger landscape adjacent to protected areas, with both humans and animals living within it, is often as important as the protected core. To protect these "Living Landscapes," WCS has created an approach that involves not only parks and protected areas, but neighboring people, governments and the private sector.
>
> Today, the Wildlife Conservation Society is using this approach in some 28 land-and-sea scapes across Africa, Asia, Latin America and North America. While creatively resolving threats to wildlife and wild places while minimizing the costs to humans, WCS is creating a landscape that is sustainable for both.
>
> Conservation in the real world is not only about establishing preserves to protect Earth's diversity, but going beyond them to save wildlife on all fronts.

Among the Wildlife Conservation Society's "living landscapes" is the Maya Biosphere Reserve, an area that WCS considers the "most important segment of the Mesoamerican Biological Corridor" and which Rabinowitz (2006) considers crucial to jaguar conservation (see Section 3.5.2).

3.4. Population Status and Trends.

Much like "habitat," "population" is a contested term within JAGCT. At the core of the debate is whether the collection of jaguar occurrences in the AZ-NM borderlands is a discrete population, or merely dispersing individuals at the edge of a population that is centered elsewhere. To some, acknowledging that a population of any sort exists seems to invite regulatory protective actions. For others, the issue stems from ecological principles, not matters of law.

Estimation of population status and trends for any large carnivore is challenging, particularly when the species is nocturnal, secretive, and present in low numbers. Absent a rigorously-gathered, long-term data-set, inferences must be based on the available information and any conclusions drawn about presence and status must acknowledge information gaps. So it is with the borderlands jaguar. No firm historical population baseline exists for the jaguar, but rangewide population decline is evident in recent history, as Rabinowitz (2006) summarized:

> By the 1960s, environmental degradation and decades of harvesting spotted cat skins for the North American and European fashion industries had decimated many jaguar populations. In 1969 alone, nearly 10,000 jaguar skins valued at more than $1.5 million were imported into the U.S. By the time most of the jaguar range countries outlawed the trade, during the 1970s, sharp declines in jaguar numbers were noted from areas where the cats had once been abundant. Meanwhile, Latin America's human population was growing faster than that of any other region except Africa.

Swank and Teer (1989) estimated that as of 1987 the jaguar's range had been reduced by 67 percent in Mexico and Central America, and 38 percent in South America. Similarly, Chávez and Ceballos (2006) estimated that: 60 percent of the jaguar's historical range in Mexico had been lost; the nationwide population was less than 5000 individuals; and a variety of threats suggested that, absent effective conservation efforts, jaguar imperilment in Mexico would only worsen. If the core of the northern Mexico population were lost, or if its connectivity with the United States were broken, our present understanding suggests there could be little hope that jaguars would persist in Arizona or New Mexico.

Although Valdez (2000) asserted the "United States probably had a viable jaguar population early in the 20th century," the size of the U.S. population and the number of jaguars present in Arizona or New Mexico at any given time (whether now or historically) are unknown. Regardless, the best available information indicates that, until 1996, jaguars in the American Southwest did not survive for long once they were discovered. Between 1885 and 1959 in Arizona and New Mexico, 45 jaguars were killed, six were sighted, and two were documented by evidence such as tracks and/or droppings (Hock 1955; Lange 1960). Overlapping assessments documented 58 jaguars killed or photographed in Arizona and New Mexico from 1900 to 2000 (Brown and López-González 2000, 2001; Girmendonk 1994). When plotted at 10-year intervals, the records of jaguars reported killed in Arizona and New Mexico between 1900 and 1980 demonstrated decline characteristic of an over-exploited resident population (Brown 1983, 1987). Indeed, over the past 50 years the number of jaguars observed in Arizona and New Mexico has been considerably lower than for the previous 50 years (see Brown and López-González 2001).

Another aspect of population status is whether animals are resident year-round, seasonally present, or present only occasionally, perhaps as dispersers. The documented record for both Arizona and New Mexico since the late 1800s is mostly of males (Brown and López-González 2001). Six of the seven jaguars confirmed in Arizona and New Mexico from 1960 through 2009 and identified to gender have been males (the lone female was killed in 1963 near Big Lake, White Mountains, Arizona) and all have been solitary individuals (AGFD unpublished data;

Brown and López-González 2001; McCain and Childs 2007, 2008, 2009). This information has led many to infer that the jaguars present in Arizona and New Mexico historically and in recent years have been dispersing animals, not year-round or seasonal breeding residents.

The contrary case has also been made, however. Although only a few female jaguars have been reported north of Mexico, three historical records from Arizona suggest evidence of breeding: a reported kill of a female with two kittens near the Grand Canyon between 1885 and 1890 (Lange 1960), a reported kill of a female and a cub at the head of Chevelon Creek in 1910 (Brown 1983; Brown and López-González 2000, 2001; Nowak 1975), and a newspaper report of a female killed and her two kittens captured in the Chiricahua Mountains in 1906 (Brown 1989, 1991; Brown and López-González 2000, 2001). Thus, Valdez (2000) contends that jaguars probably were breeding residents in Arizona in recent history (no such claim has been made for New Mexico).

In addition to historical aspects, we must consider current jaguar status and trends in the borderlands. From 1996 through 2009, jaguar occurrence has been confirmed repeatedly along the U.S.-Mexico border in southern Arizona and New Mexico (Childs 1998; Childs and others 2007; Glenn 1996; McCain and Childs 2008, 2009). Since 1997, when JAGCT monitoring began, through use of remote cameras, presence has been documented in Arizona and/or New Mexico in every calendar month, with one male confirmed in the same area over a period of 13 years (1996-2009) and a second (different) male confirmed in a nearby area over a period of three years (Childs and others 2007; McCain and Childs 2008, 2009). Both of these males were mature, healthy adults. The most recent confirmed records are camera-trap photographs taken in southcentral Arizona in January through March 2007 that document a male engaged in territorial behavior – scent marking (McCain and Childs 2008). Whether the display might have been in response to near-by presence of another male, or a female, is unknown, but McCain and Childs speculate the species may now (again?) be resident (albeit in low numbers) in the AZ-NM borderlands.

Status information is increasingly becoming available on the core of the northern jaguar population in Mexico (see Rosas-Rosas 2006), and the Borderlands Jaguar Detection Project has provided invaluable information from southcentral Arizona since 1997 (see McCain and Childs 2008). However, monitoring has not been sufficient to conclusively determine (except for Macho B) whether the jaguars observed in Arizona and/or New Mexico since 1996 have been present continuously or sporadically (perhaps seasonally) in any specific area. Nor has monitoring in Arizona and New Mexico been sufficient in scope and intensity to draw definitive conclusions as to whether all jaguars – male or female – occurring in the area have been found or whether breeding is or is not occurring in Arizona and/or New Mexico. These difficulties are not unexpected. As Emmons (1999) stated, “Rarely is more than one adult jaguar at a time found in the same geographic area, and the number of individuals that can coexist is limited.” With regard to borderlands jaguars, it is thus crucial to remember that absence of evidence is not necessarily evidence of absence.

3.5. Conservation Efforts

The human dimension provides important context for assessing borderlands jaguar conservation effort. In southern Arizona and New Mexico, extensive public lands and rural private and leased ranchlands form a mosaic supporting many species of native wildlife. Across the International Border, in northern Mexico (i.e. States of Chihuahua and Sonora), private and communal rural agrarian lands predominate over governmentally-protected areas. This is an area of rugged topography and great natural diversity, used for many purposes and widely appreciated for its immeasurable values. It is a working landscape for many people, and a conservation/recreation landscape for many more.

In the face of ever-increasing urban encroachment, collaboration[17] among the people who live in, visit, or otherwise value these diverse borderlands is essential to conserving a wealth of life forms and lifestyles. Among those who have a stake in how these lands are managed are: academics, artists, backpackers, birdwatchers, campers, conservationists, environmentalists, government agencies, hikers, hunters, Native Americans, photographers, ranchers, retirees, school children, urbanites, and writers. How these stakeholders work out their differences and cooperate on issues of common concern will greatly influence whether some species thrive or disappear from these borderlands.

From the 1970s into the 1990s, federal environmental laws provided much of the framework for resolving public-lands conflicts in the United States. The concepts of laws such as the ESA were broadly focused on ensuring that the Nation's natural resources were protected for current and future generations. Representative John D. Dingell (Foreword in Rohlf 1989), chairman of the House Committee that introduced the bill that eventually became the ESA, recalled congressional intent as follows: "When Congress passed the [ESA], it set a clear policy that we would not be indifferent to the destruction of nature's bounty." It was an act of national altruism that set a remarkable foundation for conservation worldwide, and that foundation was regulatory protection. However, forced compliance and even more so the expectation and fear of forced compliance soon began generating acrimony, distrust, and litigation (e.g. Hage 1990; Ray and Guzzo 1994) that even today lie close to and sometimes boil over onto the surface in land-use discussions. In such circumstances, stakeholder opinions too often reflect the strength of absolute conviction that "my position is right" and any conflicting viewpoint is not just wrong but unacceptable. Finding common ground, or at least a balance of values, among such conflicting viewpoints can be difficult, but it is not impossible. Bean and others (1991), Kohm (1991), and Bowles and Whelan (1994) were among the first to synthesize emerging approaches through which rhetoric, regulatory issues, and values roadblocks could be overcome and common ground (workable solutions that protected wildlife values as well as stakeholder interests) could be found. Clark (1997) provided more experience-based insight into how bureaucracy and conflict affect endangered species conservation efforts and new approaches, including more open collaboration with nongovernmental stakeholders, that could lead to greater success.

[17] Buck and others (2001), Hargrove (1998), and Wondolleck and Yaffee (2000) are instructive resources regarding "collaboration" as the term is used in this document.

One of the borderlands species that would benefit from better understanding and collaboration among humans is the jaguar, the most magnificent of all wild cats native to the United States and Mexico. Fortunately, there is good reason for cautious optimism. In northern Mexico, productive local collaborations have begun emerging through community-based conservation that in part is using innovative economic incentives to capture private landowner interest (see: Rosas-Rosas 2006; http://www.northernjaguarproject.org). Those efforts complement work on the Arizona-New Mexico side of the border by the Malpai Borderlands Group (MBG) and others. In both areas, the primary focus is on voluntary rather than regulatory approaches to complex land-use and conservation issues.

An abundant literature is emerging on the merits of voluntary, collaborative conservation. One of the more insightful books is Wondolleck and Yaffee (2000). Years earlier, Yaffee (1982) wrote a primer on the Endangered Species Act (ESA) of 1973, describing the ESA as prohibitive policy. The more recent book builds on his original premise that the ESA really does provide a solid framework for balancing interests through negotiation (collaboration), even though those approaches superficially appear to be prohibited by the statute itself and for the first 20 years of the ESA life were too little used by ESA practitioners.

The opening passage in Wondolleck and Yaffee (2000) seems particularly relevant to the borderlands jaguar conservation effort:

> A new style of environmental problem solving and management is under development in the United States. Government agencies, communities, and private groups are building bridges between one another that enable them to deal with common problems, work through conflicts, and develop forward-thinking strategies for regional protection and development. From management partnerships and interagency cooperation to educational outreach and collaborative problem solving, this new style of management is developing organically in many places in response to shared problems and the simple need to move forward. In other places, agency initiatives have helped to create opportunities for meaningful involvement that were not possible in the past.

Sillero-Zubirir and Laurenson (2001) advocate that movement toward community-based conservation is “clearly essential for carnivore conservation.” They speak to the futility of seeking solutions that do not involve local communities. Among the problems they recognize as causing conflict between carnivores and local communities are several familiar to borderlands jaguar conservation: attacks on humans (or fear of such), predation on livestock, predation on game species or other endangered wildlife, consumptive use of carnivores, conflict over land [use]. They assert that community tolerance (if not support) can be gained by recognizing these problems, gaining local participation, improving economic benefits to the community, and improving the community’s aesthetic and moral benefits. “Each solution must be worked on a case-by-case basis, to fit a unique set of ecological, cultural, and economic circumstances.”

In no small way, finding a balance between the regulatory approach and the voluntary approach to conservation is essential to ensuring the jaguar’s presence in the southwestern landscape. The ESA is what it is, and the letter of the law must be obeyed. So, too, must the spirit of the law be obeyed, and both the spirit and the letter of the ESA include leaving “the ecosystems on which

they (e.g. jaguars) depend" in better shape than they are now. This theme echoes conceptually through Wallach's (1991) book, *At Odds with Progress*, as reflected in a telling passage excerpted from an essay by his intellectual mentor, Carl Sauer (1956):

> The prophets of a new world by material progress may be stopped by economic limits of physical matter. They may fail because people grow tired of getting and spending as measure and mode of living. They may be checked because men come to fear the requisite growing power of government over the individual and the community. The high moments of history have come not when man was most concerned with the comforts and displays of the flesh but when his spirit was moved to grow in grace. What we need more perhaps is an ethic and aesthetic under which man, practicing the qualities of prudence and moderation, may indeed pass on to posterity a good earth.

"Building bridges" among disparate interests, "meaningful involvement" by stakeholders, and passing on to posterity "a good earth" are, we believe, at the heart of the borderlands jaguar conservation effort in Arizona and New Mexico, and companion efforts in northern Mexico.

3.5.1. Conservation Efforts in the United States.

Conservation efforts are ongoing for borderlands jaguars; many are voluntary actions by non-governmental entities. Below, we summarize and assess these efforts to define and meet the needs of jaguars within the borderlands.

Jaguar Conservation Team – In March 1996 and August 1996, live jaguars were documented in New Mexico and Arizona (Glenn 1996; Childs 1998). In contrast to the previous recent jaguar occurrences in Arizona, in 1971 and 1986 (Brown and López-González 2001), neither of the jaguars observed in 1996 was killed on discovery (Glenn 1996; Childs 1998). However, like the 1971 and 1986 killings, the 1996 sightings stimulated tremendous public interest in jaguar presence in the borderlands.

In September 1996, AGFD, NMDGF, and Texas Parks and Wildlife Department (TPWD) began discussing a state-led conservation agreement for jaguars as an alternative to federal listing. TPWD soon dropped out, anticipating that if Federal listing for the United States occurred it would not include the *veraecrucis* subspecies historically present in Texas. AGFD and NMDGF continued discussions, eventually creating a state-led effort to (a) conserve the jaguar in Arizona and New Mexico through voluntary collaborative-conservation, and (b) preclude the need for federal listing of the jaguar north of the U.S.-Mexico border (Johnson and Van Pelt 1997; Van Pelt and Johnson 2002).

On March 24, 1997, AGFD and NMDGF completed a *Conservation Assessment and Strategy for the Jaguar in Arizona and New Mexico* (Johnson and Van Pelt 1997; Van Pelt and Johnson 2002). The assessment portion described the current status of the jaguar in the United States, and identified and assessed risks in Arizona and New Mexico. The strategy portion described goals, objectives, strategies, and activities intended to conserve jaguars in Arizona and New Mexico, and recognized the need to encourage and support parallel conservation in northern Mexico. A companion Memorandum of Agreement, executed in 1997, provided for state, federal, and

county government participation, under auspices of the JAGCT (AZ-NM Jaguar Conservation Team). Collectively, the two documents are known as the AZ-NM Jaguar Conservation Agreement. Although the Agreement was intended to preclude the need for federal listing, the conservation effort continued after USFWS (1997) extended endangered status to the jaguar in the United States, and affirmed that the AZ-NM Jaguar Conservation Agreement would serve as a template for protections necessary for conservation of the jaguar.

JAGCT first met on April 30, 1997, in Douglas, Arizona. Since then, it has met twice or more each year to discuss recent jaguar sightings, management issues, education and outreach opportunities, and research efforts. Each JAGCT meeting has had 40 to 75 participants, including ranchers, conservationists, academics, researchers, journalists, and government agency staff. Various committees have been formed to address issues and complete tasks. Three progress assessments have been produced by the JAGCT (Johnson and Van Pelt 2000; Van Pelt 2004; Van Pelt and Johnson 1998). Povilitis (2002) has also critiqued the effort.

To date, JAGCT's borderlands jaguar conservation efforts have had mixed results (see: Johnson and Van Pelt 2000; Povilitis 2002; Van Pelt 2004; Van Pelt and Johnson 1998). Notable impediments to success have included: (a) lack of funding; (b) irregular or inadequate agency resources (e.g. staff time); and (c) ongoing conflict and debate among interest groups and individuals within JAGCT on key issues, including: status of jaguars in the AZ-NM borderlands (resident or transient); applicability of recovery planning to jaguars in the United States; what constitutes jaguar habitat (occupied, potential, suitable, etc.); possible need for reintroduction of jaguars; designation of critical habitat; and live capture of a jaguar for radiotelemetry study. Despite the Lead Agencies' (AGFD and NMDGF) resolute and oft-restated commitment to voluntary, non-regulatory conservation within JAGCT, without supporting reintroduction of jaguars or designation of critical habitat, concerns about those issues are frequently re-surfaced and must be addressed again and again. Considerable time has been lost as a result of the repetitive discussions.

JAGCT has achieved several notable accomplishments, however, including: (a) collaboration with Mexico on jaguar conservation; (b) a jaguar-based educational curriculum (in Spanish and English) that meets State and National standards and is in use in area schools; (c) enhanced public awareness of jaguar presence and conservation needs; (d) increased penalties under state law for unlawful killing of jaguars (in AZ these increased penalties apply only if the jaguar is delisted federally); (e) a jaguar detection project (using still and video camera-traps); (f) a system for evaluating and archiving sighting reports; (g) GIS-based evaluations of areas and habitats of historical and recent jaguar occurrence in Arizona and New Mexico for delineation of primary emphasis areas in both states for this conservation effort; (h) delineation of research recommendations intended to guide studies and provide JAGCT with information requisite to science-based conservation efforts; (i) a rural outreach program (see: Rinkevitch and Bashum 2003; Warshall and Bless 2003); and (j) regular public forums in Arizona and New Mexico for discussion of jaguar-related issues. Consistent participation by 40 or more disparate stakeholders in each JAGCT public meeting since 1997 is a particularly outstanding accomplishment, and testimony to the shared commitment to finding mutually agreeable ways to voluntarily conserve borderlands jaguars within the context of existing land-use practices.

In 2006 and 2007, AGFD, NMDGF, and their cooperators again reassessed the AZ-NM borderlands jaguar conservation effort. The process included developing a new Memorandum of Understanding (MOU), which was initially between AGFD and NMDGF, and this Conservation Assessment and Framework as successors to the 1997 AZ-NM Jaguar Conservation Agreement. The first JAGCT meeting under the new MOU was held in Douglas AZ on May 2, 2007. Thus, JAGCT remains the focal point of jaguar conservation in the United States. Its activities have also helped spur companion efforts in northern Mexico, where, over the past several years, considerable progress has been made. Notably, as of June 2007, Warner Glenn, Jack Childs, and their families continue to be active participants and leaders in borderlands jaguar conservation.

Although AGFD jaguar conservation efforts are largely addressed in the preceding JAGCT paragraphs, additional comment on one aspect is necessary. Over the past year, AGFD and the JAGCT were criticized for lack of effort toward indentifying and protecting habitats important as wildlife movement corridors, particularly along the Mexican border. AGFD believes such criticism reflects a lack of understanding about (a) JAGCT's role as opposed to AGFD's role in this area, and (b) of AGFD's extensive efforts in this area.

In summary, AGFD applies JAGCT jaguar location information on virtually a daily basis. AGFD's Habitat Program, which includes a robust project-specific (environmental) review component, provides land management agencies and other state and federal agencies with information relevant to the full spectrum of wildlife issues of concern. One key facet of this comprehensive effort is effort to identify and conserve wildlife movement corridors. This project, known as the **Arizona Wildlife Linkages Workgroup,** is an important collaborative effort between public and private sector organizations working to address habitat fragmentation in a cohesive, systematic approach in order to maintain and improve wildlife diversity in Arizona. Comprised of representatives from AGFD, the Arizona Department of Transportation, the Federal Highway Administration, U.S. Forest Service, Bureau of Land Management, USFWS, Northern Arizona University, the Wildlands Network, and the Sky Island Alliance, the Workgroup is developing a statewide map identifying wildlife movement corridors to provide a visual tool to guide future planning, engineering and mitigation efforts. Much of the wildlife information used in the models (GIS layers) is influenced by various sensitive species lists, such as the Department's Comprehensive Wildlife Conservation Strategy, and includes information specific to potential jaguar movements. AGFD and its collaborators use the GIS-based information to refine linkage or fracture zones into more site-specific areas that will guide future conservation and planning efforts. A pilot project is underway in northern Arizona to begin using this tool. Further information on the Workgroup and its recent assessment of Arizona wildlife linkages is available at:

http://www.azdot.gov/Highways/OES/AZ_Wildlife_Linkages/index.asp

Borderlands Jaguar Detection Project. Early in its development, the JAGCT began to recognize the BJDP (http://www.swjag.org) as its field arm, focused on assessing jaguar presence first in southcentral Arizona and eventually (funding permitting) across the entire span of possible occurrence in the AZ-NM/Mexico borderlands. Under Jack Childs' guidance, with Emil McCain and volunteers increasingly doing the bulk of the fieldwork, BJDP has become the primary JAGCT vehicle for increasing knowledge of jaguars in the borderlands. As of January 2009 (see BJDP 2009), BJDP: is maintaining 45-50 remote-camera stations in Pima, Santa Cruz, and Cochise counties, Arizona; conducts track and scat surveys opportunistically; and follows up on

credible sighting reports from other individuals. This work has produced (all in Arizona) 85 jaguar photographs representing 74 different events and 31 sets of jaguar tracks (105 locations). These data represent two adult male jaguars and possibly a third jaguar of unknown sex (see McCain and Childs 2008 for details).

BJDP productivity and effectiveness is directly related to the cooperative relationships it has developed throughout southern Arizona, including with the Altar Valley Conservation Alliance, San Rafael Valley Alliance, Save the Scenic Santa Ritas, and many individual landowners and public lands ranchers (see BJDP 2009 for a list of cooperators). BJDP has also given more than 100 public presentations, hosted and given countless interviews to dozens of reporters and writers, published one peer-reviewed article (McCain and Childs 2008) and more than 15 progress reports to JAGCT, and published a book (Childs and Childs 2008) about BJDP's work with jaguars in the unique biological and social circumstances of the AZ-NM/Mexico borderlands. All of this has been done to assist the JAGCT and to increase public awareness of and support for jaguar conservation efforts and issues.

Malpai Borderlands Group - The MBG is a grassroots, landowner-driven non-profit nongovernmental organization (NGO) consisting of private landowners living in the borderlands of southeastern Arizona and southwestern New Mexico, near the U.S.-Mexico border (http://www.malpaiborderlandsgroup.org; also see Sayre 2005). MPG was the first "rural" group in the AZ-NM borderlands to resolve land management issues bridging private and public lands through collaborative, landscape-level planning. The lands covered by MBG total about 800,000 acres and include approximately 30 privately-owned ranches and a mosaic of state and public lands. MBG's goal is to restore and maintain the natural processes that create and protect a healthy, unfragmented landscape, to support a diverse, flourishing community of human, plant, and animal life.

Among the MBG's founding members is Warner Glenn. After Glenn's 1996 sighting and photographs of a jaguar in the Peloncillo Mountains of New Mexico, MBG met with AGFD and NMDGF and the Bureau of Land Management, U.S.D.A. Forest Service, and USFWS to discuss implications of the event. As a result, MBG established a fund to help compensate its members for livestock confirmed to have been killed by jaguars. A portion of the proceeds from sale of the book in which Warner Glenn described his 1996 jaguar sighting (*Eyes of Fire: Encounter with a Borderlands Jaguar*, Glenn 1996) is donated to the Jaguar Fund.

Note: although a 2007 jaguar depredation on livestock occurred in AZ nearly 200 miles west of the its management area, MBG voluntarily used its funds to compensate the rancher for the loss.

Sky Island Alliance. The Sky Island Alliance (http://www.skyislandalliance.org) is a grassroots NGO dedicated to protection and restoration of the rich natural heritage of native species and habitats in the Sky Island region of the southwestern United States and northwestern Mexico. The Alliance works with volunteers, scientists, land owners, public officials, and government agencies to establish protected areas, restore healthy landscapes, and promote public appreciation of the region's unique biological diversity. The Alliance is active in promoting jaguar conservation, and believes that establishing a Tumacacori Highlands Wilderness Area (ca. 84,000 acres) on the Coronado National Forest in southcentral Arizona, in an area of known

recent jaguar occurrence, would be a significant contribution to conservation of the species. Opposing viewpoints, including those of the Arizona Game and Fish Commission and AGFD, are that current land uses on the Coronado National Forest are not in conflict with jaguar conservation and protection under the Wilderness Act of 1964 is not needed.

Wildlands Project. WP (now known as Wildlands Network; http://www.twp.org) is an NGO that was founded in 1991 by conservation biologists and wilderness advocates concerned about worldwide extinction rates for plants and animals. The founders believed the traditional system of protecting wildlife and wildlands was no longer working. Unless protected areas such as parks, wilderness areas, and wildlife refuges were linked together, the landscape would increasingly become islands of habitat surrounded by a sea of development. The long-term survival of many species would continue to become increasingly threatened.

Rather than focus on simply protecting more land, the Wildlands Project asked conservationists to think about innovative ways in which existing islands of protected habitat could be connected by wildlands networks – mosaics of public and private land linked together so wildlife has the room it needs. From this mindset evolved a one hundred year vision: to create a continental-scale network of connected wildlands. It is a bold and sweeping vision from the private sector that most government agencies have not yet embraced, and one that causes considerable concern among private individuals who have stakes in the areas that would most likely be affected.

More than a decade later, the basic concepts first proposed by the Wildlands Project are now mainstream. The idea of reconnecting and restoring wildlands on a continental scale has been widely adopted by conservation groups both large and small. Today, the Project's vision can be seen working across North America and around the globe. Dozens of partner groups are developing landscape-scale conservation plans using cutting-edge science to establish conservation priorities for very large regions, and are actively working to turn these hopeful visions of “what could be” into reality on the ground. The science in the Wildlands Project’s approach to conservation is clearly evident, and its focus on connectivity meshes very well with the primary jaguar conservation needs in the borderlands. Within the JAGCT, however, the Wildlands Project is not universally embraced. Some stakeholders are concerned that its intent is to pursue land protection actions that will conflict with existing local custom and culture. The dichotomy is a familiar one and the jaguar is caught between the two.

At least some of the local resistance is a legacy from the Wildlands Project’s early rhetoric and stated goals, which evoked perceptions of ecological elitism and immediate, massive change that would inevitably result in exclusion of traditional rural land uses, such as ranching, from public lands. However, in recent years the Project’s approach has shifted toward inclusivity and collaboration (see goals published at http://www.twp.org). It now works with a broad range of stakeholders, including local communities, landowners, and regulatory agencies, in addition to conservation organizations. In short, the Project is striving to identify common ground that enables all interest groups to support the organization’s vision for continental conservation (K. Vacariu personal communication). Nevertheless, some JAGCT participants seem not to have recognized (or not to trust) that the leopard has indeed changed its spots. It remains to be seen whether essential common ground can be found among the disparate groups.

In 2007 the Wildlands Project (now known as Wildlands Network), to further borderlands jaguar conservation, identified possible movement corridors within the northern population, connecting areas of recent jaguar occurrence in Arizona and New Mexico with the "Nácori Chico" [Sahuaripa-Huasabas] area of Sonora, Mexico (K. Vacariu personal communication). Their approach consisted of using Geographic Information System (GIS) technology and a "Jaguar Corridor Mapping Workshop" that was convened on April 13, 2007. The goal of the invitation-only workshop was to produce two versions of a jaguar movement corridor map: a multi-layered, scientifically-defensible GIS corridor base map and a more user-friendly corridor map (see Fig. 2) for general distribution.

The Wildlands Project GIS base corridor map was produced through use of several data layers, including terrain, land cover, roads, population, property and land ownership, The Nature Conservancy's "Human Footprint" layer, and a multiple-layer-based habitat suitability analysis that was funded by the Wildlands Project and produced by Dr. Enrique Martinez of UNAM in Mexico City. The workshop was the first time that all the above GIS data were compiled into a single map showing highly-predictable jaguar movement corridors.

The "user-friendly" corridors map (see Fig. 2) nicely illustrates JAGCT's ongoing discussion of likely routes by which jaguars move between the United States and Mexico. Except for the San Pedro River corridor (east of the Huachuca Mountains), the map is generally well supported by historical records of jaguars in the United States and Mexico (see Brown and López-González 2001), by ongoing Borderlands Jaguar Detection Project (BJDP) jaguar monitoring and survey work in southcentral Arizona (see Section 3.5.1), and by recent jaguar research and conservation effort in northern Mexico (see Section 3.5.2). Again with the exception of the San Pedro River corridor, the corridors mapped are also reasonably consistent with habitat assessments published by Brown and López-González (2001), Grigione and others (2009), and Hatten and others (2003, 2005). In regard to the San Pedro Rover corridor: we are not aware of any documented jaguar locations on the San Pedro River or in the mountains immediately east or west of the river. Regardless, our use of the map does not in any way connote agreement with its depictions of "safe passages," "suitable habitat," or "ideal habitat;" nor does it indicate support for advocating acquisition of "Ranches needed to complete [a jaguar] reserve" in the United States or Mexico. Our use of the map is purely to depict an important aspect of jaguar biology (i.e. possible movement corridors) in the borderlands.

U.S. Fish and Wildlife Service – The *Listed Cats of Texas and Arizona Recovery Plan (With Emphasis on the Ocelot)* (USFWS 1990) addresses the jaguar and jaguarundi, but primarily focuses on the ocelot. The plan provides limited information on the jaguar, stating that the status in northern Mexico needs to be determined before recovery recommendations can be made. The ocelot portion of the plan is undergoing extensive revision, but the jaguarundi and jaguar portions have been given much less attention (T.B. Johnson personal observation).

USFWS has been an active participant in JAGCT activities since the borderlands conservation effort was initiated in 1997, including: participating in and providing briefings at JAGCT meetings; helping provide funding for BJDP camera work; cooperating with AGFD and NMDGF to develop JAGCT documents pertaining to jaguar conservation and to receive and evaluate jaguar sighting reports; and consulting extensively with agencies and other entities that

are subject to ESA Section 7 and NEPA environmental review processes. Section 7 consultations are often complex and time-consuming but they are perhaps the most direct and effective way that JAGCT-generated information is applied to the benefit of jaguar conservation in the United States (e.g. USFWS 2007; other USFWS Biological Opinions on border fence issues are available at: http://www.fws.gov/southwest/es/arizona/biological.htm).

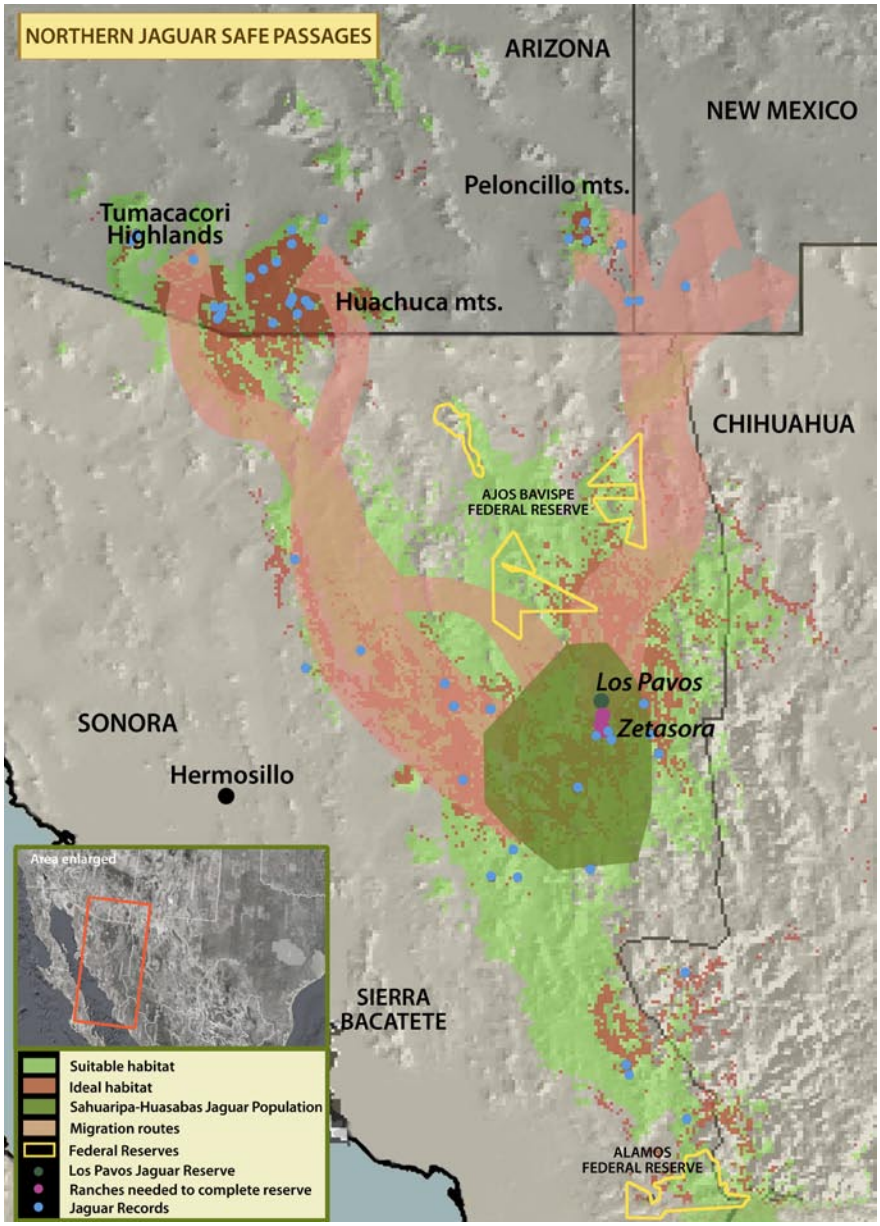

Figure 2. Corridors thought to enable jaguar movement between the United States and Mexico. Map adapted from and provided courtesy of the Wildlands Project (WP 2007). Note: this map is used herein only to illustrate possible jaguar movement corridors. This use does not imply agreement with, or accuracy of, the map's depictions of "safe passages" or "suitable habitat" or "ideal habitat," or indicate support for advocacy for acquisition of "Ranches needed to complete [a jaguar] reserve" in the United States or Mexico.

3.5.2. Conservation Efforts in Mexico.

Mexico considers the jaguar a national priority species for conservation. It elevated jaguar conservation to the highest level of government when the President of the Republic declared 2005 to be "The Year of the Jaguar" (Ceballos and others 2006; Chávez and Ceballos 2006; Fox-Quesada 2005). On October 12-15, 2005, Mexico, under direction of CONANP (Comisión Nacional de Áreas Naturales Protegidas, the National Commission for Protected Natural Areas) and auspices of SEMARNAT, sponsored its first national symposium on jaguar conservation, El Jaguar Mexicano en el Siglo XXI: Situación Actual y Manejo (Chávez and Ceballos 2006). JAGCT participation in the symposium furthered coordination and cooperation between the two countries at a variety of levels, including developing national and local jaguar conservation strategies.

Despite a shortage of funding, CONANP clearly recognizes the value of conservation strategies, known in Mexico as PREPs (Proyectos de Recuperación de Especies Prioritarias), for diverse species and the need to identify threats to species and prioritize consensus actions, set specific dates, and establish clear goals, indicators of success, responsible parties, resources, and follow-up to implement actions for conservation. CONANP's *National Technical Consultants Subcommittee for Conservation and Management of the Jaguar* completed a PREP for jaguars in Mexico in 2006 (Ceballos and others 2006). The PREP identifies on-the-ground conservation actions such as protection, management, and restoration of the species and its habitat. It also provides for indirect actions such as information dissemination, integrating jaguar conservation into the existing fabric of local cultures, and administration. The action plan was intended to be carried out over a five-year period.

During "The Year of the Jaguar," approximately 38,000 ha (93,897 ac) of the Sierra de Vallejo (State of Nayarit) were decreed as State Natural Protected Areas, in cooperation with Hojanay (a Mexican NGO). Banamex and the Fideicomiso Fund for Natural Heritage in Mexico also reached an agreement with the Ejido Ursilo Galvan (a local cooperative from the same mountain range) to set aside 1900 ha (4695 ac) as an Ejidal Sanctuary for the jaguar. Likewise, Mexico signed a brotherhood pact for protected areas with Belize and Guatemala to support a biological corridor in this critical area of "Jaguars without Borders" (Rabinowitz 2006) with Unity for Conservation (another Mexican NGO). State-specific jaguar conservation strategies have been produced for Jalisco, Michoacán, and Oaxaca. In cooperation with PROFEPA (Procuraduría Federal de Protección al Ambiente; Mexico's Federal Ministry for Environmental Protection), communities and NGOs have already implemented community watch groups in 14 states. All told, 25 watch groups have been established (none in Sonora or Chihuahua), with more than 400 rural community members who protect areas to stop illegal hunting and change land use.

Mexico's national jaguar conservation planning efforts continued in 2006 with a March workshop conducted by the National Institute of Ecology, although the proceedings are still being completed (G. Ceballos personal communication). The stated goal of the workshop was to develop a plan that will lead to recovery of the jaguar in Mexico. Key objectives were to evaluate the current status of the jaguar in Mexico; determine threats to jaguar existence; and determine priority conservation actions at the local, regional, and national scale. Subcommittees were established to work at the local level, including one for the northern jaguar population in

Chihuahua and Sonora. JAGCT participation provided opportunities for both countries to share experiences and inform development of mutual conservation strategies, including research projects that would help fill the information gaps that impede progress.

On November 21-24, 2006, Mexico hosted an invited-participation jaguar **Population and Habitat Viability Analysis** (PHVA) workshop, in Cuernavaca, Mexico (the proceedings are still in review). The workshop was the second element of the Simposio El Jaguar Mexicano en el Siglo XXI. Again, JAGCT participated, and on JAGCT's behalf AGFD provided funding to help support the workshop. The IUCN Conservation Breeding Specialist Group facilitated the event. More workshops are anticipated, as relevant information is generated through field projects. Adequate information is lacking in many key areas, but considerable progress has been made in the past few years. The overall process is intended to generate (eventually) extinction risk assessments based on information on life history, population dynamics, ecology, and history of the populations. The November 2006 workshop again underscored the need to develop regional jaguar management (conservation) plans, including one for the Sonora-Sinaloa region (which includes the northern jaguar population). Support for this concept was garnered, and a lead for the Sonora-Sinaloa area was requested, at the May 2007 Trilateral Committee[18] meeting, in Quebec City, Canada (Mexico has not yet taken action on the request).

Defenders of Wildlife – Defenders is a U.S.-based NGO with an increasing presence in on-the-ground jaguar conservation in Mexico, where it partners in jaguar conservation with Naturalia

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[18] The Trilateral Committee for Wildlife and Ecosystem Conservation and Management was established in 1996 through a Memorandum of Understanding among Canada, Mexico, and the United States. The following description is adapted from the Committee's Web site, at http://www.trilat.org/index.htm:

> The Committee facilitates and enhances cooperation and coordination among the three nations in projects and programs for conservation and management of wildlife, plants, biological diversity, and ecosystems of mutual interest. The Trilateral also facilitates development of partnerships with other associated and interested entities. Delegations from each country come together annually for discussions on a wide range of topics, including: joint, on-the-ground projects; issues of law enforcement; and development of information databases. Typically, state and provincial wildlife agencies and nongovernmental organizations with an interest in specific topics are invited to attend the annual meetings and are encouraged to work on specific issues.
>
> Trilateral Committee discussions take place under the auspices of working tables that report to an executive body comprising the directors of the lead federal wildlife agencies from the three countries (e.g. USFWS for the United States). Because the issues that are important to the three nations change over time, working tables are established and discontinued as needed. Currently, seven working tables are active: Species of Common Concern, Law Enforcement, Ecosystem Conservation, Migratory Birds, Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), and the Executive Committee. Jaguar issues can be (and have been) discussed at several or the working tables.

and the Northern Jaguar Project (Defenders 2009; see also below). Elements of the joint program include a "camera contest" on cattle ranches surrounding Naturalia's Northern Jaguar Reserve. The camera contest, which was partially funded in 2006 by a grant from the USFWS "Wildlife Without Borders - Mexico" program, uses remote, motion-triggered cameras (re-set monthly) to record pictures of jaguars, pumas, ocelots, and bobcats. Project objectives are to: (1) promote the recovery of the jaguar through a significant portion of its historic range by expanding the population in Mexico and preserving habitat connectivity for dispersal and re-colonization into appropriate areas in the U.S.; (2) implement a jaguar camera survey contest as a vital component of a larger northern jaguar conservation plan; (3) obtain information about population size, spatial distribution and abundance of jaguar and other wildlife; (4) gain access to private lands that are not included in the current research area; (5) provide economic incentives for the continued presence of jaguar and counter local bounties; (6) engage landowners and ranchers in jaguar conservation; (7) build local tolerance for jaguar and a self-policing environment.

The camera-contest project awards $50 to $500 for each photograph of targeted wildlife. In return, participating ranchers agree to protect these species and all other wildlife on their ranches. Further information on the Defenders-USFWS jaguar camera survey project is available at:

http://www.fws.gov/international/DIC/regional%20programs/mexico/pdf/Mexico_Project_Summaries_2006.pdf

Defenders also cooperates with Naturalia and the Northern Jaguar Project in a Jaguar Guardian Program to help stop jaguar killing and to provide field assistance to an on-site research project. The guardians work directly with ranchers to minimize conflicts with livestock and reduce killing of jaguars. They also assist Naturalia with security and stewardship activities on the Northern Jaguar Reserve.

Naturalia – Founded in 1990, Naturalia (Comité para la Conservación de Especies Silvestres; http://www.naturalia.org.mx; see also Bravo 2006) is one of Mexico's most active and most forward-looking conservation NGOs. In 2003, it purchased Rancho Los Pavos, a 10,000-acre ranch in northern Sonora that has become the core of a new protected area, the Northern Jaguar Reserve (Friederici 2006). The Reserve is dedicated to protection of jaguars and all other wildlife species present, and to rehabilitation of habitat. It has a small research field station, one of a handful in Sonora. Staffing and operations at the field station are the responsibility of the Northern Jaguar Project. In the Reserve, biologists are working on the first inventories of birds, mammals, butterflies, and plant species ever done in northern jaguar habitat. In 2008, Naturalia and the Northern Jaguar Project (see below) completed purchase of the 35,000 acre Ranch Zetasora, bordering the 10,000 acres already included in the Northern Jaguar Reserve, bringing the Reserve to nearly 70 square miles, with further expansion anticipated (D. Hadley and O. Moctezuma personal communication). Naturalia and the Northern Jaguar Project hired two experienced jaguar guardians trained in biology and a reserve vaquero to conduct basic research, monitor jaguars, and maintain a consistent physical presence on the Reserve (NJP 2008).

Naturalia is also working with other collaborators to build capacity in indigenous communities to monitor jaguars, an effort that has already resulted in detections, and to conduct jaguar surveys outside established reserves (E. Fernandez, personal communication).

In 2005, Naturalia acquired another wildlife reserve, the 10,000-acre Rancho Los Fresnos, through transfer from The Nature Conservancy. Los Fresnos is located in Sonora, near the U.S.-Mexico Border. NJP (2008) suggests the reserve, which primarily includes grassland and riparian habitats in the upper San Pedro River drainage, might someday have value as border-corridor habitat for jaguars. Although the reserve undoubtedly has significant value for a variety of species of wildlife, we are not aware of any recent or historical records documenting jaguar presence in the area.

Northern Jaguar Project – NJP, an NGO based in Tucson AZ, is dedicated to conservation of jaguar habitat in Sonora and creation of a safe-haven corridor between the northernmost breeding population in Sonora and the U.S. borderlands (see http://www.northernjaguarproject.org). NJP promotes conservation ranching, stewardship, and increased regional awareness of the value of wildlife, particularly charismatic endangered species like the jaguar. It also works to eliminate conflict between ranchers and wildlife, particularly mountain lions and jaguars. It is partnering with Naturalia to create jaguar preserves in Mexico. The two organizations cooperate under a Memorandum of Agreement to operate, manage, and expand the Northern Jaguar Reserve in northern Sonora.

All funding received by the Northern Jaguar Project goes to support protection of habitat and wildlife in the Northern Jaguar Reserve and the surrounding area. The Project operates a small field station and research program on the reserve, in conjunction with Naturalia. Researchers are conducting studies related to large carnivores, using trip cameras and hair snares to gather data on population densities, movement, dispersal, diet, and habitat needs. Visiting researchers are conducting plant inventories and making preliminary lists of birds and insects. The Project's "jaguar guardian" program maintains a permanent presence on the reserve, to help ensure protection for all species.

The Northern Jaguar Project and Naturalia (see above) also jointly fund and operate a compensation program on ranches near the Northern Jaguar Reserve, in Sonora, Mexico, that requires participating ranchers not to kill predators (NJP 2008). Instead, the ranchers are paid for photos of wild felids that are taken by trip-cameras that NJP and Naturalia install. A full-time technician is dedicated to working with the local community on these issues.

Sky Island Alliance. The Sky Island Alliance (http://www.skyislandalliance.org; also see above and http://www.skyislandalliance.org/jaguars.htm), a U.S.-based NGO working in Mexico, has implemented conservation outreach efforts for private landowners in northern Sonora and commenced collecting wildlife data using remote camera traps integrated with track counts. The project's long-term goal is to build cooperative relationships with landowners in the "Sonoran Sky Islands" to encourage jaguar conservation and facilitate ongoing scientific research through partnerships with landowners and other conservation organizations. On the ground, the Alliance's "Jaguars of the Sonoran Sky Islands" project is groundtruthing the results of GIS habitat models suggested by Menke (2004) and Boydston and López-González (2005), to identify corridors and wildlife linkages across the landscape between the breeding population in east-central Sonora and areas where jaguars have been recorded in southern Arizona and New Mexico.

Wildlands Project. As noted above, the WP continental conservation vision includes elaboration of conservation corridors in Mexico to connect with wild areas farther south and to the north. WP is actively engaged in corridor work to help Mexico "connect the dots" (see Rabinowitz 2006) of its fragmented landscape, thus paralleling its work in the United States. The WP vision also seems to mesh well with Mexico's participation in the "Mesoamerican Biological Corridor" (MBC), which is intended to protect key biodiversity sites in Middle America and ultimately connect the Yucatan Peninsula to other ecologically rich areas in the region (see http://www.biomeso.net/magazin.asp), and to the "Paseo Tigre" (Path of the Jaguar; Rabinowitz 2006), which is intended to become a network of corridors connecting jaguar conservation units from Mexico to Brazil. The MBC evolved from the "Paseo Pantera" (Path of the Panther) initiative launched by the Wildlife Conservation Society and its partners in the 1990s (see: Carr 1992). The Paseo concept was initially an unbroken strand of protected and restored forest lands stretching from southern Mexico to Panama, perhaps beyond. However, it foundered on opposition from indigenous and campesino groups to protecting land for wildlife and thereby excluding people. The MBC has tempered that approach, has been endorsed by the appropriate heads of state, and appears to be moving forward (Miller and others 2001).

Rosas-Rosas/Valdez Jaguar Study. [Note: the following passages are adapted from Childs and Childs (2008), with permission from the authors. See also Rosas-Rosas and Valdez 2006.] In Sonora, Mexico, north and east of the Northern Jaguar Reserve and across the Río Aros, a doctoral study at New Mexico State University has led to another jaguar conservation program. The study was initiated to collect biological information on jaguars and to examine jaguar-human relationships (see Rosas-Rosas 2006). It concluded that livestock was a major prey item for jaguars and, as a result, conflicts occurred that often led to jaguars being killed to reduce livestock depredation. While the field study was underway, however, Rosas-Rosas stimulated actions that could prove even more significant to jaguar conservation than his valuable research.

While Rosas-Rosas pursued his field studies, he discussed the local situation with two hunters/biologists from the United States during a jaguar capture effort. As they sat around the campfire, they conceived the idea of establishing an association of area ranches that would benefit financially from the wildlife resources found on their properties. Ranchers would receive financial incentives in exchange for not killing jaguars depredating on their livestock. The potential benefits were obvious to the three men, but they wondered how such an innovative approach might be received by local communities.

To find out about the local perspective on possible jaguar conservation, Rosas-Rosas conducted meetings, workshops, and talks among landowners and held a three-day environmental jaguar instruction session with school children and members of the municipality of Nácori Chico. He emphasized the known and potential value of wildlife conservation. The discussions were difficult at times because livestock depredation was relatively frequent in the area, and some of the large carnivores responsible (e.g. mountain lions) had been known to attack humans. However, Rosas-Rosas persisted in educating the communities about jaguars and the possible benefits possible benefits of conserving them.

As a result of Rosas-Rosas' efforts, in 2003 Mexico established the "Programa de Conservación de Jaguar en la Sierra Alta de Sonora" as an official unit of wildlife conservation and

management recognized by the Mexican government. This type of program is known in Mexico as an UMA. The initials in Spanish stand for *Unidades de Manejo para la Conservación de la Vida Silvestre* (the English translation is Management Units for Conservation of Wildlife). Ten ranches have joined the UMA, and three more are expected to join, for a total of 120,000 acres under conservation agreement and jaguar protection [Note: as of 2009, 11 ranches have joined the conservation program]. All the ranchers have agreed to sustain livestock depredations by jaguars in exchange for tourists being allowed to visit their properties with the possibility of sighting a jaguar.

Primero Conservation Outfitters (PCO), an outfitting business, was created as a result of its founders' participation in Rosas-Rosas's project, including that seminal campfire discussion referenced above (Note: the founders wish to remain uncredited by name). In 2004, PCO began bringing ecotourists and conservation-minded hunters to ranches participating in the UMA. As its part in the UMA, Mexico facilitated issuance of deer permits to the ranchers. During PCO's first year of operation, 20 hunters and 20 ecotourists and students traveled to the Nácori Chico jaguar conservation area. To date, ranchers participating in the Programa de Conservación de Jaguar have received approximately $75,000 in direct financial return on their conservation investment. Whether the program can be sustained is unknown, but the early results are encouraging.

PCO has also been instrumental in furthering jaguar research in the Nácori Chico UMA. The founders have cooperated with the UMA to implement a trip-camera project to document jaguar presence. They have also helped develop and secure funding for "multi-taxa conservation research" in the UMA that will be initiated in 2009. The research will use a large scale semi-permanent camera-trapping grid in combination with occupancy modeling methods to identify factors affecting occupancy and co-existence of large carnivores and their prey (the UMA is inhabited by a significant population of mountain lions as wells as by jaguars). Further information on this project is proprietary and only available directly from the lead investigators, Drs. Clayton K. Nielson and Joseph Kolowski (both of the Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale, Illinois).

U.S. Fish and Wildlife Service – USFWS is actively engaged in jaguar conservation efforts in Mexico, including conservation planning. This work is carried out through direct participation in the Trilateral Committee and coordination with several governmental entities in Mexico, participation in JAGCT, and various other mechanisms (including law enforcement coordination and cooperation). USFWS also administers a grant program "Wildlife Without Borders - Mexico" (see http://www.federalgrantswire.com/wildlife-without-borders--mexico.html) that funds projects in one of several areas: academic and technical training in the conservation and management of biological resources; training in management of nature reserves and other protected areas; applied research and monitoring in support of natural resource management activities; community-level conservation education; technology transfer and information exchange; and the promotion of networks, partnerships and coalitions that assist in the implementation of conventions, treaties, protocols and other international activities for the conservation and management of Mexico's biological resources. If project work is to be conducted in the United States the proposal should show a clear Mexican component to be eligible for funding. Examples of jaguar-related projects that have been funded through this

program since it was established in FY2003 include: jaguar camera survey contest (in Sonora, Mexico; Grant MX 06-G061); wildlife conservation and management training for local communities in a biological corridor linking jaguar habitat in four nature preserves in Mexico (Grant MX 08-016); strengthening local capacity for jaguar conservation community protected areas in Oaxaca (Grant MX 08-051); and training in management of nature reserves throughout Mexico (Grant MX 08-053).

Wildlife Conservation Society and Panthera. There is no doubt that these two NGOs are the most influential entities, nongovernmental or otherwise, in jaguar conservation worldwide (the WCS Web site is http://www.wcs.org; Panthera's is http://panthera.org). Although WCS, established in 1895, precedes Panthera, established in 2006, by more than 100 years, they share a common purpose: conserving the "Path of the Jaguar," from Mexico south to Brazil and Argentina (see: http://www.savethejaguar.com and http://ngm.nationalgeographic.com/2009/03/jaguars/white-text/2). This network of core areas of jaguar presence and interconnecting movement corridors that are essential to genetic integrity and long-term viability of the species is depicted at the aforementioned Web sites and described by White (2009) in the current issue of National Geographic. Notably, the Path of the Jaguar does not extend into the United States.

4. Summary

4.1. Jaguar Status

The jaguar is clearly native to the AZ-NM/Mexico borderlands, with a long documented record of historical presence and a well documented record of occasional presence from the late 1800s through 1986 and persistent presence from 1996 through 2009. Some of these records might represent transient animals, and a few perhaps stem from captive animals released for "canned hunts" (see: Brown 1987; Nowak 1975). However, the best available information (for 1997 through 2009) indicates natural residency at very low levels. The salient question to be answered by further field investigation is whether one, two, a few, or perhaps even several jaguars occur in the U.S. borderlands at any given time.

Historical records indicate that female jaguars with young occurred at least occasionally in Arizona as far north as the Grand Canyon, but no historical evidence of breeding exists for New Mexico. Nor is there recent evidence of breeding, or even presence of females, in either state since the current spate of sightings began in 1996. However, this does not mean that females do not occur in this area. Survey and monitoring efforts are insufficient, sample sizes are too small, and jaguars are too elusive and wide-ranging for anyone to establish a statistically valid scientific "certainty" at this time that females do not occur and never again will occur on the AZ-NM side of the border or to conclude that jaguars do not and never will breed here.

The jaguars known from AZ-NM are almost certainly part of a population that is centered about 140 miles south of the U.S.-Mexico border, in east-central Sonora, Mexico. The Mexico portion of the "northern population" as a whole continues to be pressured by habitat loss (ranging from outright destruction to fragmentation, and prey base depletion) and illegal take (primarily for livestock depredation prevention or control but also for unlawful sporthunting). The potential for border security measures to prevent jaguars from moving freely across the AZ-NM/Mexico

border is the central threat to continued jaguar presence in AZ-NM. Other factors that were historically important in rangewide jaguar population declines (from the United States to Argentina) are unlikely to become significant problems again in the United States, due to sufficiency of regulations, adequacy of law enforcement, and social pressure.

4.2. Jaguar Conservation Effort Status

The AZ-NM/Mexico borderlands jaguar conservation effort has been underway since 1997. It has had successes and shortcomings. Expectations for public engagement have been exceeded, as a core of stakeholders with diverse backgrounds and interests have helped shaped the JAGCT effort since it was initiated and continue to be engaged in all aspects. The core includes the two men who "rediscovered" borderlands jaguars in 1996, and their families. New stakeholders have also come into the effort recently, and their perspectives have challenged the collective group to reassess both the direction and nature of the effort. Funding and agency commitments of staff time have not been sufficient to accomplish tasks in timely manner (if at all). Lack of a rangewide vision for jaguar conservation (and recovery per ESA) limits agreement, let alone consensus, among stakeholders on long-term goals for the borderlands conservation effort. Diverse philosophies, opinions, and preferences among JAGCT stakeholders on any number of issues has impeded progress at times, caused horrendous loss of time and energy in repetitive re-discussion of a variety of topics, and has been a major factor in stimulating discussions and work that have resulted in progress. The interplay has been dynamic and at times difficult to manage, but overall it has been constructive and the stakeholder commitment to active participation and to helping shape the future is, to say the least, commendable.

Integration of conservation efforts on the U.S. and the Mexico sides of the border has been uneven. Significant progress has been made on a variety of fronts by both governmental and nongovernmental partners, although at times serendipity and good will seem to have played greater roles in it than planning and follow-through. Nevertheless, the core of a refugium for jaguars is being established in northern Mexico, and ranchers and local communities are being involved in productive ways. Progress is also being made on a national level. With JAGCT support and participation, Mexico has effectively used PHVA workshops to set the stage for national and regional jaguar conservation planning. Within the year, planning for the northern jaguar population will be well underway, again with JAGCT participation, and this will better inform the current AZ-NM efforts.

With the exception of activities pertaining to borderland security (i.e. antiterrorism and illegal immigration), most public and private lands managers on the United States side of the border are well aware of jaguar presence and values, and have begun integrating both into their management programs. USFWS continues to dialog with U.S. agencies involved in borderland security, but it remains unclear whether and how jaguar needs will be considered in designing and implementing projects and activities intended to meet Congressional directives.

In summary, then, we know the following about jaguars in the AZ-NM borderlands:

1. AZ-NM has limited, marginal jaguar habitat that is occupied by an unknown number of jaguars (from zero on up) at any given time.

2. The number of jaguars present in AZ-NM at any given time is not sufficient to be considered a "population" in any ecological sense of the word. In fact, there is no evidence that the number of jaguars present here at any given time since the mid-1800s, when records of their post-settlement presence began accruing, has ever been more than 0 to a very few individuals (mostly males and since the mid-1900s all males).
3. Logically, any jaguars that occur in the AZ-NM borderlands are part of the population that is roughly centered about 140 mi south in Mexico and which appears to be at risk from a variety of threats.
4. Documentation of Macho B's presence from August 31, 1996 through March 2, 2009 establishes reasonable likelihood that he was resident in the AZ-Sonora borderlands but does not provide a scientific basis for the contention that a resident population exists in AZ, NM, or in the contiguous northernmost parts of Sonora or Chihuahua.
5. AGFD and NMDGF can legally protect and monitor jaguars that occur here, increase state civil and/or criminal penalties for unlawful take, educate agencies and the public about jaguar conservation, do their best to ensure that jaguar habitat continuity persists between AZ-NM and the northernmost population core in Mexico, and collaborate with Mexico on its conservation efforts, but recovery of the species must be focused much further south than AZ-NM – i.e. on the Paseo del Jaguar (Path of the Jaguar) efforts as depicted by the Wildlife Conservation Society and now Panthera and their collaborators (see White 2009). Developing a recovery plan and describing critical habitat for the jaguar in AZ and NM would not accomplish anything in terms of recovery of the species.

4.3. Recommendations

In assessing the status of jaguars and jaguar conservation in the AZ-NM/Mexico borderlands, it is important to remember that this area is in effect merely the tip of the jaguar's tail. The rest of the tail and the body, heart, and head lie well to the south. Undeniably, jaguar conservation is both a legal and a professional obligation for AGFD and NMDGF and hugely important to both agencies, to USFWS, and to a wide variety of other stakeholders and interested parties. However, from a biological perspective, neither endangerment nor recovery of the species as a whole hinges on the AZ-NM portion of historical or current range, except perhaps in one important area. Innovation, leadership, and public education in AZ-NM can help spur and have already helped spur conservation efforts in other parts of the range. Although there is no scientific basis for contending that there is or in recent history has been (in an ecological sense) a viable, resident jaguar population in Arizona and/or New Mexico, clearly successes in jaguar conservation in the AZ-NM borderlands can help increase public and governmental support in the United States and elsewhere for rangewide conservation.

With that premise in mind, and based on the body of this reassessment and JAGCT discussions, below we offer recommendations for AZ-NM borderlands jaguar conservation that are consistent with the AGFD-NMDGF Jaguar Conservation Framework (see AGFD and NMDGF 2007).

1. The Conservation Strategy under which JAGCT has been operating since 1997 has been superseded by the 2007 AGFD-NMDGF Jaguar Conservation MOU and by the 2007 AGFD-NMDGF Jaguar Conservation Framework. These documents provide an appropriate

foundation for future jaguar conservation actions in AZ-NM; they should be updated and renewed as necessary.

2. JAGCT cooperating agencies should allocate sufficient resources (staff and funding) to facilitate timely progress on priority issues, including but not limited to: administrative support for the JAGCT, education and outreach, conservation planning with Mexico for the northern jaguar population, and effective jaguar surveys and monitoring along the full length (from a jaguar perspective) of the AZ-NM border with Mexico.

3. In concert with Recommendation 2 above, AGFD and NMDGF (the JAGCT Lead Agencies), must ensure that JAGCT tasks are completed and that final (approved) documents are posted to JAGCT's Web site at http://azgfd.gov/jaguar in timely fashion.

4. JAGCT should reconvene and re-staff Committees to revitalize the conservation effort. Its Research Committee should review methods by which to standardize methods of camera trapping that will enable development of an occupancy model. Its Outreach Committee should plan and conduct another series of public presentations in southern Arizona, southern New Mexico, and northern Sonora and Chihuahua, Mexico, to heighten public awareness of borderlands jaguar conservation activities and issues.

5. JAGCT cooperating agencies should help fund and cooperate in more extensive field monitoring for jaguar occurrence (including increased use of camera traps in AZ, NM, and the adjacent Sonora-Chihuahua borderlands) and field research into jaguar distribution and movements to delineate areas of occupancy and use, including movement corridors between the AZ-NM and Mexico.

6. JAGCT should encourage and, where possible, assist further inquiries into the phylogeny and taxonomy of the jaguar north of central Mexico. Recent published papers on subspecies of the jaguar (e.g. Eizirik and others 2001; Johnson and others 2002; Johnson and others 2006; Larson 1997; Ruiz-Garcia and others 2006; Wozencraft 2005) lacked comparative samples from north of central Mexico, including the northern Sonora population that apparently spills over into Arizona and New Mexico.

7. JAGCT should use JAGSAG and other resources (e.g. consulting veterinarians and individuals with extensive experience in capturing jaguars) as appropriate to update and revise its capturing and handling protocols, which were last revised in 2007.

8. In accordance with recommendations by McCain and others (2006), AGFD, NMDGF, and USFWS should authorize and commit to capturing and GPS-collaring any age and condition-appropriate jaguar that occurs in either State. These agencies should commit adequate funds for post-capture monitoring, data analysis, and publication of results. Capture and collaring should be carried out in accordance with updated JAGCT guidance protocols (see Recommendation 7). Cavalcanti's (2008) work on jaguars in the Pantanal (Brazil) affirms beyond a shadow of doubt that GPS-collaring can provide crucial detail on virtually all aspects of jaguar behavior, including movement patterns, habitat use, foraging behavior, and

social interactions. Cavalcanti's study of 10 GPS-collared jaguars yielded 11,878 locations over a period of 31 months, with three to five jaguars monitored at any one time.

9. JAGCT should ensure that all available jaguar information and scientific expertise is available to the agencies involved in planning and implementing U.S.-Mexico borderland security measures and in managing lands throughout the borderlands that have importance as jaguar habitat, including movement corridors. We understand that JAGCT cannot require or otherwise ensure that the agencies consider, let alone use, the information, but it can help ensure that it is readily available to them.

10. JAGCT should work with Mexico to build on recent jaguar conservation successes there, in both planning and implementation, and work toward ensuring long-term stability in the northern population. In an ecological sense, if not a political or legal sense, jaguars in Arizona and New Mexico are clearly part of that "northern Mexico" population. In the long term, presence of jaguars in the AZ-NM borderlands almost certainly depends on connectivity and genetic exchange with that core area (McCain and Childs 2008). An excellent foundation for country-wide jaguar conservation planning in Mexico has been laid by, among others: Ceballos and others (2006), Chávez and Ceballos (2006), Medellin and others (2002), Quigley and Crawshaw (1992), Rabinowitz (1995), Rosas-Rosas (2006), Sanderson and others (2002a, 2002b), Sanderson and others (2002c), Swank and Teer (1987, 1988, 1989), and Wittmer and others (1995). All these works recognized to one degree or another the crucial importance of collaboration, cooperation, local engagement, sound science and education, and resolution of social issues as well as biological issues to building effective jaguar conservation programs that will last long beyond ribbon-cutting ceremonies and press conferences.

11. JAGCT should encourage interested parties to participate in rangewide conservation planning for the jaguar (including recovery at the species level) through the "Pathway of the Jaguar" (see http://panthera.org and http://www.savethejaguar.com). The "Pathway" articulates a comprehensive, science-based vision for rangewide population stabilization into which northern jaguar population conservation strategies can be integrated. Again, the works cited above (see Recommendation 10) provide an excellent foundation for such an effort, as does Weber and Rabinowitz (1996).

12. JAGCT should encourage AGFD, NMDGF, and USFWS to coordinate and cooperate more effectively with Mexico on law enforcement actions to protect jaguars from unlawful killing.

13. JAGCT should encourage NMDGF to seek legislative support for making State civil and criminal penalties for unlawful take of a jaguar commensurate with Federal penalties under ESA, contingent upon Federal delisting of the jaguar in New Mexico.

14. JAGCT should encourage AGFD to seek legislative support for making State criminal penalties for unlawful take of a jaguar commensurate with Federal penalties under ESA, contingent upon Federal delisting of the jaguar in New Mexico.

15. JAGCT and each of its cooperating agencies should, as often as necessary, reaffirm for all cooperators, stakeholders, and interested parties that:

    a. They remain fully committed to a voluntary, collaborative, and effective approach to jaguar conservation, based on shared values and incentives rather than regulatory requirements (regulatory approaches to jaguar conservation would only be advocated if the current course of action proves unproductive), with appropriate respect for private property rights and multiple use of public lands and with full recognition of Mexico's authority for and interest in shaping its own jaguar conservation program.

    b. They acknowledge the importance of compatible rural livelihoods and activities (such as ranching and outdoor recreation, including hunting, fishing, and wildlife watching) to existence of jaguars in the Southwest, and the importance of participation by such stakeholders in wildlife conservation.

    c. Consistent with the 2007 MOU and Framework, they do not support jaguar reintroduction in the AZ-NM borderlands but will continue working to ensure that habitats in that area are appropriately managed, that connectivity between jaguar habitats in the United States and Mexico is not severed or further degraded, and that human killing of jaguars, for whatever purpose, will not be allowed to be an impediment to jaguar dispersal, seasonal movement, or persistence in specific areas.

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APPENDIX A: GLOSSARY

The definitions provided below, with two exceptions, are derived from Allaby (1994), Begon and others (1996), Hanski and Simberloff 1997), Meffe and others (1997), Ricklefs and Miller (1999), or the Merriam-Webster Dictionary Collegiate Dictionary (2003, Eleventh Edition). The first exception is "adaptive management," the definition of which is taken from the British Columbia Forest Service (BCFS), at http://www.for.gov.bc.ca/hfp/amhome/amhome.htm. The BCFS website also provides a variety of alternative definitions used by workers in the field of adaptive management. The second exception is Part D of "conservation biology," which is taken from Western (1989).

Adaptive management: Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. Some of the differentiating characteristics of adaptive management are: (1) acknowledgement of uncertainty about what policy or practice is "best" for the particular management issue, (2) thoughtful selection of the policies or practices to be applied (the assessment and design stages of the cycle), (3) careful implementation of a plan of action designed to reveal the critical knowledge that is currently lacking, (4) monitoring of key response indicators, (5) analysis of the management outcomes in consideration of the original objectives, and (6) incorporation of the results into future decisions.

Colonization: The entry and spread of a species (or genes) into an area, habitat, or population from which it was absent.

Conservation: (A) The principles and practices of the science of preventing extinction. (B) In modern scientific usage conservation implies sound biosphere management within given social and economic constraints, producing goods and services for humans without depleting natural ecosystem diversity and acknowledging the naturally dynamic character of biological systems.

Conservation biology: (A) A field of study involving the application of genetics and population and community ecology to problems of biodiversity loss. (B) An integrative approach to protection and management of biological diversity that uses appropriate principles and experiences from basic biological fields such as genetics and ecology; from natural resource management fields such as fisheries and wildlife; and from social sciences such as anthropology, sociology, philosophy, and economics. (C) The branch of biological sciences that deals with the effects of humans on the environment and with conservation of biological diversity (variety of life forms). It uses principles, experiences, and information (e.g. data) from the biological sciences, natural resource management, and the social sciences, oftentimes including economics. (D) The aims of conservation biology are to: (1) provide scientific conservation principles; (2) identify conservation problems; (3) establish corrective procedures; and (4) bridge science and management by making scientists responsive to the conservation problems and managers responsive to biological issues.

Dispersal: The spreading of individuals away from each other, e.g. offspring from their parents and from regions of high density to regions of lower density.

Habitat: (A) The place where an animal or plant normally lives, often characterized by a dominant plant form or physical characteristic (e.g. the stream habitat, the forest habitat). (B) The particular place or environment in which an organism (for example, an animal or plant) occurs. Examples: a species of bat might occupy a maternity roost in a cave but have its late summer roost (post breeding) in the attic of a building or an underpass on a roadway. Its winter roost might be a cave in a different (perhaps more southerly) country. In summer its foraging habitat might be pine forests in the United States, while in winter it might forage in elfin woodland in central Mexico. In short, a species' "habitat" can and often does vary seasonally, in different phases of the life cycle (juvenile, young adult, adult, senescent), in response to changing weather conditions, drought, prey abundance, or competition with or pressure from other animals. Some species have narrow habitat preferences or tolerances (for example, talussnails). Others have relatively broad habitat preferences or tolerances (for example, jaguars and humans).

Habitat patch: An area of habitat that contains the necessary resources and conditions for a population (or species or individual) to persist.

Historical range: Where a species used to occur, long ago. Oftentimes the historical range is larger than the currently occupied range, perhaps (for example) because something caused a population decline, or rendered a portion inhospitable to that species.

Inhabit: To live somewhere, whether seasonally, year-round, at a specific stage of a life-cycle, etc.

Metapopulation: (A) A set of con-specific populations occupying an array of habitat patches within a larger area, in which local populations that are lost (reach zero) are recolonized through migration from another local population within the set. (B) A network of semi-isolated populations with some level of regular or intermittent migration and gene flow among them, in which individual populations may go extinct but can later be recolonized (through dispersal) from other populations within the network.

Niche: (A) The ecological role of a species in the community; the many ranges of conditions and resource qualities within which the organism or species can persist, often conceived as a multi-dimensional space. (B) The limits, for all important environmental features, within which individuals of a species can survive, grow, and reproduce. (C) In ecology, "niche" describes the relational position of a species or population in an ecosystem. The description of a niche may include descriptions of the organism's life history, habitat, and place in the food chain. According to the competitive exclusion principle, no two species can occupy the same niche in the same environment for a long time. The full range of environmental conditions (biological and physical) under which an organism can exist describes its fundamental niche. As a result of pressure from, and interactions with, other organisms (e.g. superior competitors) species are usually forced to occupy a niche that is narrower than this and to which they are mostly highly adapted. This is termed the realized niche. Different species can hold similar niches in different locations and the same species may occupy different niches in different locations. If a niche is left vacant, perhaps by extinction or disease, other organisms can fill that position. When

organisms are introduced into a new environment, they can occupy new niches or the niches of native organisms, out-compete the indigenous species, and become serious pests.

Occupied range: The portion of a species' historical or recent range that it now inhabits. "Occupied range" implies that a portion of the species' historical range is unoccupied, perhaps (for example) because of population declines or habitat changes.

Occupied habitat: The habitats within an area that a species actually inhabits.

Population: (A) Those organisms of the same species living in the same place and time. (B) A group of individuals of one species in an area, although the size and nature of the area is defined, often arbitrarily, for the purposes of the study being undertaken. (C) A group of organisms of the same kind, usually the same species, inhabiting a given area.

Population and Habitat Viability Analysis: (A) A collaborative workshop approach to species conservation that centers on, but encompasses more than, a PVA (a quantitative assessment of the probability of species viability or vulnerability under defined sets of assumptions and circumstances). The workshop process brings to bear the knowledge of many people (particularly an array of experts who have knowledge of the species or problem) on species conservation, eliciting and assessing multiple options for conservation action, principally by using the tool of the PVA as a way to evaluate present threats to population persistence and likely fates under various possible scenarios. (B) PHVA encompasses two different but closely related tools for analyzing the conservation status and needs of a species. A PHV Analysis usually refers to computer modeling of biological processes, whereas a PHV Assessment is an in-depth examination and synthesis of the species' life history, ecology, management, and other factors to determine courses of action to manage for viable populations. Assessments include consideration of model analysis, habitat management, captive breeding (if appropriate), genetic tracking (if appropriate), life history, status, threats, geographic distribution, education and information, other conservation efforts, human demography/dimensions, research, and any other component that is deemed necessary. By itself, model analysis would have little real world utility without considering the context in which a species lives. Habitat management, human influences, and other components are therefore assessed and added into the conservation/recovery equation, at least in a qualitative way. PHV Assessments can be thought of as a tool to compile, evaluate, and synthesize data and build a framework for conservation action.

Population dynamics: The variations in time and space in the size and densities of populations.

Safe Harbor Agreements: Voluntary arrangements between the USFWS and cooperating non-federal landowner to promote management for ESA-listed species on non-federal property while giving assurances to the participating landowners that no additional regulatory restrictions will be imposed.

Scientific method: The body of techniques for investigation of natural or other phenomena and acquisition of new knowledge of the natural world, as well as correction and integration of previous knowledge, typically based on observable, empirical, measurable evidence, and subject to the laws of reasoning. The scientific method generally involves observation, formulation of a

hypothesis, experimentation (data gathering), and analysis and conclusion that validates or modifies the hypothesis.

Sink population: A population in a low-quality habitat in which the birth rate is generally lower than the death rate and population density is maintained by immigrants from source populations.

Source population: A population in a high-quality habitat in which the birth rate is greatly exceeds the death rate and the excess individuals leave as emigrants.

Suitable habitat: An area of habitat that contains the necessary resources and conditions for a population (or species or individual) to persist, but which may or may not be occupied at a given time, presently, historically, or in the future.