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A GIS ASSESSMENT OF SNOW LEOPARD POTENTIAL RANGE
AND PROTECTED AREAS THROUGHOUT INNER ASIA;
AND THE DEVELOPMENT OF AN INTERNET MAPPING SERVICE
FOR SNOW LEOPARD PROTECTION

by

Patricia Ann Williams

B.Sc. The University of Montana, Missoula, 1995

presented in partial fulfillment of the requirements

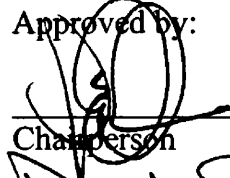
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Master of Arts

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May 2006

Approved by:



Chairperson



Dean, Graduate School

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A GIS Assessment of Snow Leopard Potential Range and Protected Areas throughout Central and South Asia; and the Development of an Internet Mapping Service for Snow Leopard Protection

Chairperson: Jeffrey A. Gritzner *JAG*

Snow leopard distribution knowledge is a critical conservation need. During the 2003 Snow Leopard Symposium, a pressing demand for a comprehensive collection of observation data became apparent. Expanding the knowledge of population distribution will help identify areas for conservation and add validity to the potential range map developed by Hunter and Jackson (1997). An equally strong need is an analysis of the extent of protected-area coverage of snow leopard habitat. Another crucial requirement is accurate representation and immediate availability of data to researchers throughout the range.

This project was developed in cooperation with the International Snow Leopard Trust, the Snow Leopard Conservancy, and International Center of Applied Ecology. It is also supported by the Snow Leopard Network, an affiliation of individuals working together to establish effective conservation of the snow leopard throughout Inner Asia. The specific goals of this project are to collect and graphically depict existent knowledge of snow leopard distribution and identify areas lacking data; evaluate the potential range map; assess protected areas to see if snow leopards occur indiscriminately; and produce an internet geographical database and interactive mapping service for research.

This thesis validates the potential range map created by Jackson and Hunter (1997). The majority of sightings (88%) fall within the modeled potential range. This suggests that the map is accurate in representing habitat that supports snow leopards. The thesis also highlights varying degrees of support for protected areas. Most of the potential range lies outside of protected areas. Consequently, most countries contain less than 47 percent of their sightings within protected area boundaries.

This thesis organized and analyzed existing snow leopard data in a geodatabase to evaluate the potential range map and effectiveness of protected areas throughout the range. The geodatabase and internet mapping service provides a standardized method of data exchange and communication among researchers. This is a small step forward in the conservation of the snow leopard, but creates a necessary foundation for future collaborative data exchange projects to follow. The technologies and methodologies used here should be expanded to meet the individual needs of projects.

Acknowledgments

This study was made possible with grants from the International Snow Leopard Trust, the Snow Leopard Conservancy and the USGS International Center for Applied Ecology. The support and cooperation from Tom McCarthy, Rodney Jackson and Don Hunter have been critical to the success of this work.

Numerous individuals have been instrumental in making this work possible. I sincerely thank my advisor, mentor and friend Jeff Gritzner. Jeff advocated this project from the beginning, knowing this work was truly meant for me, even before I knew. And despite my scarceness in the Geography Department the last year, he believed in me.

I would like to thank Eric Edlund for his support and excitement about the project and threatening to be “an even bigger pain if he wasn’t involved.” His advice on the technical portions of this project has been invaluable and will be as I continue to pursue this topic.

I would like to thank Don Bedunah for not only his support and assistance, but also taking Thad kayaking so that I would have time to work.

For their cooperation in the early stages of this work, I’d like to thank the members of the Snow Leopard Network that contributed their data. I’d also like to thank my friends and family for their support (and pestering) in the completion of this project.

Finally, I’d like to thank my partner, confidant, husband, Thad Jones. He’s been there every step of the way, supporting and encouraging, and sometimes scolding, but all in the effort to see me through. Thanks for being there!

Dedication

The circumstances of this thesis are purely coincidental. However, I don't believe in coincidences. From a very young age I've had an interest in white, "snowy" critters: leopards and owls mostly. Little did I know that I was setting the stage for the future. And, little did I know that my first trip outside the United States in January of 2002 would lead me here. I traveled with a group of students to Moscow, Russia to study Russian language for a month. It petrified me! But, it also captivated my heart. A year and half later I was doing research, thanks to the efforts Dr.'s Jeff Gritzner and Sarah Halvorson, in the middle of Kyrgyzstan, Central Asia. While there, Jeff and I had the pleasure of being introduced to 'a fellow American,' Dr. Tom McCarthy of the International Snow Leopard Trust. Coincidence? Maybe. But whatever you believe, here I am, presenting to you a subject that I am passionate about. All thanks to a childhood dream and a truly amazing Russian professor that changed my life forever. In honor of her, I will continue down the path of Russian language, traveling to exotic places half way around the world, a touch of vodka on occasion, and wild cats.

In loving memory of Marina Kanevskaya,
for your inspiration

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INTRODUCTION

Background

The remarkable snow leopard (*Uncia uncia*) is known for its beautiful, soft, spotted coat, long tail, and its cryptic character. This medium-size cat's weight can range from 27 to 45 kilos and boasts adaptations for high-altitude life, including a dense, woolly under fur, an enlarged nasal cavity and shortened limbs. The snow leopard, also referred to as ounce, is part of the subfamily Pantherinae in the family Felidae and is placed alone in its genus. It is a secretive cat, preferring harsh, rugged, mountainous regions, and can be found in twelve Inner Asian countries, with China containing as much as 60 percent of the snow leopard's potential habitat (Jackson 1998).

The elusiveness of this predator and the inaccessibility of its habitat make establishing abundance and distribution quite difficult (Jackson 2002; Jackson and Ahlborn 1984). The snow leopard's historical range is largely restricted to the Hindu Kush, Karakoram, Tien Shan, Pamir, Himalaya, Altay, and Kun Lun ranges and the range is believed not to have changed much over the past centuries (Jackson 2002).

For many years, snow leopards have been hunted for their beautiful, thick coat. Today, although protected across most of their range, snow leopards are still opportunistically killed in many areas, and are projected to decline by 50 percent over the next three generations owing to exploitation (McCarthy and Chapron 2003). Loss of prey from hunting, competition with livestock, loss of habitat and killing in retribution for livestock predation pose tremendous threats to the survival of the snow leopard. Large-scale pika and marmot poisoning programs, and increasing use of leopard bones in

Oriental medicine (owing to the decline in availability of tiger bones) also place this magnificent creature in jeopardy (Dexel 2001).

Cooperators

This project is developed in cooperation with the International Snow Leopard Trust (ISLT), the Snow Leopard Conservancy (SLC), and the United States Geological Survey (USGS) International Center for Applied Ecology (ICAE). Further, it is supported by the newly developed Snow Leopard Network (SLN), an affiliation of individuals from government and private sector working together to establish effective conservation of the snow leopard throughout Central Asia. The SLN currently includes ninety members with representatives in all of the range states, including nearly every active snow leopard researcher or conservationist.

The International Snow Leopard Trust, founded in 1981, is the oldest organization focused upon protecting the snow leopard and its habitat. The Trust has offices and programs in five of the snow leopard range countries where it maintains research and conservation projects. It has organized a protocol for standardizing field survey techniques, known as the Snow Leopard Information Management System (SLIMS), and has held training workshops in China, Mongolia, Pakistan, Kyrgyzstan, India, and Bhutan (Jackson 1998). The Trust also believes strongly in community-based conservation, and strives to find solutions to conflicts between snow leopards and people living in their mountainous habitat. They have worked on more than 100 projects with local populations throughout Central Asia (International Snow Leopard Trust 2006).

Another partner, the Snow Leopard Conservancy, is a grassroots organization helping local people live with these reclusive cats. The Conservancy provides technical

training, and in return, the local communities take responsibility for protecting the snow leopard. The SLC has reduced livestock predation by building predator-proof corrals. In addition, they have shifted the economic reliance from snow leopard pelts to ecotourism. Finally, in protecting the natural-prey base, they help ensure that habitat requirements are met, and thereby reduce conflict with domestic livestock (Snow Leopard Conservancy 2006).

The International Center for Applied Ecology at the Fort Collins Science Center (FCSC) within the USGS is focused upon finding solutions to international resource problems. Scientists from other countries visit Fort Collins and exchange knowledge and expertise so that it might be utilized in both this country and abroad. The ICAE scientists offer technical assistance and training in cooperating countries. Specifically, the ICAE assisted in the development of the current snow leopard potential range map. From this effort, researchers and conservationists are able to focus their efforts on snow leopard conservation (USGS 2006).

Project development

Knowledge of snow leopard distribution is a critical conservation need. During the 2003 Snow Leopard Symposium, a pressing demand for a comprehensive collection of observation data for future analysis became apparent. While a population distribution survey was presented at the symposium, the information was incomplete (per.com. McCarthy 2005). Expanding this knowledge will identify areas for conservation and add validity to the potential range map developed by Hunter and Jackson (1997). An equally strong need is to determine the status of protected areas and their influence upon snow leopards. An analysis of the extent of protected-area coverage of snow leopard habitat is

a critical, and thus far missing, step in snow leopard conservation. Another crucial requirement in the conservation of the snow leopard is accurate representation and the immediate availability of data to researchers in the field for analysis.

The specific goals of this thesis are to: 1) collect and graphically depict existent knowledge of snow leopard distribution; 2) assess the effectiveness of protected areas within the range; 3) identify areas lacking distribution data; and 4) produce a geographical database (geodatabase) for future analysis by researchers.

My thesis provides a general overview and background of snow leopard conservation, the potential range map produced by Hunter and Jackson (1997), the status of protected areas, and conservation in a digital world: geodatabases (GDB) and internet mapping services (IMS). Chapter 1 presents conservation, the potential range map, protected areas and GDB and IMS from the literature. Chapter 2 provides a summary of protected areas within snow leopard range and their current status along with laws regulating the protection of endangered species broken down by country. Chapter 3 introduces the twelve countries in which the snow leopard occurs and the steps taken to collect data for the knowledge map and protected areas, and the process followed to compile this data in a GDB and construct an internet mapping service for snow leopard conservation. Chapter 4 discusses the results of data compilation. Chapter 5 examines the Internet Mapping Service. Finally, Chapter 6 presents a summary of the findings and some recommendations for future research.

Chapter 1

Literature Review

Conservation

Since the 1960s, snow leopards have been listed as endangered in the IUCN Red List of Threatened Animals and, in March 1972, the U.S. Fish and Wildlife Service designated them as endangered. Furthermore, they were banned from international trade as an Appendix I¹ species under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1975 and under the Convention on Migratory Species of Wild Animals (CMS) in 1985. However, Kyrgyzstan and Tajikistan are not parties to CITES, other countries have only recently joined, and enforcement varies from country to country. Only India, Mongolia, Pakistan, Tajikistan and Uzbekistan are parties to the CMS (Table 1) (McCarthy and Chapron 2003).

¹ Appendix I species includes those species threatened with extinction and prohibits trade of these species except under strictly defined exceptional purposes.

Table 1.
RANGE STATES PARTICIPATION IN ENVIRONMENTAL AGREEMENTS.

Country	CITES	CMS
Afghanistan	Yes	No
Bhutan	Yes	No
China	Yes	No
India	Yes	Yes
Kazakhstan	Yes	No
Kyrgyzstan	No	No
Mongolia	Yes	Yes
Myanmar	Yes	No
Nepal	Yes	No
Pakistan	Yes	Yes
Russian Federation	Yes	No
Tajikistan	No	Yes
Uzbekistan	Yes	Yes

Original snow leopard populations were estimated in the 1970's at 2,000 animals. These estimates are now considered low and has since been increased to between 4,500 and 7,350 (Jackson 2002). Snow leopard numbers are believed to be declining (Sumiya and Buyantsog 2002) and in need of assistance if they are to survive.

With such an elusive animal, determining status of the snow leopard offers a considerable challenge. Green (1982) and Chundawat et al (1988) mention problems of collecting data about the snow leopard. Ahmad (1994) considered the lack of communication among government officials, non-governmental organizations (NGOs), and local communities as factors hampering data collection. Most information is therefore derived from indirect evidence, such as pugmarks, scrapes, scat, scent markings, and livestock killings along with occasional sightings (Malik 1995). As a result, a standardized method for collecting data was considered necessary.

Potential Range Map

Rodney Jackson of the SLC and Don Hunter of the ICAE produced a map of the potential range of the snow leopard in 1995 (Jackson 1998). Using small-scale (1:1,000,000) maps of the region, they stratified the study area based upon snow leopard habitat requirements – a key requirement being mountain ranges. These polygons were hand drawn on Operational Navigation Charts (ONCs), and then digitized. The lower elevation limit of the mountain range polygons varied. For example, in Mongolia the lower elevation was around 1,219 meters, but Pakistan and western Nepal was below 2,743 meters. In eastern Nepal the lower limit was 3,353 meters. The upper limit originally was set at 5,182 meters, but this excluded much of the Tibetan Plateau high plains areas. So, the upper limit in China was extended to 5,486 meters.

Boundaries for protected areas were also digitized. Some protected areas lacked boundary information and were represented by points, but were not included in the model. This information was combined with country boundaries to produce an initial range map. This map showed the geographical extent, but unsuitable habitat remained in the model.

Unsuitable habitat was then systematically excluded. Such habitat included areas above 5,182 meters (except in China), permanent ice and snowfields, and water bodies. By using slope, ruggedness could be approximated: higher or steeper slopes equate to greater ruggedness and thus better habitat. Habitat quality was broken into two subjective categories: fair (0-30 degrees) and good (>30 degrees). Marginal use areas such as transportation corridors and population centers were left in the map but included in the fair category. The following criteria were used: large cities were buffered by 10

km and small towns or villages by 5 km; major roads were buffered by 2.5 km and minor roads by 1.0 km. These parameters enabled a thirteenth country, Myanmar, to contain potential range. Figure 1 portrays the snow leopard potential range map produced (Hunter and Jackson 1997) and Table 2 lists the estimated extent of potential range in square kilometers within each country.

Table 2.
POTENTIAL SNOW LEOPARD HABITAT IN KM² BY COUNTRY

Country	Potential Range (km ²)	Percent Range
Afghanistan	117,653	3.89
Bhutan	7,349	0.24
China	1,824,316	60.37
India	89,271	2.95
Kazakhstan	71,079	2.35
Kyrgyzstan	126,162	4.18
Mongolia	277,836	9.19
Myanmar (Burma)	4,730	0.16
Nepal	27,432	0.91
Pakistan	81,016	2.68
Russia	302,546	10.01
Tajikistan	78,440	2.60
Uzbekistan	13,834	0.46
Total	3,021,664	100

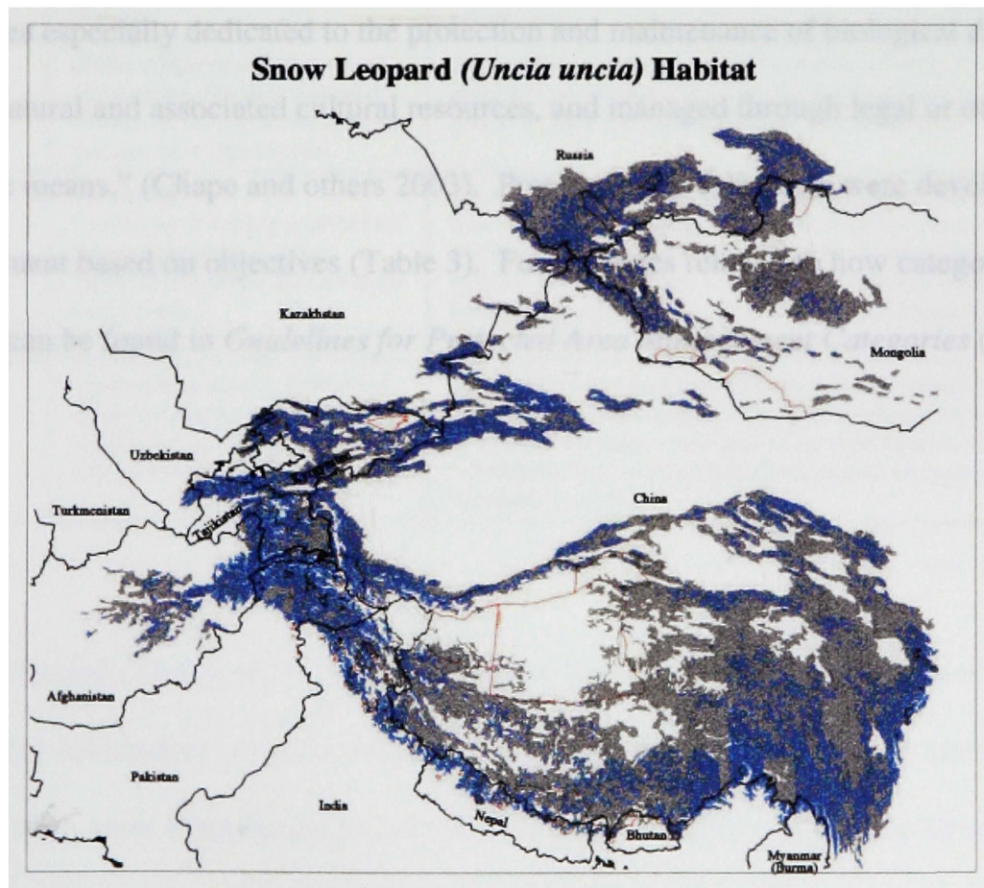


Fig. 1. Range wide model of potential snow leopard habitat.
(Blue represents good habitat, gray represents fair habitat)

Protected Areas

The snow leopard, while legally protected throughout their range, is still threatened by poaching, retaliation killing and loss of prey. Many countries are developing conservation education programs and involving local peoples in conservation efforts. Support of tourism and local revenue from governments are making this an even more positive expansion.

The core database representing protected areas at a global scale is the World Database on Protected Areas (WDPA). Compiled from multiple sources, the WDPA is the most complete compilation of protected areas data ever developed. The IUCN World Commission on Protected Areas (WCPA) defines a protected area as: “An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means.” (Chape and others 2003). Protected area categories were developed for management based on objectives (Table 3). Further notes relating to how categories are defined can be found in *Guidelines for Protected Area Management Categories* (IUCN 1994).

Table 3.
IUCN PROTECTED AREA CATEGORIES AND DEFINITIONS (IUCN 1994).

Category	Name	Definition
Ia	Strict Nature Reserve: protected area managed mainly for science	Area of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and/or environmental monitoring.
Ib	Wilderness Area: protected area managed mainly for wilderness protection	Large area of unmodified or slightly modified land, and/or sea, retaining its natural character and influence, without permanent or significant habitation, which is protected and managed so as to preserve its natural condition.
II	National Park: protected area managed mainly for ecosystem protection and recreation	Natural area of land and/or sea, designated to (a) protect the ecological integrity of one or more ecosystems for present and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area and (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible.
III	Natural Monument: protected area managed mainly for conservation of specific natural features	Area containing one, or more, specific natural or natural/cultural feature, which is of outstanding or unique value because of its inherent rarity, representative or aesthetic qualities or cultural significance.
IV	Habitat/Species Management Area: protected area managed mainly for conservation through management intervention	Area of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats and/or to meet the requirements of specific species.
V	Protected Landscape/Seascape: protected area managed mainly for landscape/seascape conservation and recreation	Area of land, with coast and sea as appropriate, where the interaction of people and nature over time has produced an area of distinct character with significant aesthetic, ecological and/or cultural value, and often with high biological diversity. Safeguarding the integrity of this traditional interaction is vital to the protection, maintenance and evolution of such an area.
VI	Managed Resource Protected Area: protected area managed mainly for the sustainable use of natural ecosystems	Area containing predominantly unmodified natural systems, managed to ensure long term protection and maintenance of biological diversity, while providing at the same time a sustainable flow of natural products and services to meet community needs.

Selected country reports and unpublished sources have provided much of the range-wide information on protected areas. However, according to Jackson and Hunter (1997; 1996), snow leopards occur in at least 45 protected areas encompassing more than 7 percent of their range. Green and Zhimbiyev (1997) reported 109 protected areas known to have snow leopards or to contain potential snow leopard habitat. According to the

information set contained in the Snow Leopard Information Management System (SLIMS), the number of protected areas is closer to 120, but many are far too small to harbor a significant number of snow leopards. For example, only 25 percent of 102 protected areas exceeded 1,000 km² in size, while 55 percent covered an area of 500 km² or less (Nowell and Jackson 1996). Also, many protected areas contain relatively high percentages of non-habitat in the form of rock and permanent ice, so that size alone can be rather misleading (Jackson 2002).

Snow leopard home range size is not well known, but several studies have indicated a wide range of requirements (Jackson 2002). In Nepal, areas of prime habitat, home range varies from 12 to 39 km². In Mongolia, though, where food can be scarce, home range exceeds 400 km². Potential home range areas need to be at least 1,000 km² to maintain a viable population (Green and Zhimbiev 1997). Home ranges may also overlap. Core areas tend to be used and marked more frequently, which space individuals apart.

There is little information on the current management status of protected areas or their role in sustaining snow leopard populations (Fox 1994; Green 1992; 1994; Green and Zhimbiev 1997). Transboundary or transfrontier protected areas (TPA) may play an especially important role in sustaining the overall snow leopard population, since much of the species' range encompasses mountain ranges that constitute international borders (Fuller 1997; Green 1994; Singh 1999). Green and Zhimbiev (1997) claimed that 66 percent of the snow leopard protected areas serve as de facto or potential transboundary protected areas.

Singh and Jackson (1999) suggest establishing transboundary conservation areas (TBCAs), or transboundary protected areas (TPAs), as not only a means to protect the snow leopard and species diversity, but also to diffuse tensions across borders. Wars can result in refugees and military transportation that threatens the ecological health of borders. Given the socio-economic and political complexities associated with these regions, the fate of the snow leopard, along with other endangered species, is threatened (Singh 2002). Organization of data and knowledge is a key goal to reduce these threats.

Geodatabase and Internet Mapping

The geographical database, or geodatabase (GDB), is a geographical information model to organize and manage spatial and attribute data and the relationships that exist among them. The GDB defines the types or classes of data that can be used, such as polygon, point or line features and raster or grid layers, and it also specifies rules for how they are represented, stored, managed, and accessed. The steps in building a GDB are modeling the user's view of data, defining objects and relationships, selecting appropriate geographical representations, matching these to GDB elements, and organizing a GDB structure. Some of the advantages of a GDB are that data is stored completely in a single database, that multi-users can access and share versions of the data, and that behaviors can be used to support network modeling, data entry error prevention and custom forms for inspecting or entering attributes (Zeiler 1999).

ArcIMS is one solution for distributing dynamic maps and Geographic Information Service (GIS) data across the web to meet the demands of worldwide internet access. ArcIMS is a scalable Internet Map Server and is widely used for GIS Web Publishing to deliver maps, data, and metadata to many users on the Web (Zeiler

1999). For example, ArcIMS enables users to publish and share geographical knowledge with other users by providing browser-based access to many GIS catalog portals.

ArcIMS services can be used by a wide array of clients including the ArcGIS Desktop, mobile and wireless devices and custom Web applications.

CHAPTER 2

SNOW LEOPARD PROTECTION

Protected areas are now considered one of the most effective means of conserving biodiversity. A considerable amount of resources have gone into their construction and most countries have implemented or planned protected area systems (Green 1997). This section gives an overview of protected areas within the range of the snow leopard and the laws under which they are protected in each country.

Afghanistan (Appendix H)

Afghanistan has nine protected areas, of which four (Nuristan, Ajar Valley, Band-e-Amir and Pamir-i-Buzurg) are within the range of the snow leopard. The Ajar Valley is currently listed twice in the WDPA as a Designated Wildlife Reserve (Category IV) and Proposed as a National Park (unset at this time).

Given the long history of civil war and conflict, Afghanistan's laws protecting wildlife and protected areas are not being enforced (Adil 1995). The United Nations Environment Program (UNEP) reported that "the legal status of all protected animals in Afghanistan is currently in question and no management is taking place to protect and conserve their biological integrity and wildlife" (UNEP 2003), and difficulties have been reported with enforcing any existing laws.

Bhutan (Appendix I)

Of the nine protected areas in Bhutan, the Jigme Dorji, Bomdeling, Sakteng, and Toorsa protected areas are the only areas within the snow leopard's range in Bhutan. The Jigme Dorji National Park is the largest with 4,349 km² and is designated as a Category II National Park. The Bomdeling and Sakteng are Category IV Wildlife Sanctuaries. Toorsa is a Category Ia, a Strict Nature Reserve.

The existing protected area system contains as much as 57 percent of the potential snow leopard range. The Jigme Dorji, the largest area, began in 1974 as a wildlife sanctuary encompassing the entire northern border. It was then upgraded to national park status in 1995, but reduced in size by almost half.

All mammals and birds are protected from hunting by law, however some species are given greater protection by having severe fines (Norbu 1995). Hunting the snow leopard is strictly prohibited by the Forest and Nature Conservation Act of 1995 and can result in a significant fine (McCarthy and Chapron 2003).

China (Appendix J)

China contains 116 protected areas within the snow leopard potential range out of 634 within the country. Of these 115 have been designated Category V (Protected Landscape) and the remaining protected area is designated Category VI (Managed Resource Protected Area). Both categories are managed for human use along with sustaining natural diversity.

The two principal laws providing full protection to the snow leopard are the Wildlife Animal Protection Law (WAPL) for the People's Republic of China (1989) and the Enforcement Regulations for the Protection of Terrestrial Wildlife of the People's

Republic of China (1992). Provinces may also adopt regulations, but must be more stringent than the national legislation (Theile 2003).

India (Appendix K)

Previous documents have reported anywhere from 18 to 34 protected areas within snow leopard potential range in India (McCarthy and Chapron 2003). However, according to the WDPA, out of 342 protected areas in India, 46 fall within snow leopard potential range. The WDPA has listed 21 Category IV's, 11 Category II's, and 14 as Unset. The Unset protected areas are mostly located in the Jammu and Kashmir or Arunachal Pradesh administrative boundaries.

The snow leopard is protected under the National Wildlife Protection Act of 1972 and the Jammu and Kashmir Wildlife Protection Act of 1978. The Government of India launched Project Snow Leopard in 1988. However, unlike the success of the Project Tiger model, few steps have been taken in management (McCarthy and Chapron 2003).

Kazakhstan (Appendix L)

Only the eastern and southeastern portions of Kazakhstan have potential range for the snow leopard. Of its 34 protected areas, only nine fall within these regions. According to the literature, the majority of snow leopard reports are in the northern Tien Shan region bordering Kyrgyzstan (Loginov 1995).

The Law on Wildlife Protection of January 1993 protects the snow leopard from hunting, possession and sale. It is also included in the Red Data Book of 1978².

² The Red Data Books provide taxonomic, conservation status and distribution information on taxa that have been globally evaluated using the IUCN Red List Categories and Criteria. This system is designed to determine the relative risk of extinction, and the main purpose of the IUCN Red List is to catalogue and

Kyrgyzstan (Appendix M)

Kyrgyzstan has most of its land (approximately 84 percent) and 28 of its 29 protected areas within the potential range. Over 50 percent of these are designated Category IV (Wildlife Refuge). Half of the remaining protected areas are Category Ia (State Nature Reserve) and the other half is Category II (Nature Park).

The snow leopard is strictly protected under the Law on the Animal World (1999). In 1999, the German Society for Nature Conservation NGO (NABU) established an anti-poaching unit (Grupa Bars) in Kyrgyzstan that not only focuses on the illegal killing and trading of snow leopards, but also their prey species (Dexel 2001).

Mongolia (Appendix O)

Mongolia has 55 protected areas with 25 inside potential snow leopard range. McCarthy (2000) reported at least 10 protected areas harboring snow leopards, including the Transaltay Gobi Strictly Protected Area (SPA), Khokh Serkh SPA, Otgontenger SPA, Tsagaan Shuvuut SPA, Turgen Uul SPA, Govi Gurvansaikhan NCP (National Conservation Park), Altai Tavaan Bogd NCP, Burhan Buudai Nature Reserve, Alag Khairkhan Nature Reserve, and Eej Uul National Monuments.

Hunting of the snow leopard in Mongolia was prohibited upon listing in the Red Data Book in 1972. However, sport hunting was legal until 1992. The Hunting Law of 1995 now disallows killing or selling of animals, hides or any other parts, but there was no legal restriction on owning or possessing snow leopard parts until 2000 when the new

Law of Fauna was enacted. In 1999, the Mongolian Snow Leopard Conservation Management Plan was developed, but not fully recognized as an official policy.

Myanmar (Appendix N)

Myanmar, a member of CITES, contains a small portion of snow leopard potential range, and only one protected area is within this range, the Mt. Hkakabo Raza National Park. However, the presence of snow leopards has not been confirmed in the country (McCarthy and Chapron 2003).

The Protection of Wildlife and Conservation of Natural Areas Law of 1994 protects wild animals, wild plants and natural areas; however it does not specifically list the snow leopard.

Nepal (Appendix P)

Nepal has 25 protected areas with only eight within the potential range, found along its northern border. Snow leopard presence has been confirmed in all but one of the following protected areas: Langtang National Park, Shey-Phoksundo National Park, Dhorpatan Hunting Reserve, Annapurna Conservation Area, Sagarmatha National Park, Kangchenjunga Conservation Area, and possibly the Makalu-Barun National Park and Conservation Area (McCarthy and Chapron 2003). The Qomolangma Nature Preserve in Tibet provides a corridor linking many of the above areas, providing the opportunity for a vast transfrontier protected area (Fig. 2) (Singh 1999).

In Nepal, the snow leopard's range is restricted to the upper limits of the Himalaya bordering Tibet (Jackson 1979). It is fully protected under the National Parks and Wildlife Conservation Act 2029 (1973) of Nepal. The Fourth Amendment of this

Act increased the penalties for snow leopard poaching, possession and selling its pelt. Also a signatory to the CITES, Nepal is responsible for implementing its agreements. Nepal has established a provision for paying for information that leads to the conviction of an offender (Kattel 1997).

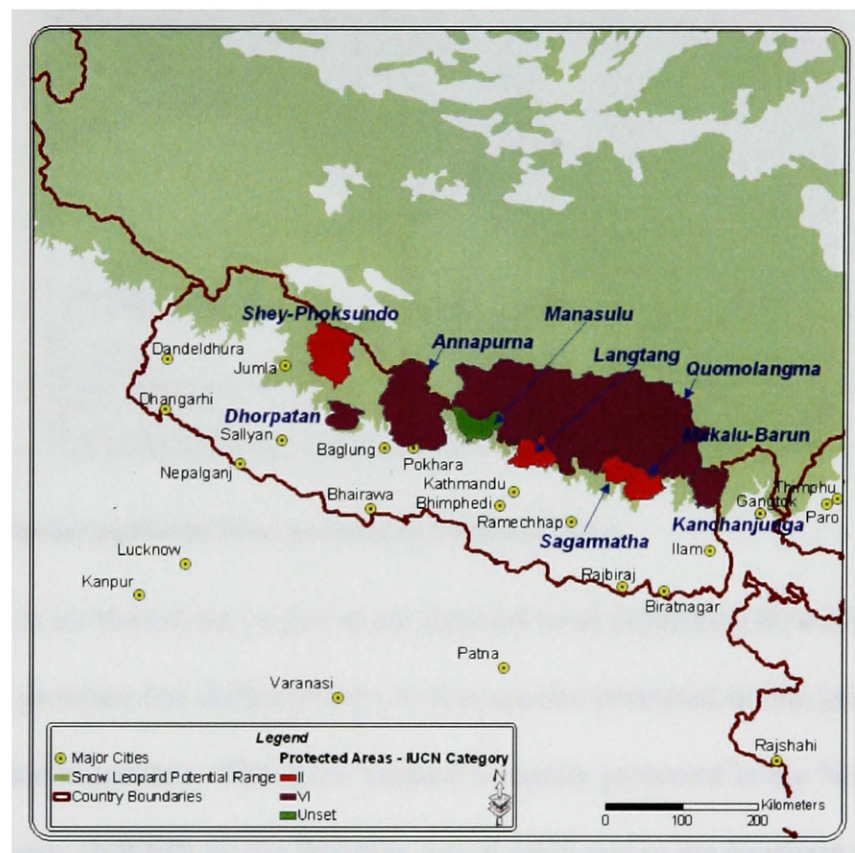


Fig. 2. Transfrontier protected area potential in Nepal/China.

Pakistan (Appendix Q)

Pakistan has 139 protected areas with 24 within the range of the snow leopard. These are located in the northern portion of the country with half of those designated as Game Reserves. The other half is designated National Parks and Wildlife Sanctuaries. Tashikuerganyeshengdongwu Nature Reserve in China provides a corridor between the Pakistan protected areas bordering China (Fig. 3).

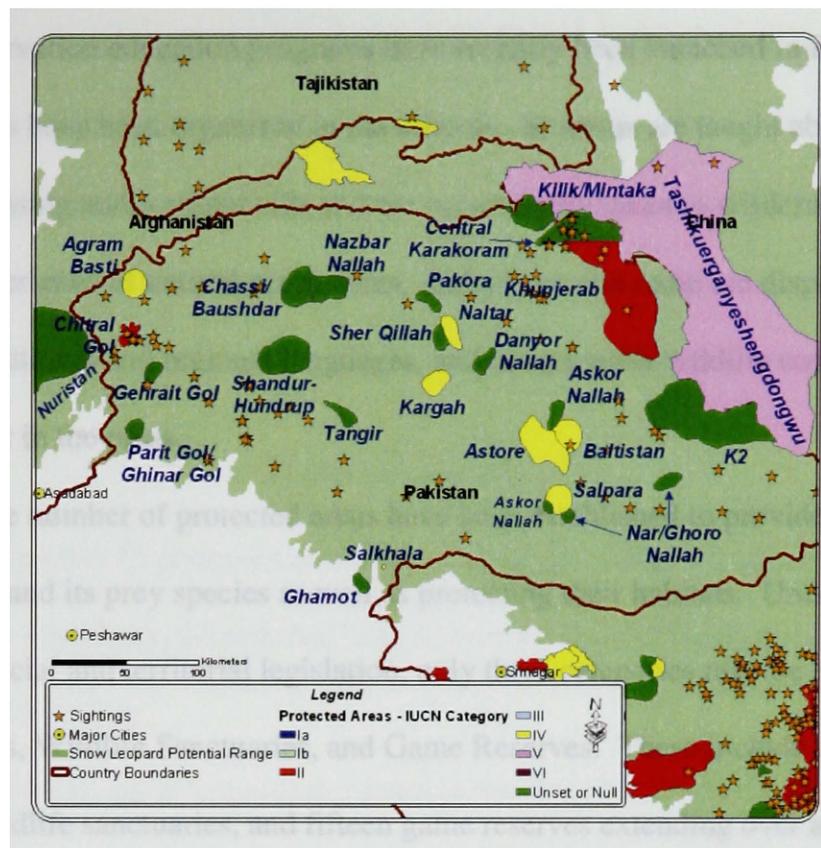


Fig. 3. Transfrontier protected areas potential in Pakistan/China.

There is no federal act or law at the national level protecting the snow leopard. Instead, each province has different laws so that species protected in one province may not be protected in another. The snow leopard is legally protected in the North-West Frontier Province (NWFP) by the Wildlife Act of 1975 and in the Northern Areas by the Wildlife Conservation Act. These acts prohibit hunting but the Northern Areas WCA does allow for the eradication of “problem animals.”

As in other countries, the snow leopard is protected in Pakistan and hunting and ownership of any part of a snow leopard is illegal. Likewise, wildlife laws protect its prey species (Marco polo sheep, Blue sheep, Asiatic ibex, musk deer, Markhor, Urial and Himalayan snow cock) (Malik 1995).

Conservation education programs have recently been launched in Pakistan and Wildlife Clubs have been organized in the schools. Students are taught about nature conservation using audio-visual aids and are occasionally taken to wilderness areas for first hand experience of natural ecosystems. Television and radio are dispersing programs in national and regional languages, and occasionally wildlife conservation articles appear in the press.

A large number of protected areas have been established to provide refuge to the snow leopard and its prey species as well as protecting their habitats. Under Pakistan's current provincial and territorial legislation, only three categories may be established: National Parks, Wildlife Sanctuaries, and Game Reserves. These include eight national parks, five wildlife sanctuaries, and fifteen game reserves extending over an area of 2.5 million hectares (Malik 1995). However, these areas are few and far apart, and most are quite small. Absence of secure corridors makes the species vulnerable to poaching. It has been proposed to increase the number of protected areas to make them larger and interconnected with safe corridors.

Russia (Appendix R)

Russia has over 2,200 protected areas, however only 69 protected areas fall within potential snow leopard range. With the breakup of the Soviet Union, protected areas became adversely affected owing to less funding and poor recruitment, so the status of these areas with regard to snow leopards is unknown. Many of these affected areas overlap with designated protected areas and are categorized as Unset or Null in the WDPA. Two protected areas have confirmed snow leopard presence: the Sayano Shushensky State Nature Reserve and the Altaiskiy State Nature Reserve.

There are three main laws that protect the snow leopard in the Russian Federation: the Law of Environment Conservation, the Law of the Animal World (Fauna) No. 52 of March 1995, and the Law of Strictly Protected Natural Areas No. 33 of February 1995. Enforcement of these laws is limited, and with the changes in government agency, roles and responsibilities for wildlife protection have shifted and become less effective.

Tajikistan (Appendix S)

Tajikistan has 15 protected areas. Only seven are within the potential snow leopard range: Aktashsky, Iskanderkul'sky, Komarou, Muzkulsky, Pamirsky, Ramit, Shirkent, and Zorkylsky.

In Tajikistan, snow leopards are listed in the Red Data Book as "rare," and are protected under the Law on Nature Protection and the Law on Preservation and Use of Fauna. However, these laws are typically not enforced or obeyed (Theile 2003).

Uzbekistan (Appendix T)

Shatkalskiy, Gissarskiy, Ugam-Chatkal, Zaamin, and Zaaminskiy are the five protected areas located within the potential range out of ten total in the country.

The snow leopard is protected under the Law on Nature Protection of January 1993 in Uzbekistan and is included in the Red Data Book of Uzbekistan. Similar to other range states, though, enforcement of these laws is lax.

CHAPTER 3

STUDY AREA AND METHODOLOGY

This chapter describes the study area and details the steps taken to collect and graphically depict existent knowledge of snow leopard distribution, assess the effectiveness of protected areas within the range, identify areas lacking distribution data, and produce a geographical database and internet mapping interface.

Study Area

The distribution of snow leopards is extensive (Fig. 4), extending in a 6,000 km arc and falling mostly along the borders of twelve countries (Table 2), with the majority of the habitat in Tibet and China (Nowell and Jackson 1996). Nevertheless, it is extremely fragmented – consisting of the harsh, arid mountains; long, narrow mountain systems; and islands of montane habitat scattered through a vast region of deserts and plateaus in Inner Asia (Jackson 1995). Snow leopards are associated with steep rocky slopes with arid and semi-arid shrubland, grassland, or steppe vegetation. In parts of the Tien Shan, they inhabit open coniferous forest along the edge of the snow line, but generally avoid dense forest. They are generally found at elevations of 3,000 to 4,500 meters, but occasionally are found above 5,500 meters in the Himalayas and as low as 900 meters in parts of Russia and Mongolia (Jackson 1998).

Although the overall range extends over 2.3 million km², occupied habitat is estimated at only 1.6 million km², this is because of much of the snow leopard range is occupied by permanent ice or snowfields and water bodies (Hunter and Jackson 1997).

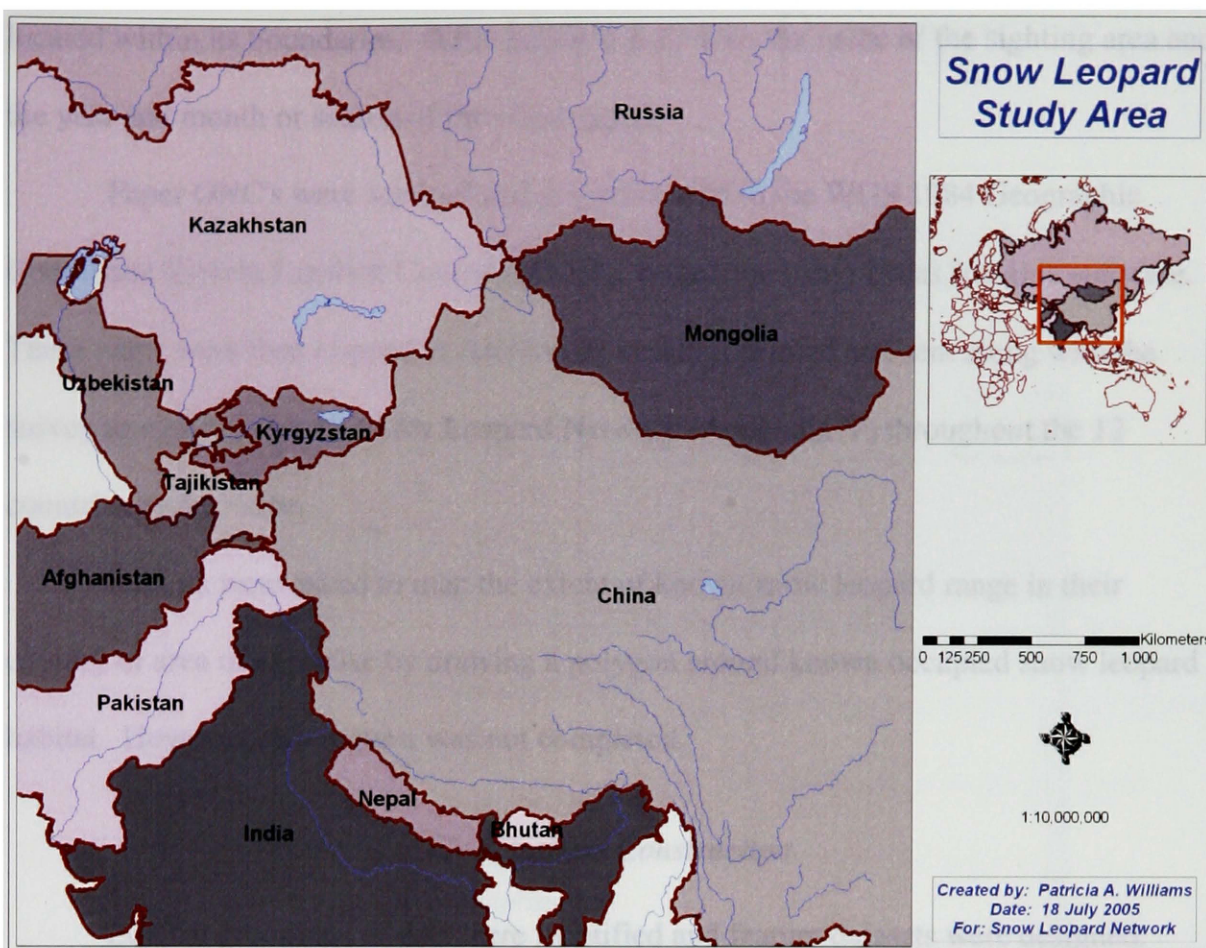


Fig. 4. Study Area for Snow Leopard conservation.

Data Collection

A survey (Appendix A) was developed in cooperation with the International Snow Leopard Trust to obtain specific data regarding snow leopard sightings. The survey requested that an “X” be placed on the provided map for every observation, including snow leopards, their sign (scat, scrapes, and pugmarks) or cases of confirmed livestock predation, confirming snow leopard presence. Alternatively, if sighting locations were recorded using a GPS, researchers were asked to provide the geographic coordinates. Experts were also asked to provide protected area names if a sighting was

located within its boundaries. Other required data were the name of the sighting area and the year and month or season of the observation.

Paper ONC's were scanned and georeferenced to the WGS 1984 Geographic Coordinate System Lambert Conformal Conic projection using Erdas Imagine software. These maps were then clipped in ArcMap by country, printed and sent along with the survey to members of the Snow Leopard Network (Appendix V) throughout the 12 countries in the range.

Experts were asked to map the extent of known snow leopard range in their country or area of expertise by drawing a polygon around known occupied snow leopard habitat. However, this request was not completed.

Geodatabase Construction

Logical groupings of data were identified and feature datasets were designed. Feature classes were then created. Fig. 5 shows the GDB structure. Feature datasets include Base Layers, Habitat, Hydrology, Sightings, and Protected Areas. Country boundaries, cities, populated places, administrative boundaries, and hydrology were imported from Environmental Systems Research Institute, (ESRI) and reprojected to the Lamberts Conformal Conic projection. Habitat was imported from the digital version of the Snow Leopard Potential Range Map created by Hunter and Jackson (1997) and reprojected. Protected areas were imported from the IUCN's World Database of Protected Areas 2005, reprojected and clipped by country using ArcMap. Sighting data was added to the GDB using a few different methods. If GPS coordinates were given, they were digitally imported using the X, Y coordinates to plot the points and attribute data entered for each point. Where X's were placed on the ONCs, the maps were

scanned and georeferenced, then the points were digitized and attribute data was entered for each point.

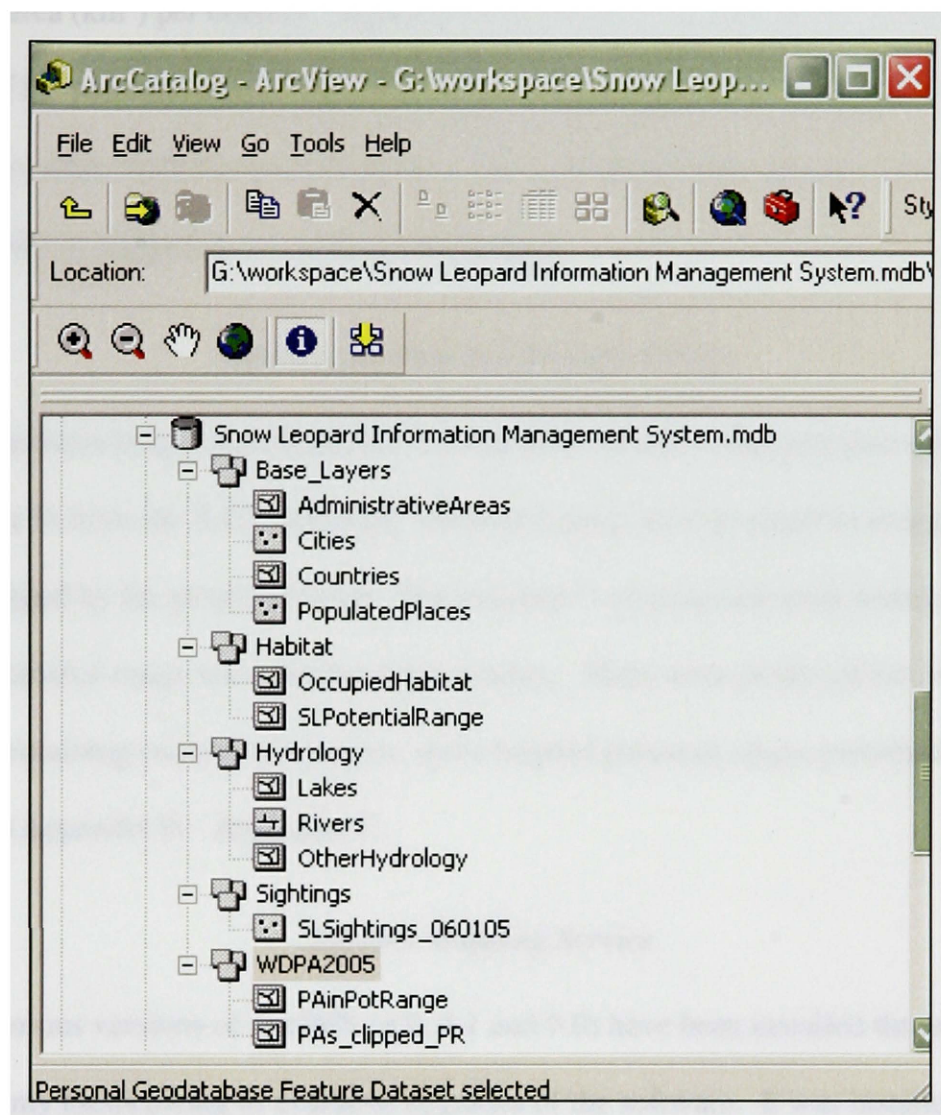


Fig. 5. Geodatabase Schema.

Knowledge Map and the Potential Range Map

Once all data was incorporated into the GDB, a knowledge map (Appendix D) was created in ArcMap to graphically depict snow leopard observations. This information was then overlaid with the potential range map (Appendix E) by D. Hunter and R. Jackson (Hunter and Jackson 1997) to help evaluate their model. The original

modeled range distinguished between good and fair habitat, however, these were grouped into one variable, suitable habitat for analysis. The range was then clipped by country to calculate area (km²) per country. Sightings were selected by their location within or outside of the potential range. Sightings within the potential range strengthen the validity of the map, while sightings outside do not. The knowledge map was also used to identify areas within the range that are lacking information.

Knowledge Map and Protected Areas

The knowledge map (Appendix D) was then overlaid with protected areas (Appendix F) from the IUCN database. Protected areas were grouped by category (Table 3) and clipped by the potential range. The area (km²) of protected areas within snow leopard potential range was calculated per country. Maps were produced for each country containing country boundaries, snow leopard potential range, protected areas and sightings (Appendix H - Appendix T).

Internet Mapping Service

Various versions of ArcIMS (4.0, 4.1 and 9.0) have been installed throughout the course of my thesis owing to available upgrades of the software. It was installed following installation procedures provided online by ESRI.

Once all data was incorporated and classified in the GDB, the internet mapping service map was created (Appendix U) using ArcMap. The service was then added to ArcIMS and served to the internet, which is accessible through a web browser. The data and web site are currently housed on a server within the Department of Geography at The University of Montana.

The mapping service was then tested by members of the Snow Leopard Network for ease of use, access and speed and will begin to be used for snow leopard conservation studies in the summer of 2006. Once security issues have been addressed, the site will be publicized in the newsletter by International Snow Leopard Trust.

CHAPTER 4

DISTRIBUTION OF SIGHTING

This section details the total number of sightings and their locations within snow leopard potential range and protected areas. A detailed discussion of these locations by country follows.

The map below (Fig. 6) shows the total snow leopard sightings within and outside of the modeled potential range. Calculated in GIS, the total potential range covers 3,231,531 km². Inside the range, there are 1,317 sightings (88 percent) and outside are 179 sightings (12 percent), totaling 1,496 sightings (Table 4). This strongly supports the validity of the map, however many areas do not contain any information.

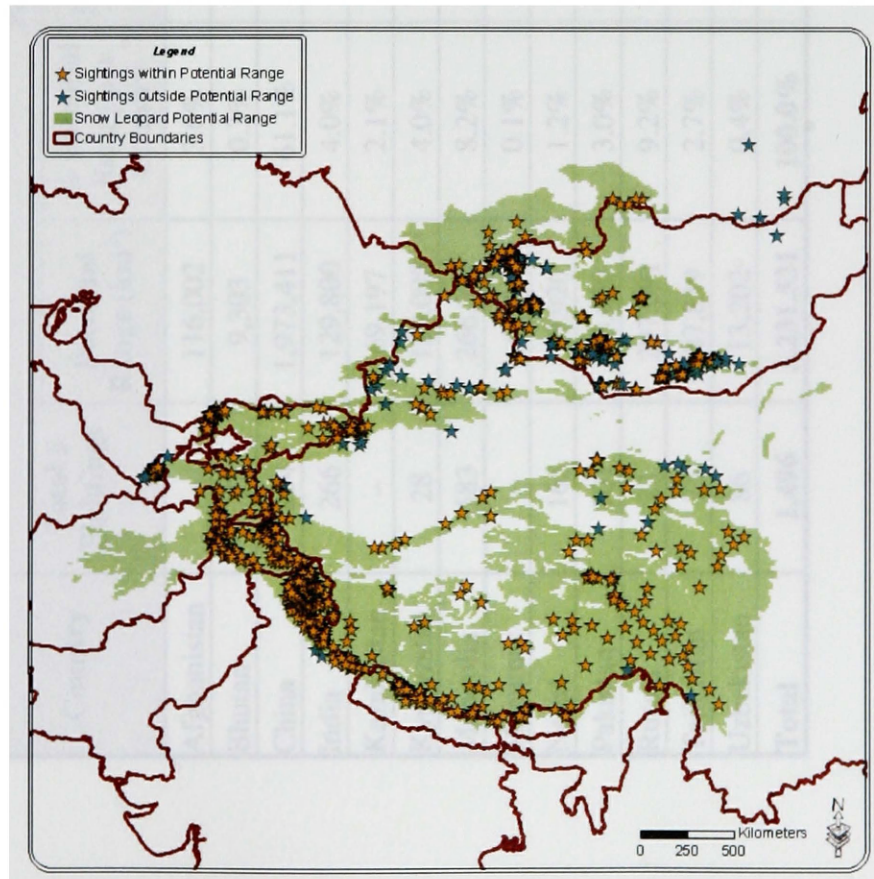


Fig. 6. Snow leopard sightings within and adjacent to potential range.

Table 4.
TOTAL NUMBERS FOR POTENTIAL RANGE.

Country	Total # Sightings	Potential Range (PR)					
		Potential Range (km ²)	% Potential Range per Country	Sightings in PR	% Sightings in PR	Sightings outside PR	% Sightings outside PR
Afghanistan	–	116,002	3.6%	–		–	
Bhutan	17	9,303	0.3%	17	100.0	0	0.0
China	204	1,973,411	61.1%	170	83.3	34	16.7
India	266	129,800	4.0%	264	99.2	2	0.8
Kazakhstan	–	69,197	2.1%	–	–	–	–
Kyrgyzstan	28	128,098	4.0%	28	100.0	0	0.0
Mongolia	583	266,377	8.2%	448	76.8	135	23.2
Myanmar	–	4,641	0.1%	–	–	–	–
Nepal	165	39,920	1.2%	165	100.0	0	0.0
Pakistan	101	96,650	3.0%	101	100.0	0	0.0
Russia	23	297,091	9.2%	18	78.3	5	21.7
Tajikistan	23	87,839	2.7%	23	100.0	0	0.0
Uzbekistan	86	13,202	0.4%	83	96.5	3	3.5
Total	1,496	3,231,531	100.0%	1317	88.0	179	12.0

Fig. 7 shows protected areas within the potential range. The literature reports close to 120 protected areas, however there are 343 protected areas within or partially within the potential range of the snow leopard (Table 5). The literature also states that only 45 protected areas contain sightings. In this study, snow leopards occur in 65 different protected areas. Many of these protected areas only have a portion of their area inside the range and much of the range does not contain protected areas. These areas only cover 24.4 percent (788,625 km²) of the potential range and only contain 28.4 percent (662) of the sightings. This is understandable since 75.6 percent of the potential range is not covered by protected areas. Table 5 shows the numbers of protected areas within snow leopard potential range are listed per country. Complete area listings are presented in the corresponding country appendices.

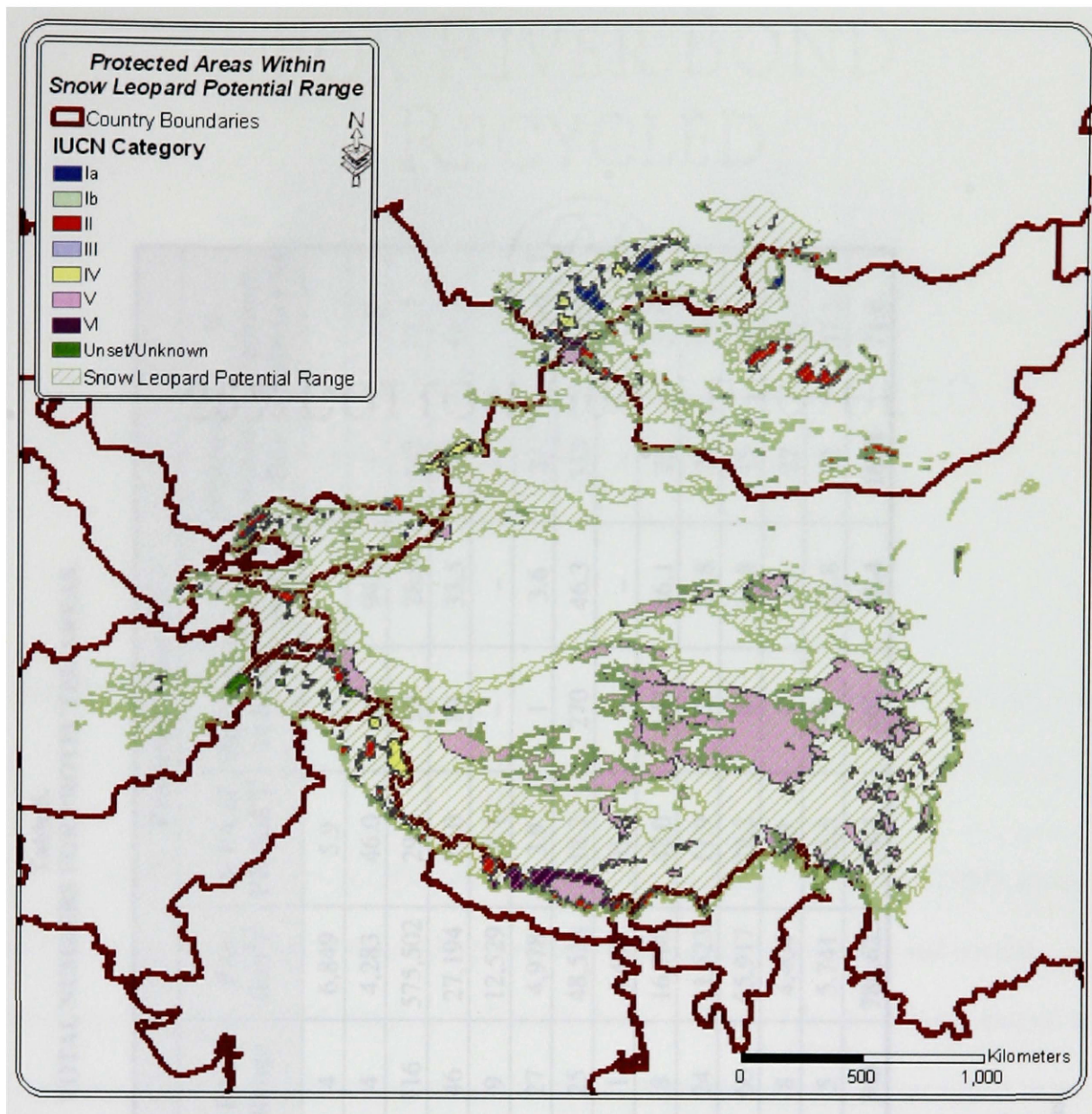


Fig. 7. Protected areas by category clipped to potential snow leopard range map.

Table 5.
TOTAL NUMBERS FOR PROTECTED AREAS.

Country	Total # Sightings	Protected Areas (PAs)						
		# PAs in Range	PAs (km ²) ³	% PA of PR (km ²) ⁴	Sightings in PAs	% Sightings in PAs	Sightings outside PAs	% Sightings outside PAs
Afghanistan	–	4	6,849	5.9	–		–	
Bhutan	17	4	4,283	46.0	16	94.1	1	5.9
China	204	116	575,502	29.2	59	28.9	145	71.1
India	266	46	27,194	21.0	89	33.5	177	66.5
Kazakhstan	–	9	12,529	18.1	–	–	–	–
Kyrgyzstan	28	27	4,978	3.9	1	3.6	27	96.4
Mongolia	583	25	48,528	18.2	270	46.3	313	53.7
Myanmar	–	1	4,408	95.0	–	–	–	–
Nepal	165	8	16,769	42.0	142	86.1	23	13.9
Pakistan	101	24	11,523	11.9	22	21.8	79	78.2
Russia	23	66	65,917	22.2	8	34.8	15	65.2
Tajikistan	23	8	4,404	5.0	1	4.3	22	95.7
Uzbekistan	86	5	5,741	43.5	54	62.8	32	37.2
Total	1,496	343	788,625	24.4	662	28.4	1668	71.6

³ Protected areas clipped to potential range boundary.

⁴ Percent of potential range covered by protected areas.

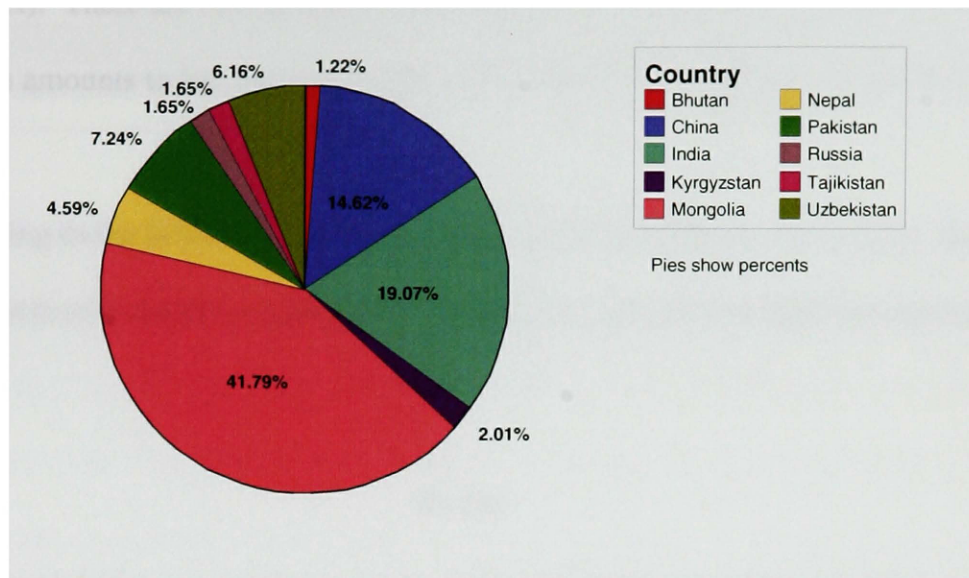


Fig. 8. Percent sightings per country.

Afghanistan

Although no data was collected in Afghanistan for this project, Adil (1995) states that the snow leopard, or *Palang-i-Barfi* in Dari, inhabits the northeastern and central portions of the Hindu Kush range as well as the Pamir valleys. They have been spotted in Laghman, Nuristan, and Badakhshan and in central Afghanistan and they are found in the Ajar Valley Reserve. Both the snow leopard and its prey species (Marco Polo sheep, ibex, and markhor) have been heavily hunted, especially during the extended war of the 1980s and 1990s and more recently. In Afghanistan there are minimal regulations against hunting wildlife or altering their habitats. Wildlife and their habitats are greatly affected by people's need for money, and social displacements during war, especially during food and fuel shortages (Adil 1995).

Afghanistan contains 3.6 percent of the total modeled potential range (Table 4, Appendix H). There are four protected areas within the range covering almost 6,900 km², which amounts to less than 6 percent of the range being under protected status (Table 4).

Owing to the lack of research and the constant hostilities in the country, snow leopard distribution data is in great need. Afghanistan should be a high priority for research.

Bhutan

Animal signs and anecdotal reports indicate that the snow leopard exists in scattered but substantial numbers at 4,000 to 5,000 meters in the northern parts of Bhutan (McCarthy and Chapron 2003). Appendix I shows the 17 sightings within the country, all residing within the boundaries of the modeled potential range (9,303 km²). These sightings support the range map. However, there are too few numbers to validate this with any degree of confidence.

According to my thesis analysis, of the four protected areas that fall within the snow leopard potential range (5.8 percent), only one contains snow leopards (Table 6). Sixteen of the seventeen sightings reported are located within the Jigme Dorji National Park, IUCN category II (Table 5). The Jigme Dorji National Park is the most prominent protected area in Bhutan that contains a significant snow leopard population. The Kulongchhu Wildlife Sanctuary, or Bumdelling, is another protected area where snow leopards are expected to occur in significant numbers, however there was only one nearby sighting (about 8 kilometers). Another sighting in India is located about 15 kilometers away from Sakteng.

Table 6.
NUMBER OF SIGHTINGS IN BHUTAN PROTECTED AREA SYSTEM

Protected Area	Number of Sightings
Jigme Dorji National Park	16
Total	16

There are too few numbers to evaluate the effectiveness of the current protected area system for snow leopards. Further research is needed to provide this information.

Many areas in Bhutan are lacking snow leopard distribution data. The potential range covers 18 percent of the area of Bhutan and less than 25 percent of that has data. Bhutan should be a priority for research.

China

China contains 60 percent of the potential snow leopard range (Table 4). Out of 204 sightings in China, 170 (83.3 percent) were within the developed range map (Table 7). Snow leopards occur in six provinces or autonomous regions (Gansu, Qinghai, Sichuan, Xinjiang, Xizang or Tibet, and Yunnan). (Appendix J).

Table 7.
NUMBER OF SIGHTINGS IN CHINA PROVINCES

Province/Autonomous Region	Number of Sightings
Gansu	20
Qinghai	37
Sichuan	2
Xinjiang	87
Xinzang (Tibet)	54
Yunnan	4
Totals	204

Protected areas make up 29.2 percent of the range and 59 sightings were within protected areas (Table 5). Of the 634 total protected areas in China, only 116 are

partially within the potential range of the snow leopard. No more than 56 percent of that area contains snow leopard habitat. Just 17 of those areas contain snow leopard sightings with Sanjiangyuan containing the most with 24 (Table 8).

Table 8.
NUMBER OF SIGHTINGS IN CHINA PROTECTED AREA SYSTEM

Protected Area	Number of Sightings
Aerjinshan	1
Bayinbuluketiane	2
Dasuganhu	1
Dunhuang	1
Ganligahai-zecha	1
Kalamailishan	2
Kekexili	1
Mangkang	2
Qiangtang	7
Quomolangma	4
Sanjiangyuan	24
Tashikuerganyesheng-dongwu	2
Tuomuerfeng	4
Yaluzangbudaxiagu	1
Yaluzangbujiangzhongyouheguoheijinghe	1
Zhumulangmafeng	5
Totals	59

Much of China is lacking snow leopard distribution data, likely because much of the area is difficult to access and is difficult for western researchers to enter these areas. There are many populated areas throughout much of the potential range, but China has significant areas, including protected areas, with low human pressure. These areas also lack snow leopard information and should be considered high priority for research.

India

India contains 3 percent of the total snow leopard potential range (Table 4) and has the second highest number of sightings with 266. Of these, 264 fall within the potential range (Appendix K). The two outliers are located within 2.5 kilometers from

the potential range. This small departure from potential range can be explained by error associated with data collected at this scale. The data for India strongly supports the potential range map.

The current protected area system covers 21 percent of the range, yet only 89 of the sightings are within 11 protected areas (Table 9). One reason for this could be associated with the size of the protected areas. Twenty-eight of the 46 protected areas within the range in India are less than 500 km², which is too small to harbor a viable snow leopard population. Many of the sightings fall between protected areas that are less than 50 km away from each other. These regions could be key corridors for the snow leopard, but with no protection could also be dangerous areas. These areas should be examined further.

India is a country where there is great potential to develop Transboundary Protected Areas (TPA). There are a few protected areas located on or close to the border with China, which has no protected areas in this area. Working with China to promote the protection of habitat in cooperation with India would greatly benefit the snow leopard. Another protected area in India, Khangchendzonga, borders Kanchanjunga in Nepal, which in turn borders Quomolangma in China. Quomolangma has already been designated as a TPA with other areas in Nepal (Green and Zhimbiev 1997). By working together, Nepal, India and China could have a successful TPA. This would provide an excellent opportunity to study the influence of TPAs upon snow leopards.

Table 9.
NUMBER OF SIGHTINGS IN INDIA PROTECTED AREA SYSTEM

Protected Area	Number of Sightings
Changthang	7
Hemis	65
Karakoram	5
Kedarnath	1
Khangchendzonga	1
Kistwar	1
Nanda Devi	2
Pin Valley	4
Sangla	1
Sechu Tuan Nala	1
Valley of Flowers	1
Totals	89

The eastern region (Appendix K) of the potential range in India between Bhutan and Myanmar is considerably lacking in snow leopard distribution data (one sighting in 21,000 km²). Less than 13 percent of this range is covered by protected areas, but very few (4) population centers occur within the range. Human pressure is prominent throughout most of the snow leopard's range. The central region (Appendix K) of India is also significantly lacking data (two sightings in 4,400 km²). Almost half (41.2 percent) of this portion of the range is under protected area status and little to no populated areas fall within snow leopard range. These areas need presence/absence and distribution studies.

Kazakhstan

No researcher from Kazakhstan (Loginov 1995) was available for this study, therefore no snow leopard sighting information was collected from Kazakhstan, however according to the literature, snow leopards are found in the most eastern, southeastern and southern mountainous regions; which include the Altai, Saur and Tarbagatai,

Dzhungarian, Alatau, Northern and Western Tien-Shan ranges. Snow leopard population numbers are low throughout Kazakhstan, but most rare in eastern Kazakhstan ranges (Katunskie Belki, South Altai, Kurchumski, Sarymsakty, Saur and Tarbagatai) (Loginov 1995).

Kazakhstan contains 2.1 percent (69,197 km²) of the potential range (Table 4). There are nine protected areas (18.1 percent) in the potential range of Kazakhstan (Table 5 and Appendix L), but snow leopards are only regularly reported in the Aksu-Dzhabagly and Almaty reserves. Hence, the main snow leopard range in the Altai region is located outside of established protected areas. Snow leopards are also found in nature reserves (*zakazniks*), which are much larger than reserves, but these areas are only partially protected and thus do not provide for protection of prime snow leopard habitat.

Kyrgyzstan

Kyrgyzstan contains 4.0 percent of the potential snow leopard range (Table 4), which covers 68.6 percent of the area of Kyrgyzstan. All 28 sightings are within the range (Appendix M), which supports the snow leopard potential range map. With only 28 sightings in the country, many areas are lacking distribution data and are in need of further studies to determine snow leopard abundance.

Only one of the sightings (Table 10) falls within a protected area, which covers 3.9 percent of the range (Table 5). Most of these areas are less than 500 km², and only two protected areas are greater than 1000 km² (Issuk-Kul and Besh-Aral). Issuk-Kul is surrounded with populated areas and is used as a resort area for many of the surrounding countries, thus limiting habitat.

Besh-Aral (1,160 km²), Chandalash (494 km²), and Manass (407 km²) in Kyrgyzstan border Ugam-Chatkal in Uzbekistan and could develop into a considerable (7,989 km²) TPA, with the cooperation of these two countries.

Table 10.
NUMBER OF SIGHTINGS IN KYRGYZSTAN PROTECTED AREA SYSTEM

Protected Area	Number of Sightings
Chandalash	1
Totals	1

Myanmar

Myanmar contains a very small portion (0.1 percent) of snow leopard potential range (Table 4), and only one protected area within this range (Table 5), the Mt. Kakabo Raza National Park (Appendix N). The presence of snow leopards has not been confirmed and would need a focused study to validate presence or absence. However, there is one sighting within 15 km of the border in China, but no sightings were reported within Myanmar.

Mongolia

Population estimates for snow leopards in Mongolia have ranged from a few hundred (Thornback 1978) to more than 4,000 (Green 1988). Schaller (1994) believed that about 1,000 existed with an overall density of 1.10 cats per 100 km² of occupied habitat. Some of the highest densities of snow leopard in Mongolia are found in the Gobi ecosystem (McCarthy 2000).

Mongolia (Appendix O) contains the third largest area of potential range (8.2 percent) and holds the majority (41.79 percent) of sightings (Fig. 8). There were 583 total sightings reported (Table 4) within Mongolia with 448 (76.8 percent) being within

the potential range, which greatly supports the range map. Many of the outliers are within 50 km of the range, in “pockets” between range areas, which could mean they are passing through to access other parts of the range. These areas warrant a closer look to determine the reason for their use.

There are 270 (46.3 percent) sightings within the 25 protected areas within the snow leopard range in Mongolia (Table 5). Table 11 shows the 13 protected areas within Mongolia where snow leopards are known to occur. The majority of the protected areas that contain sightings are over 1,000 km², with only two less than 500 km².

Table 11.
NUMBER OF SIGHTINGS IN MONGOLIA PROTECTED AREA SYSTEM

Protected Area	Number of Sightings
Alag Khairkhan	4
Altai Taven Bogd	5
Burkhan Buudai	7
Gobi Gurvansaikhan	49
Great Gobi National Park	47
Har Us Nuur National Park	45
Khangai nuruu	5
Khasagt Khairkhan	5
Khukh Serkhyn Nuruu	13
Otgontenger	1
Sylkhemyn nuruu	7
Tsambagarav mountain	5
Uvs Nuur Basin	77
Totals	270

Many of the protected areas are located on the borders of China and Russia, two of which are already established as TPAs, Khuvsogul Nuur and Uvs Nuur Basin. The Altai Taven Bogd and the Great Gobi are the two that border China. However, the Great Gobi is not located within snow leopard range in China. Development of the TPAs and

expanding the current protected areas to include corridors between ranges would greatly benefit the snow leopard.

Much of the range in Hovsgol, Arhangay, Dzavhan, and Bayanhongor is lacking snow leopard data and should be considered for future studies.

Nepal

Nepal contains 1.2 percent of the potential snow leopard range (Table 4 and Appendix P). All 165 snow leopard sightings are located within the modeled potential range map, which supports the range map.

There are 17 protected areas in Nepal and 8 within the range (Table 12). This covers 42 percent of snow leopard potential range. Within 7 of the protected areas there are 142 snow leopard sightings reported (Table 5). They are located in the northern, mountainous region, many in conjunction with Quomolangma, the large TPA in China.

Table 12.
NUMBER OF SIGHTINGS IN NEPAL PROTECTED AREA SYSTEM

Protected Area	Number of Sightings
Annapurna	12
Dhorpatan	1
Kanchanjunga	2
Langtang	1
Makalu-Barun	0
Manasulu	1
Sagarmatha	102
Shey-Phoksundo	23
Totals	142

Among Nepal's Himalayan national parks and protected areas, the Makalu-Barun, Sagarmatha, Langtang, and Shey Phoksundo national parks, the Dhorpatan Hunting Reserve, and the Annapurna Conservation Area, have either confirmed sightings or somewhat reliable evidence to indicate the presence of snow leopard within their

boundaries. There are many areas outside protected areas in the range lacking distribution data that should be considered for further study.

Pakistan

Schaller (1977) estimated the total population of snow leopards in Pakistan to be less than 250. In 1994 the Forest Department in Gilgit estimated the presence of snow leopards at 260 in the Northern Areas and around 400 for the whole of Pakistan (Malik 1995).

Pakistan contains 3.0 percent of the total potential snow leopard range (Table 4 and Appendix Q) and all 101 sightings are within it, greatly supporting the potential range map. However, only 22 of these sightings (21.8 percent) fall within protected areas. Protected areas in Pakistan make up 11.9 percent (Table 5) of the area and out of the 24 protected areas within the range most have an area less than 1,000 km². Only two have an area greater than 2,000 km², K2, which has no sightings, and Khunjerab, which has eight (Table 13).

Table 13.
NUMBER OF SIGHTINGS IN PAKISTAN PROTECTED AREA SYSTEM

Protected Areas	Number of Sightings
Baltistan	1
Central Karakoram	9
Chitral Gol	4
Khunjerab	8
Total	22

K2 and Khunjerab are border areas that are adjacent to Tashikuerganyeshengdongwu in China, which could potentially form a large TPA. The majority of the protected areas in Pakistan, and their immediate surrounding areas, are

lacking snow leopard distribution data and studies to expand snow leopard information is needed.

Russia

Russia has the second largest area of potential range with 9.2 percent of the total (297,091 km²) (Table 4 and Appendix R). There are 23 sightings in Russia. Eighteen sightings (78.3 percent) were located within snow leopard potential range (Table 5) in Russia and eight of these sightings (34.8 percent) were within the seven protected areas within the range (Table 14).

Table 14.
NUMBER OF SIGHTINGS IN RUSSIA PROTECTED AREA SYSTEM

Protected Area	Number of Sightings
Golden Mountains of Altai	3 (2 shared with Ukok)
Uvs Nuur Basin	1
Shavlinskiy	1
Kosh-Agachskiy	1
Shumakskiy	1
Khemchikskiy	1
Ukok	2 (2 shared with Golden Mountains of Altai)
Total	8

Tajikistan

Tajikistan contains 2.7 percent of the total potential snow leopard range (Table 4) with 87,839 km². All 23 sightings were within the range, which supports the potential range map.

Protected areas (eight in all) cover 5.0 percent of snow leopard potential range (Table 5). Only one sighting (Table 15) was found in a protected area (Appendix S). These protected areas, spread out over the range, are mostly under 500 km² and are not

close to other protected areas. There are many areas lacking distribution data in Tajikistan and should be closely examined for future studies.

Table 15.
NUMBER OF SIGHTINGS IN TAJIKISTAN PROTECTED AREA SYSTEM

Protected Area	Number of Sightings
Muzkulsky	1
Totals	1

Uzbekistan

There are 86 sightings, 83 of which are within the potential range, which only makes up 0.4 percent of the range (Table 4).

The snow leopard is protected in three strict nature reserves in Uzbekistan (Chatkalskiy, Gissarskiy and Zaaminskiy), and two national parks (Ugam-Chatkal and Zaamin) (Appendix T). These protected areas cover about 43.5 percent of the total area (Table 5) of snow leopard range in Uzbekistan. Table 16 shows 52 sightings within protected areas. Data is still absent for most of these areas. There are many areas bordering Tajikistan that are lacking distribution data which should be examined closely for future research.

Table 16.
NUMBER OF SIGHTINGS IN UZBEKISTAN PROTECTED AREA SYSTEM

Protected Area	Number of Sightings
Chatkalskiy	5
Gissarskiy	26
Ugam-Chatkal	21
Totals	52

Summary

The majority of sightings (88 percent) were located within the borders of the potential range map created by Jackson and Hunter (1997). For example, all sightings in Bhutan, Kyrgyzstan, Nepal, Pakistan and Tajikistan were within the potential range borders. China, India, Mongolia, Russia and Uzbekistan had greater than 75 percent of their sightings within the potential range. This is highly suggestive that the map accurately represents the portion of potential range that supports snow leopards. Only 179 (12 percent) of the total sightings were outside of the range. Possible explanations could be snow leopards chasing prey or crossing valleys to other range. The majority of sightings documented outside the potential range were in Mongolia (23.2 percent), Russia (21.7 percent) and China (16.7 percent). Seventy-two percent of sightings are within 15 km of the range, a distance easily traveled by snow leopards. Many of the countries are lacking sufficient data to verify this on a per country basis and most countries have areas that should be examined more closely. Mongolia contains the majority of the sightings (41.8 percent); however, there are also many conservation projects taking place there, In contrast, China contains 60 percent of the range and only 14.6 percent of the sightings. Possible explanations are vast landscapes and difficult access to the country.

I have highlighted varying degrees of support for protected areas. In some countries, almost all sightings were located within protected areas. For example, Bhutan and Nepal contained greater than 85 percent of their sightings within protected area boundaries and Uzbekistan follows with 63 percent.

On the other hand, most of the potential range lies outside of protected areas, leaving much of the snow leopard's range unprotected. It is expected then, to find more

sightings outside of the protected areas. Consequently, it is no surprise to find the remaining countries with less than 47 percent of their sightings within protected area boundaries.

CHAPTER 5

SNOW LEOPARD INTERNET MAPPING SERVICE

Internet mapping services (IMS) have become a popular method of hosting and displaying data. IMS is used to display information from sage grouse (Interior 2004) to fire management (Interior 2005). The snow leopard internet mapping service is an innovative step towards global snow leopard conservation. There are many databases served online to provide data worldwide.

IMS provides many benefits and services. For example, researchers will be able to access data from other parts of the range in order to better understand other work being done. Being an interactive service, the data will be able to be queried, buffered, identified for better analysis and the output printed. Interactive data forms will ease the transfer of data and communication among researchers.

Although there are many advantages, IMS also has some drawbacks. With greater access to data comes a concern with security and who is using the data. Defense against information theft is a high priority when dealing with endangered species owing to high-tech poachers and ecotourism. This can be an expensive endeavor when coupled with the general costs of data management and server hosting. Other drawbacks pertain to users and their knowledge level of GIS data manipulation. User data manipulation adds training expense. Another difficulty is standardization of data when dealing with countries having different languages, but also data entry procedures.

While there are advantages and disadvantages to developing an interactive mapping service, the benefits of distributing dynamic maps and GIS data across the web

to meet the demands of researchers throughout snow leopard range countries greatly outweighs the disadvantages of security risks and cost. In the future, the snow leopard interactive mapping service will grow into an invaluable tool. Eventually the site will contain forms for researchers to fill out their own data and related tables for storing not only sighting data but also current and past studies. The possibilities and potential are unlimited.

CHAPTER 6

CONCLUSION

My thesis contained four parts. First was to collect snow leopard sighting data and graphically depict this data. Second was to assess the effectiveness of protected areas within snow leopard potential range. Third was to identify areas lacking distribution data. And fourth was to produce a GDB and internet mapping service for data compilation and storage for future research.

My study validates the potential range map created by Jackson and Hunter (1997) because 88 percent (1,317) of snow leopard sightings fall within the modeled potential range. Because of the majority of the sightings (greater than 70 percent) resided within the “fair” category of the modeled potential range map, analysis was conducted on the combination of the two (fair and good) categories. Five countries within the study area had 100 percent of their sightings within the potential range. An additional five countries had greater than 75 percent of their sightings within the potential range. This is highly suggestive that the range map holds true in representing the landscape that supports snow leopards. Only 12 percent of the total sightings were outside of the range. The majority of sightings documented outside the potential range were in Mongolia (23.2 percent), Russia (21.7 percent) and China (16.7 percent). Seventy-two percent are within 15 km of the range, a distance easily traveled by the snow leopard. One possible explanation is the precision of the “X” drawn on the ONCs. Maps at 1:1,000,000 scale are quite small for wildlife studies and the size of one line for the “X” could measure one to two kilometers, decreasing accuracy. Other possible explanations are snow leopards chasing prey or crossing valleys to other range. Many of the countries are lacking sufficient data to

verify this on a per country basis and most countries have areas that should be examined more closely with future studies. Mongolia contains the majority of the sightings (41.79 percent), the many conservation projects taking place there may increase the potential for snow leopard sightings. China contains 60 percent of the range and only 14.6 percent of the sightings. China has potential for additional snow leopard research despite the vastness and difficulty of obtaining access.

This thesis highlights varying degrees of support for protected areas. Only two countries (Bhutan and Nepal) contained greater than 85 percent of their sightings within protected area boundaries and one (Uzbekistan) with 63 percent. On the other hand, most of the potential range lies outside of protected areas, leaving much of the snow leopard's habitat unprotected. Consequently, it is no surprise to find remaining countries with less than 47 percent of their sightings within protected area boundaries.

Size and distribution of protected areas, including corridors and border reserves are often set by bureaucrats without consideration for the ecological requirements of the target species. Snow leopards have some level of protection within the 12 range countries. However, in most areas, there are many improvements that need to be made in order to best serve the snow leopard. The Working Group of Uzbek Zoological Society and the State Committee of Nature Protection has compiled a list of improvements for Uzbekistan (Kreuzberg-Mukhina 2003). The list can be applied to the entire snow leopard range:

- Reinforce the conservation function in existing reserves
- Optimize relations between protected area administration and adjacent areas
- Establish buffers around existing reserves
- Increase the protected area network by enlarging existing areas and adding new areas
- Create ecological corridors

- Establish transboundary parks throughout the range of the snow leopard
- Develop hunting management and regulate hunting of prey species
- Involve communities in protection activity

Many of these efforts have been recognized in different areas. For example, Kyrgyzstan, Mongolia and Pakistan participate in community-based ecotourism, turning raw wool into crafts that can be sold to supplement their income. Pakistan is participating in a livestock vaccination program that reduces livestock loss to disease. India is participating in a village-run insurance program that provides incentives for good herding practices and bonuses to herders with no herd loss to predators. India has also developed grazing reserves in some villages where livestock are not grazed, reserving more areas for snow leopard prey species.

Given the socio-economic and political complexities associated with border regions, all wildlife would benefit from the establishment of transboundary conservation areas (TBCAs) (Singh 2002). Not only would this benefit the plight of the snow leopard and strengthen biodiversity and the biological health of fragile environments, but it would also help mitigate political problems, a positive step among quarreling countries. Transboundary conservation areas are a simple notion that provides both conservation and political solutions.

Because of the lack of research and the constant hostilities in many of the countries, snow leopard distribution data is still a great need. For example, Afghanistan should be a high priority for research. Many areas in Bhutan are also lacking snow leopard distribution data. The potential range covers 18 percent of the area of Bhutan and less than 25 percent of that has data, so perhaps Bhutan should be a priority for research.

While there are advantages and disadvantages to developing an interactive mapping service, the benefits of distributing dynamic maps and GIS data across the web to meet the demands of researchers greatly outweighs the disadvantages of security and cost. Snow leopard researchers have never before been able to access data so readily from other range countries. In the future, the snow leopard interactive mapping service will continue to grow and evolve. Eventually the site will contain online forms for data entry directly from researchers and related tables for not only sighting data storage, but also current and past studies. The purpose of the GDB and internet mapping service is to incorporate relationships among the variety of information that is needed in conservation. By integrating data, this information can produce a better understanding of the plight of the snow leopard. Because this is the first GDB implemented for snow leopard research, it will continue to develop as more uses are identified and more data is collected.

This thesis organized and analyzed existing snow leopard data in a GDB to provide insight to the accuracy of the potential range map and effectiveness of protected areas throughout the range. Creation of the GDB provides for a standardized method of data exchange and communication among researchers. This is a small step forward in the conservation of the snow leopard, but creates a necessary foundation for future collaborative data exchange projects to follow. The technologies and methodologies used here should be expanded to meet the individual needs of the projects. The consolidated sighting data in this paper and the interactive mapping service make it easier to communicate and coordinate research among researchers in different countries.

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APPENDICES

Appendix A: Researcher Questionnaire

Knowledge of Snow Leopard Range and Occurrence Survey

Conducted for the International Snow Leopard Trust, Snow Leopard Conservancy
and Ft. Collins Science Center

The purpose of this survey is to document the occurrence of the snow leopard across its potential range, based on the accumulated knowledge of **Snow Leopard Network** members. Many of you were present at the Snow Leopard Survival Strategy meeting in Seattle where we started the process of mapping what we know about snow leopard range. In the SLSS document, we all agreed that a better map of snow leopard range was a *CRITICAL* need. This is your chance to contribute your knowledge to building such a map. The results of this survey will be used to update the current Snow Leopard Range Map (Hunter and Jackson 1997), and to identify gaps in data.

Please use the enclosed maps and forms to tell us what you know. You need not have worked in the area personally, just have sufficient familiarity to answer the questions.

Thank you in advance for your time and effort!

Please return the map in the enclosed envelope to:
International Snow Leopard Trust
Patricia A. Williams
834 Scott St.
Missoula, MT 59802
U.S.A.

AND

Please return the digital form via email to:
PatriciaAnnWllms@aol.com

An example map and data form is also included to show clearly what we need from you. If you have *ANY* questions, please email us rather than guess! This project is very important in helping us better understand snow leopard range.

The results will only be as good as the data you provide!

Please send your questions to:

Patricia Williams at – PatriciaAnnWllms@aol.com or

Tom McCarthy at – tmccarthy@snowleopard.org

Appendix A (continued)

Instructions: You will find a 1:1,000,000 scale map, one (1) red pen, one (1) blue pen, a data sheet and a sample map in this package.

Please use the **Red** pen for drawing points and polygons and the **Blue** pen for all labeling.

STEP ONE – snow leopard range. Very carefully draw a line (red pen) around your best estimate of *active, potential, and historic* snow leopard habitat (see definitions below). Look at the example map we have provided. Follow landforms, drainages, elevation lines, and similar natural features, to demarcate range. **DO NOT** just draw a large circle or square. Make the lines that you draw ecologically meaningful.

Please label these areas as follows:

A = Active: areas known to currently have snow leopards

P = Potential: areas where there is little information but probably have snow leopards.

H = Historical: areas that contained snow leopards in the past, but definitely do not now

STEP TWO – snow leopard observations. Next, for every site where there has been an observation confirming snow leopard presence that you or other people you trust have made, place an X with a number (blue pen) on the map. Observations may include: snow leopards, their sign (scat, scrapes, pugmarks) or cases of confirmed livestock depredation. Start with Observation #1 and continue 2, 3, etc. for all observations.

STEP THREE - recording observations. For each numbered observation you place on the map fill in one line on the datasheet. Use the sheet provided for your own use, and then transfer this information to the Excel spreadsheet that has been emailed to you.

You will need to return both the paper map with markings & the digital spreadsheet!!!!

Data Required:

Name of Area – Use the official or (if no official name exists), the commonly used name for the area.

Year of Observation – e.g. 1984 (If snow leopard sign is seen often at this location, give the first and last year that observations were made, for example, 1984 – 2004).

Month or Season – Give month if known, or use Summer, Autumn, Winter, Spring, or Unknown.

Latitude & Longitude – If you know the exact latitude or longitude **from a GPS only**, enter it here. If a GPS was not used do not guess, leave this blank, but please be as accurate as possible when marking the map and we will calculate the latitude-longitude.

Type of Observation –

If a leopard was observed, list if alive or dead, and the number of adults (A) and juveniles (J) observed.

If only snow leopard sign was observed (scrape, pug mark, etc.), place an X in this column.

If a confirmed case of livestock depredation was made, list stock type (sheep, goat, cow, etc.) and about how many were killed.

Source of information -

P = personal observation made by the person(s) filling in this data form.

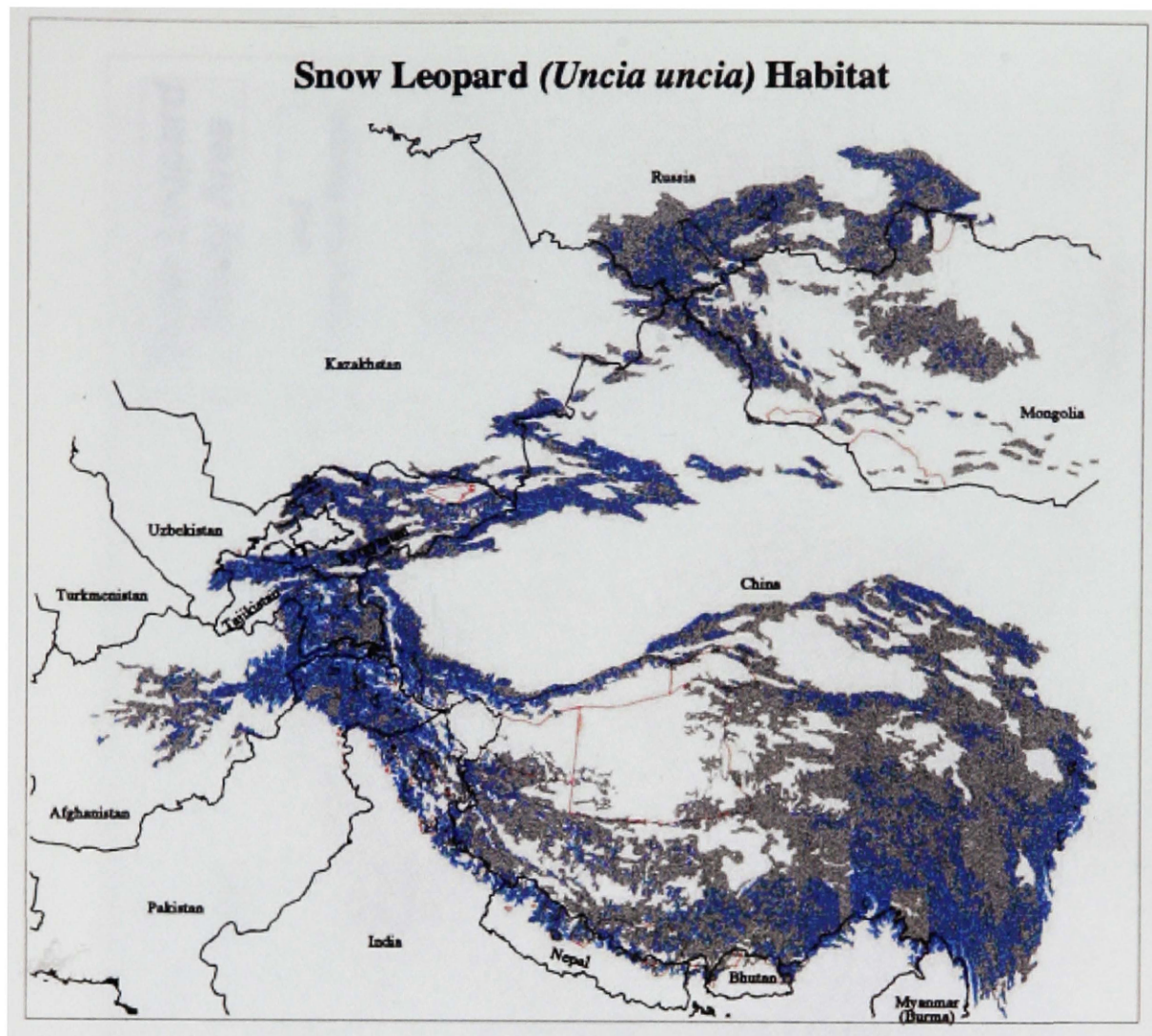
S = secondary, from someone you trust, or from the literature.

T = third-hand, rumor, or historical information. The source is questionable.

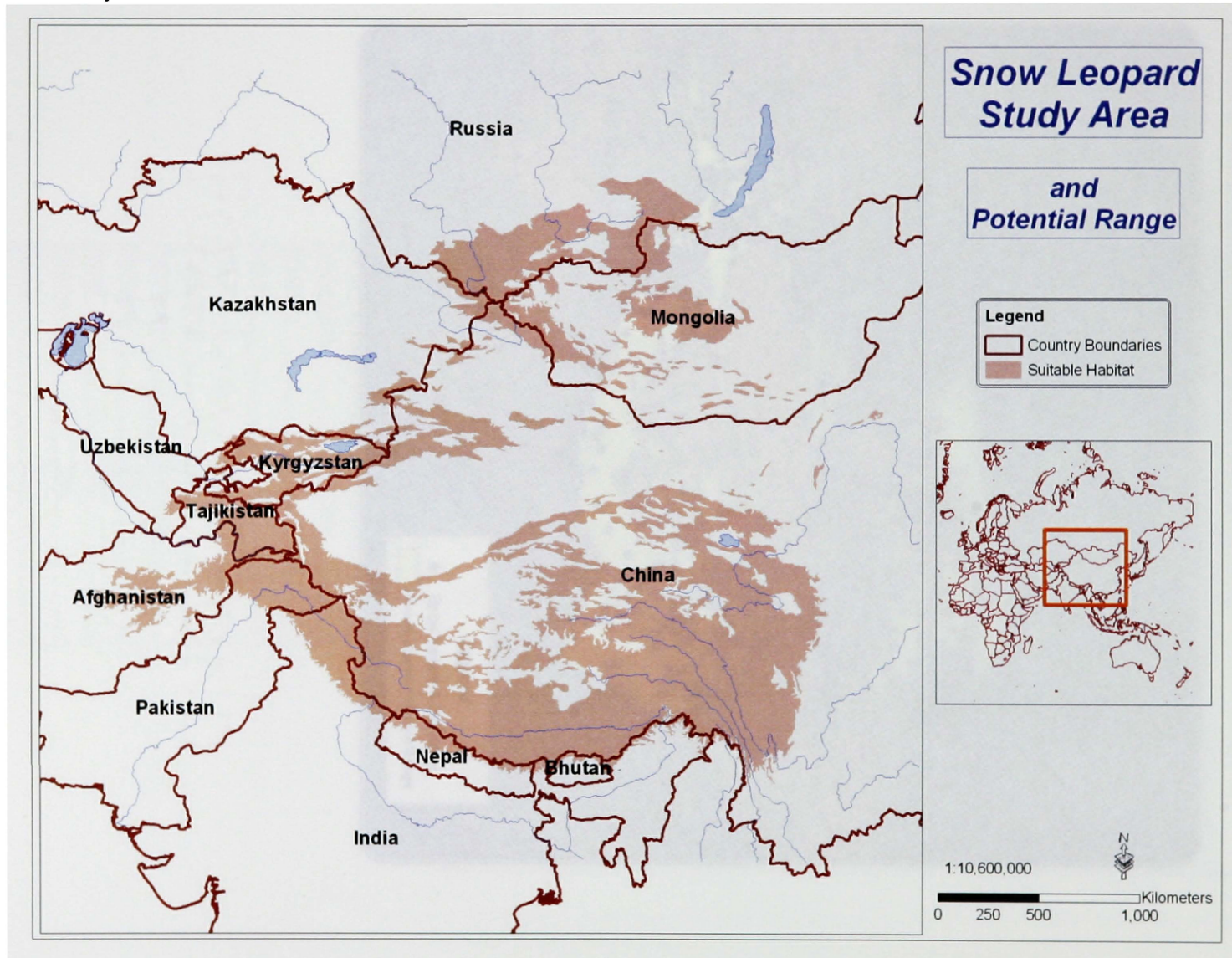
Was this sighting located in a Protected Area?

Y=Yes **N**=No

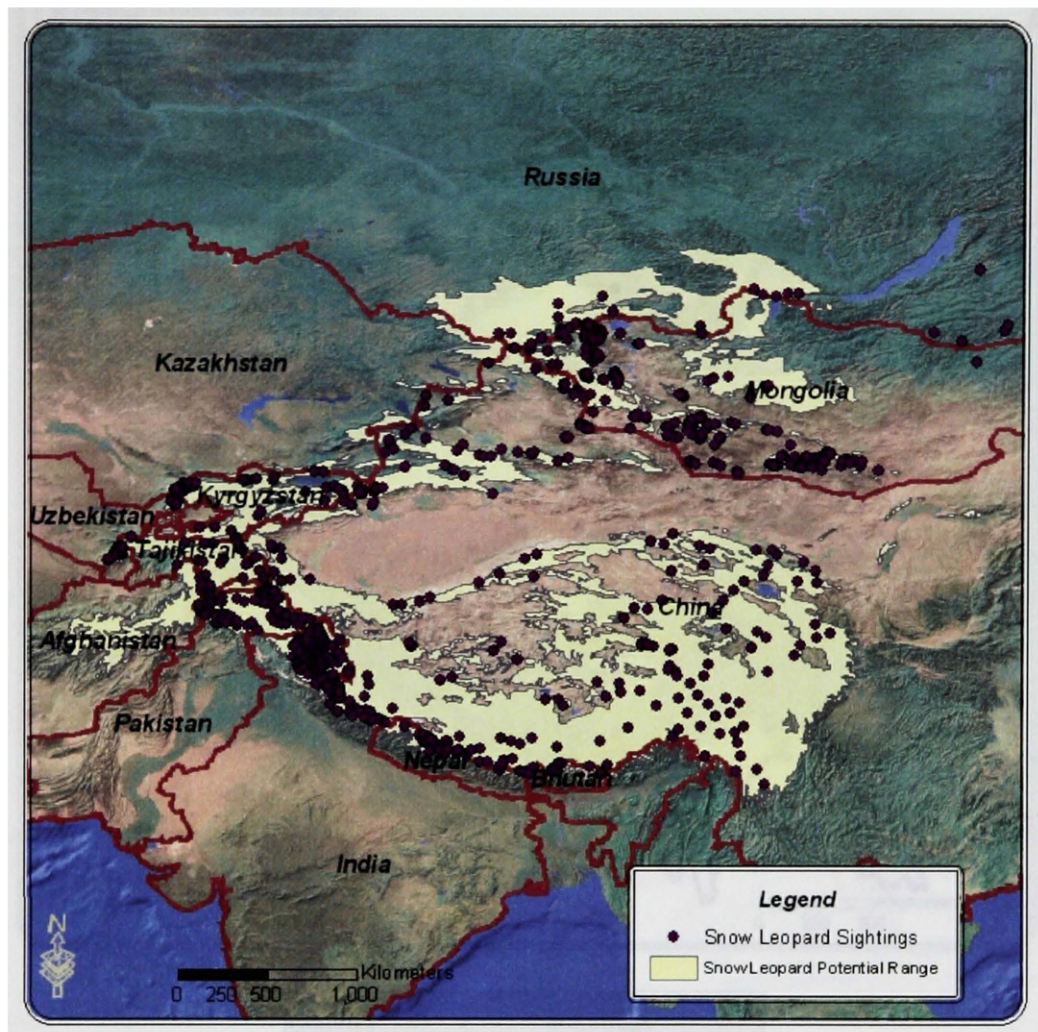
Appendix B: Range wide model of potential snow leopard habitat.
Blue represents good habitat, gray represents fair habitat.



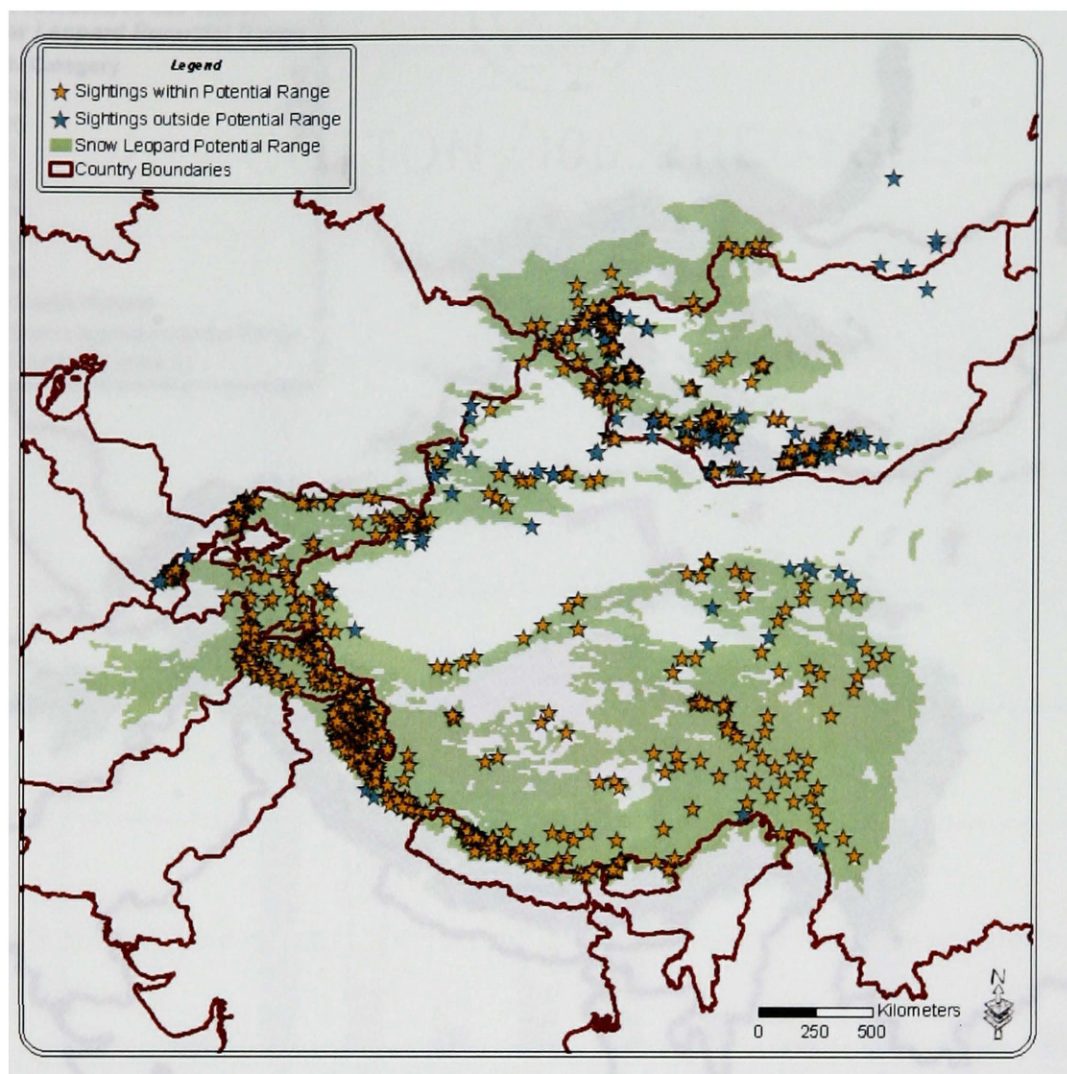
Appendix C: Study Area



Appendix D: Knowledge Map

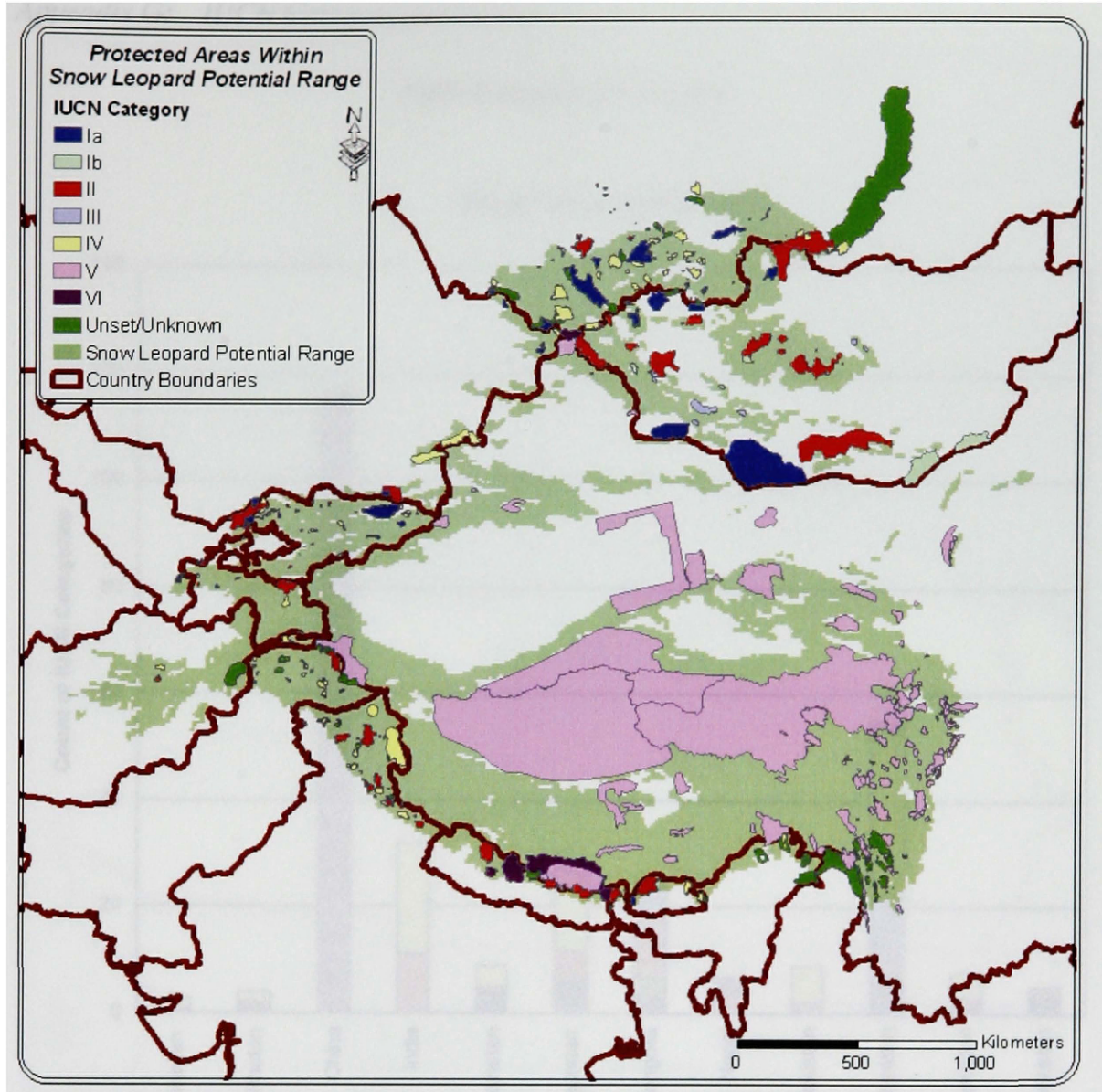


Appendix E: Knowledge Map with Potential Range



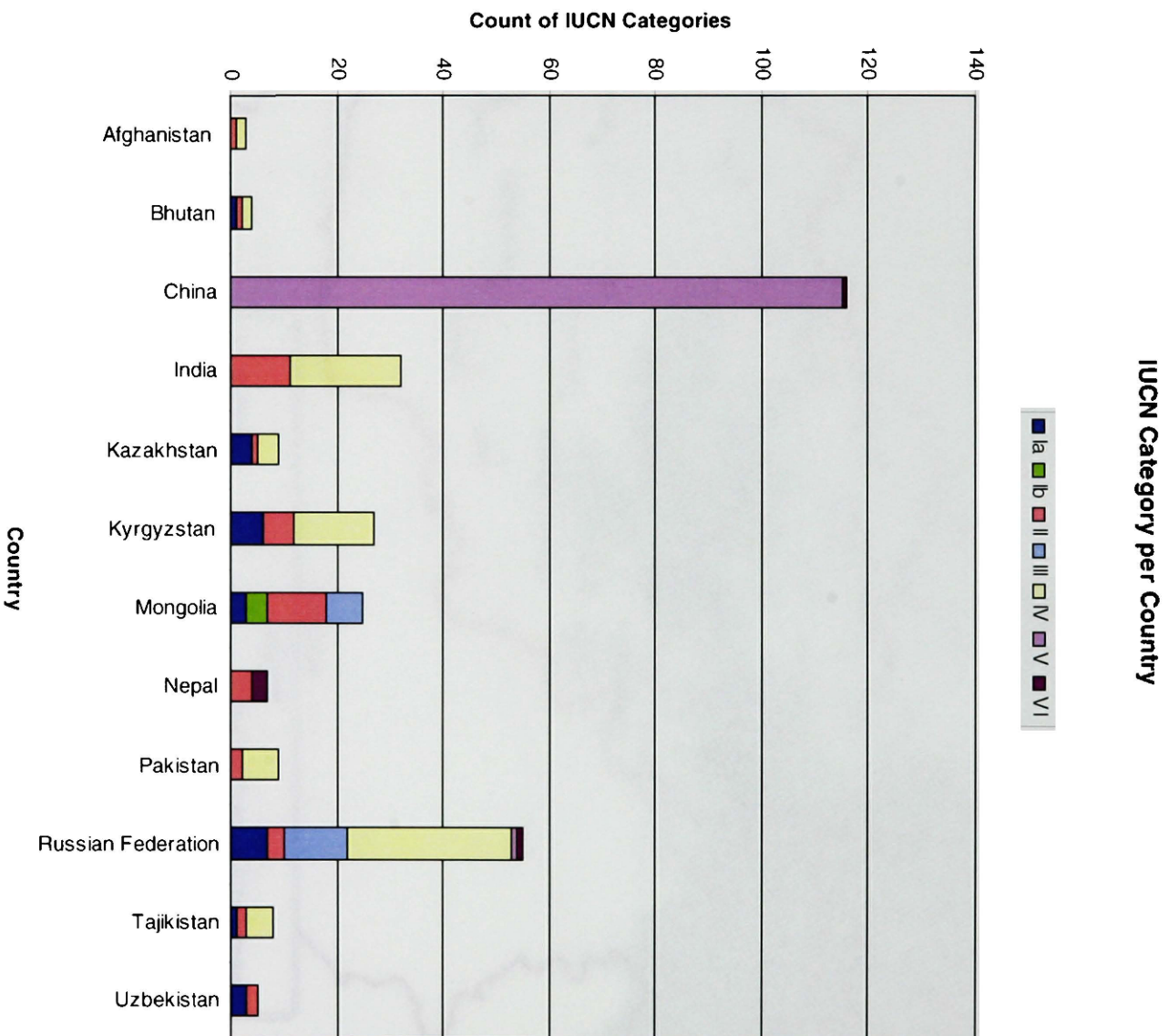
Country	Sightings
Afghanistan	No Data
Bhutan	17
China	204
India	266
Kyrgyzstan	28
Kazakhstan	No Data
Mongolia	583
Nepal	165
Pakistan	101
Russia	23
Tajikistan	23
Uzbekistan	86
Total	1,496

Appendix F: Protected Areas within Snow Leopard Potential Range

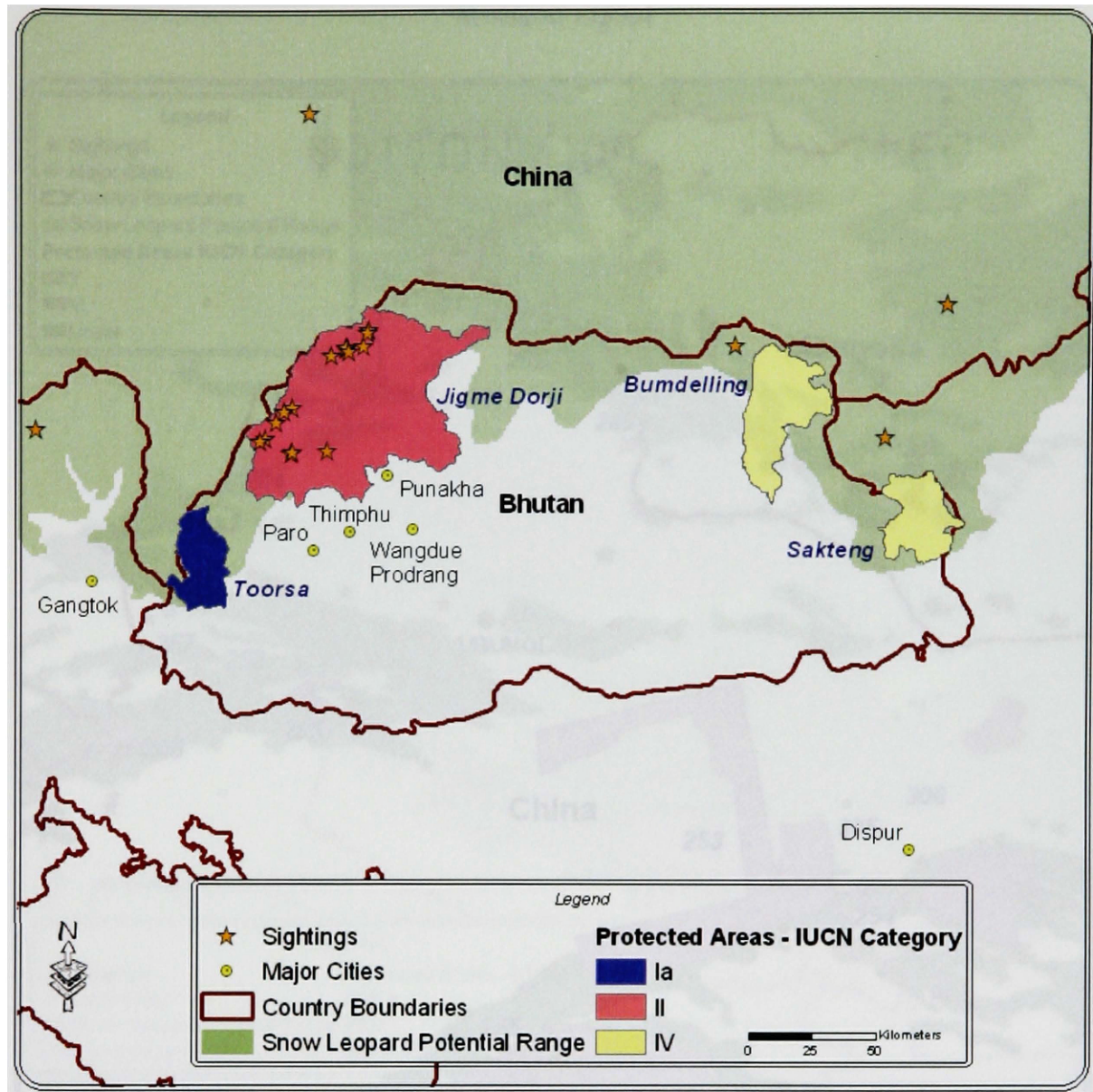


The central World Database on Protected Areas is kept at the UNEP-World Conservation Monitoring Centre (UNEP-WCMC) and is updated continuously providing the most current data on protected areas worldwide. The following link gives you access to this database: <http://www.unep-wcmc.org/parks/index.html>

Appendix G: IUCN Category per Country



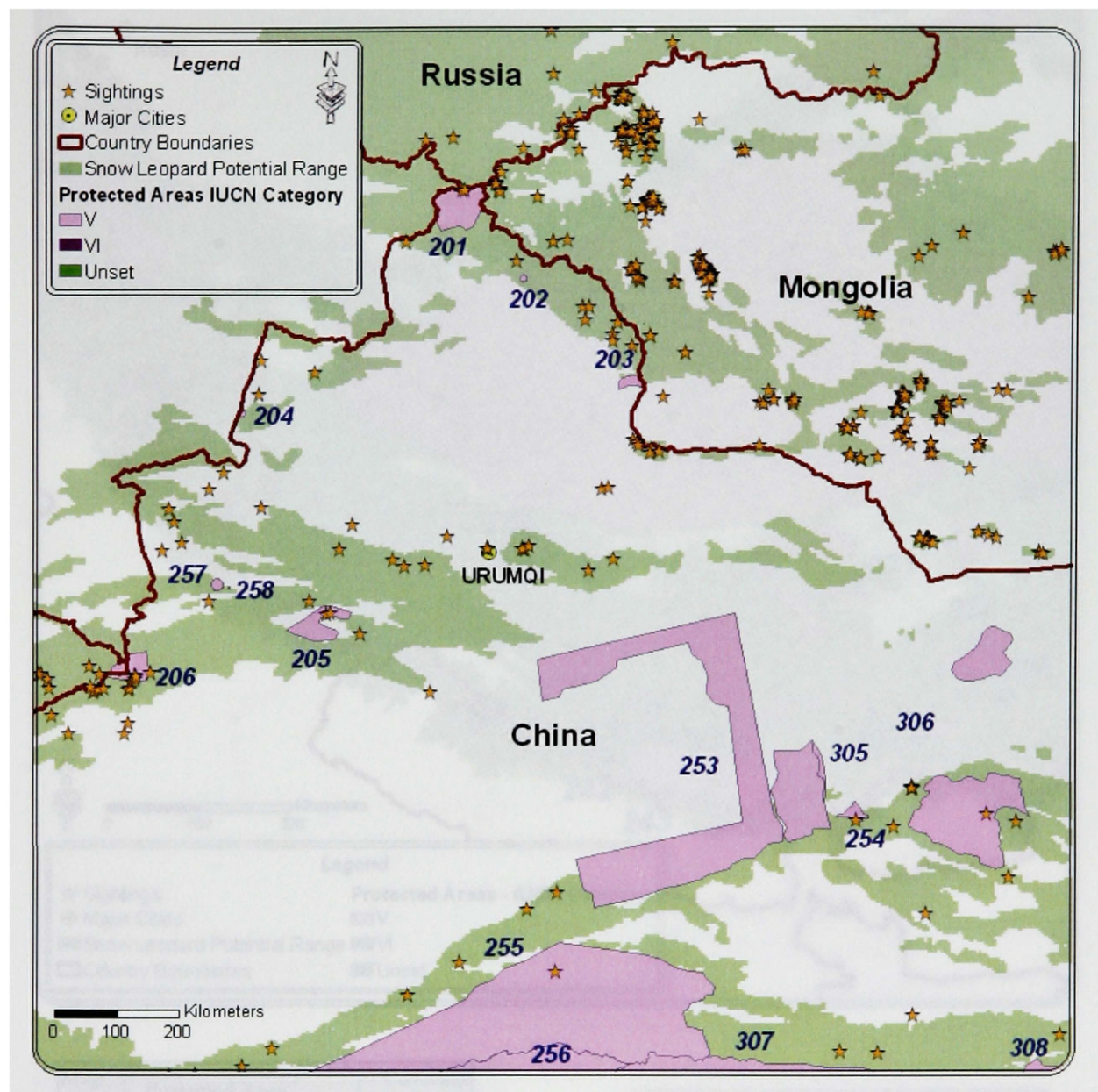
Appendix I: Bhutan



Protected Areas within Potential Range	Coverage (km ²)
Jigme Dorji National Park	4,264.62
Sakteng Wildlife Sanctuary	742.74
Toorsa Strict Nature Reserve	640.32
Bumdelling (Kulong Chu) Wildlife Sanctuary	1,162.16
Total	6,809.84

Appendix J: China

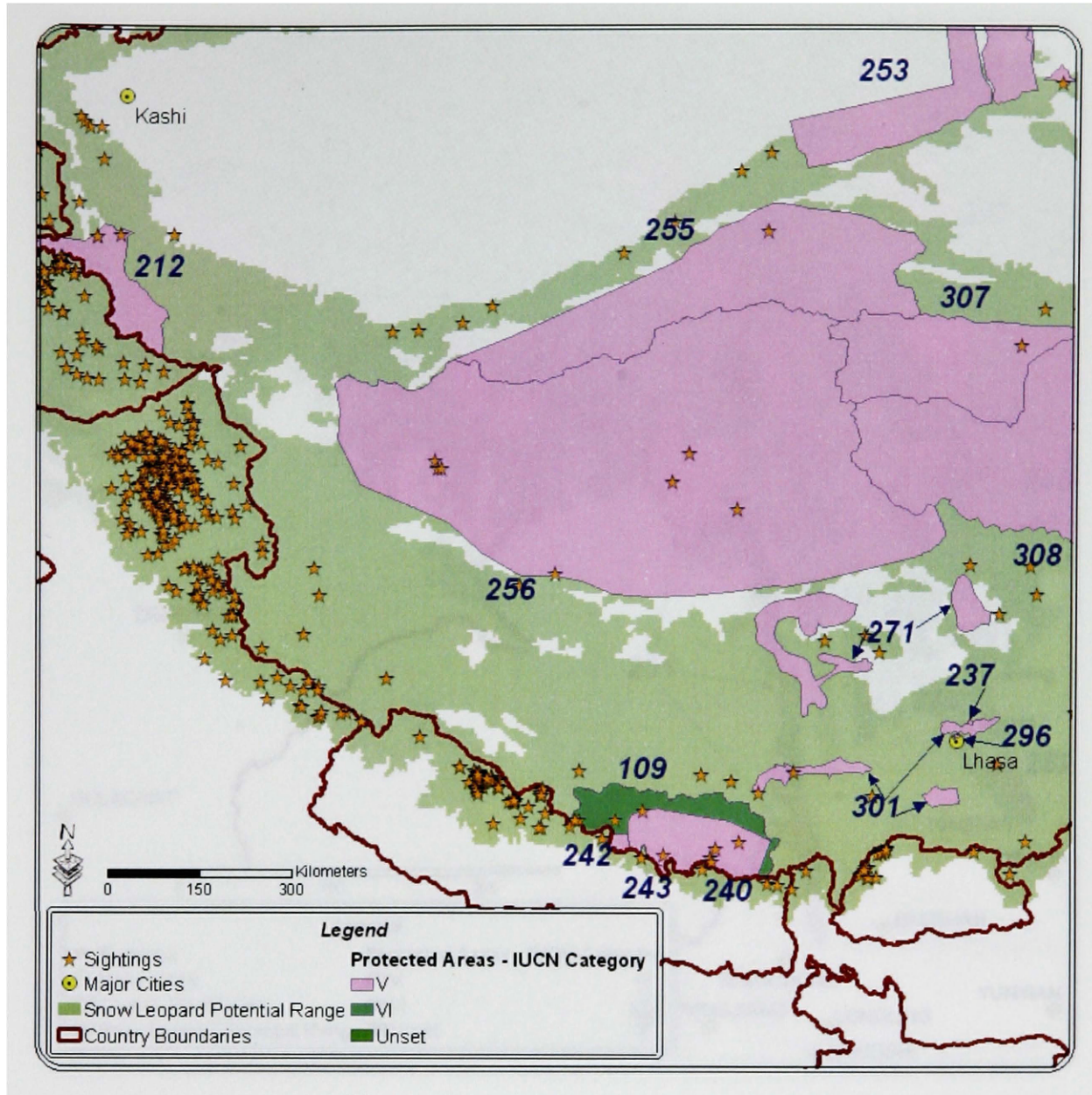
Northern region



Map No.	Protected Area	Coverage (km ²)
201	Hanasi	4,199.44
202	Jintashandicaoyuan	90.98
203	Buergenheli	623.23
204	Tachengyebadanxing	117.45
205	Bayinbuluketiane	2,761.66
206	Tuomuerfeng	2,156.25
253	Xinjiangluobupoyeshu angfengtuo	51,635.39
254	Dasuganhu	692.75

Map No.	Protected Area	Coverage (km ²)
255	Aerjinshan	88,021.11
256	Qiangtang	303,582.57
257	Xitianshan	277.33
258	Gongliuyehetao	9.90
305	Tunhuangxihu	536.41
306	Dunhuang	32,168.21
307	Kekexili	46,620.12
308	Sanjiangyuan	287,076.14

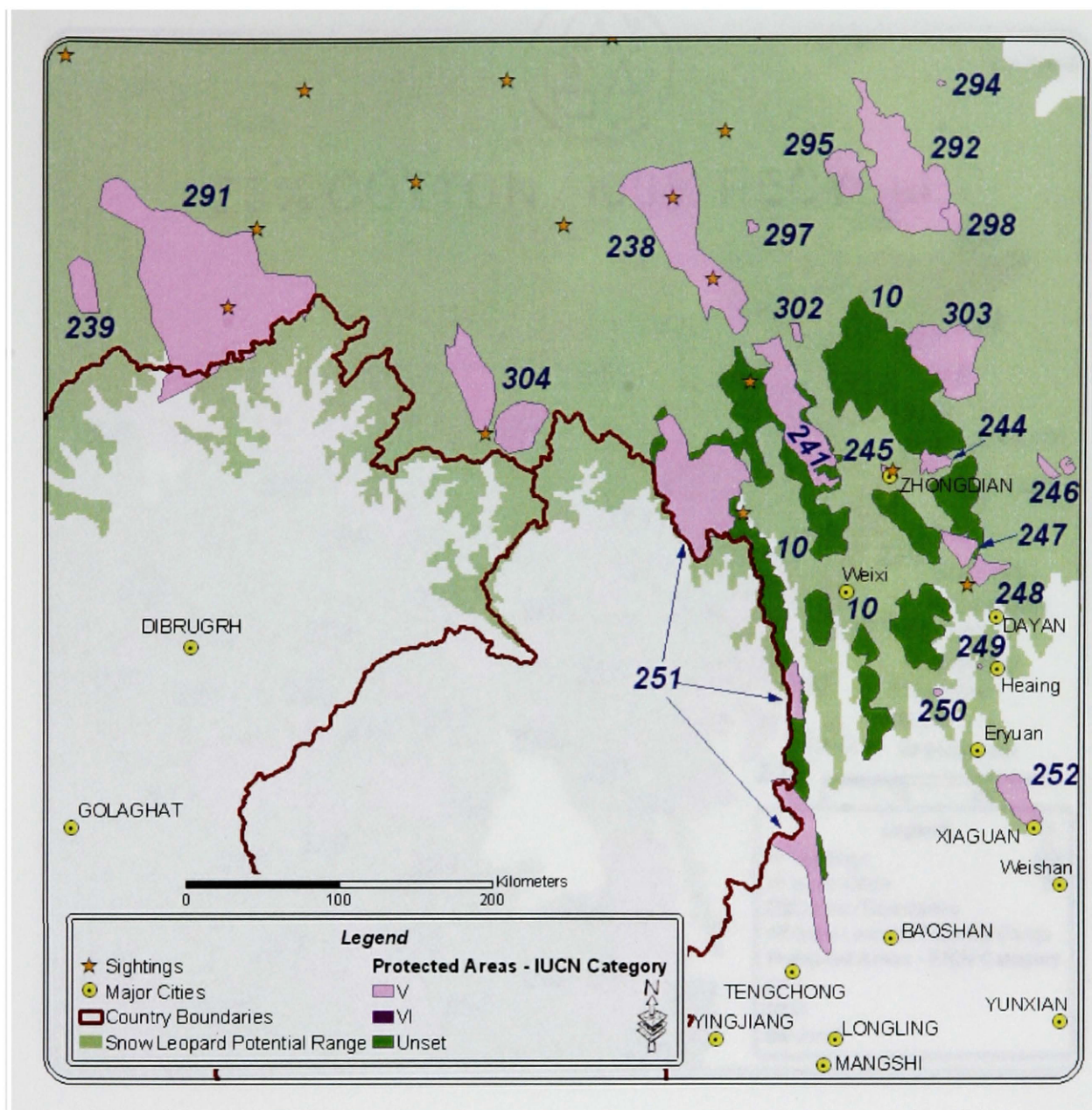
Southwest region



Map No.	Protected Area	Coverage (km ²)
109	Quomolangma	33,337.53
212	Tashikuerganyeshengdon gwu	15,377.22
237	Pengboheijinghe	62.08
240	Zhumulangmafeng	17,573.66
242	Jiangcun	724.11
243	Zhangmukouan	213.22
253	Xinjiangluobupoyeshuan gfengtuo	51,635.39

Map No.	Protected Area	Coverage (km ²)
255	Aerjinshan	88,021.11
256	Qiangtang	303,582.57
271	Selincuoheijinghe	17,097.14
296	Lalushidi	50.06
301	Yaluzangbuijiangzhongyo uheguoheijinghe	6,406.22
307	Kekexili	46,620.12
308	Sanjiangyuan	287,076.14

Southeast region



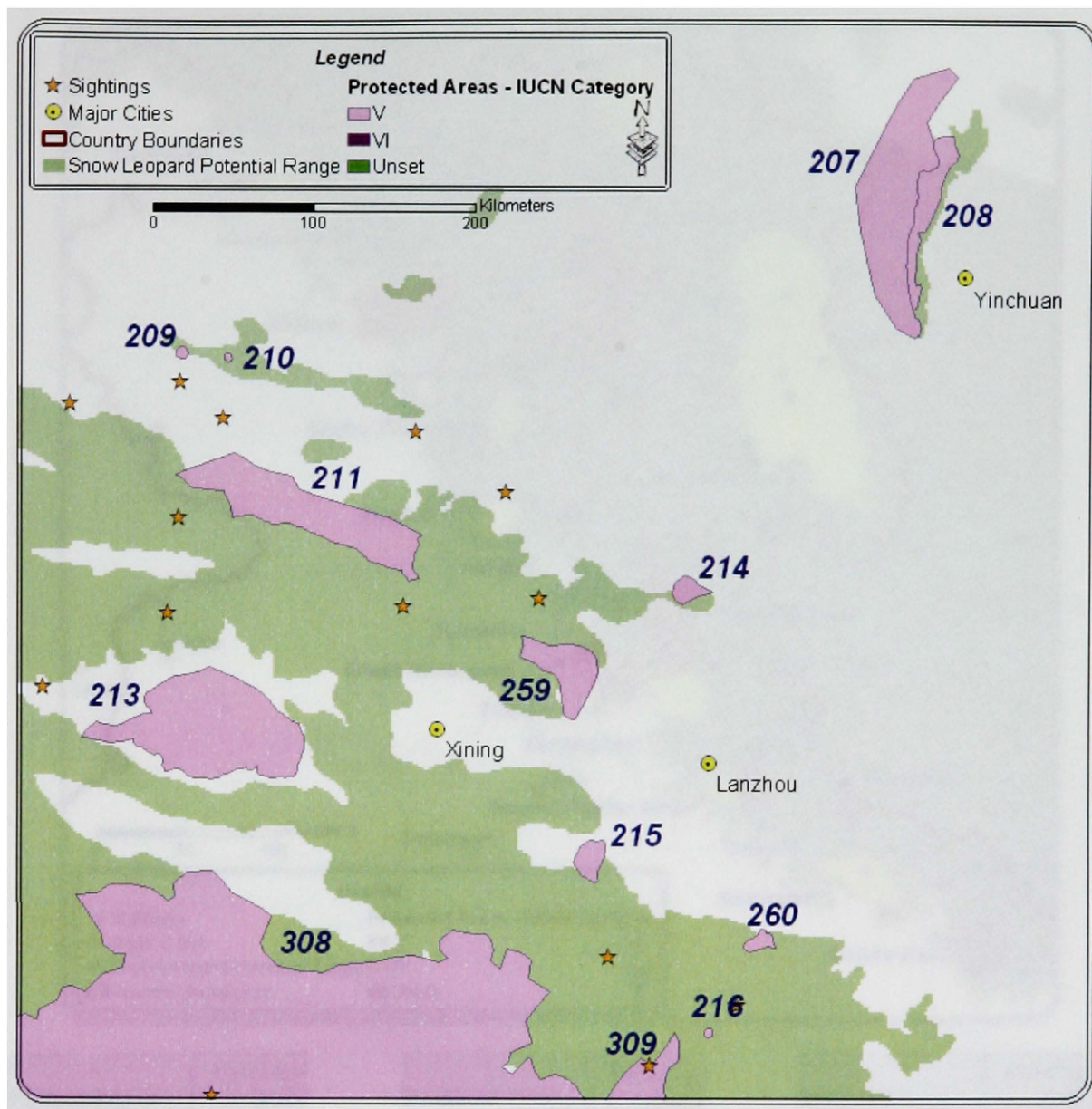
Map No.	Protected Area	Coverage (km ²)
10	Three Parallel Rivers of Yunnan	20,659.92
238	Mangkang	3,332.43
239	Bajie	537.56
241	Baimaxueshan	1,823.84
244	Bitahai	196.26
245	Napahai	21.58
246	Lugu	167.38
247	Habaxueshan	306.07
248	Yulongxueshan	255.68
249	Heqing zhaoxiamingsheng	6.54
250	Shibaoshan	26.43

Map No.	Protected Area	Coverage (km ²)
251	Gaoligongshan (Yunnan)	4,952.34
252	Changshanerhai	559.84
291	Yaluzangbudaxiagu	8,693.74
292	Haizishan	2,990.05
294	Gexigou	16.31
295	Genieshenshan	533.88
297	Zhubalong	50.28
298	Gemu	171.58
302	Xiyong	66.95
303	Yading	1,594.95
304	Chayucibagou	2,046.63

Map No.	Protected Area	Coverage (km ²)
13	Jiuzhaigou Valley Scenic & Historic IA	670.46
14	Huanglong Scenic & Historic IA	649.31
15	Huanglong Scenic & Historic IA	119.62
217	Kashahu	387.85
218	Xuebaoding	217.55
219	Sandagu	567.23
220	Yele	232.02
221	Tiebu	425.83
222	Baihe (Sichuan)	196.40
223	Jiuzhaigou	656.70
225	Baishuijiang	2,533.33
226	Wanglang	279.99
227	Huanglongsi	589.24
228	Tangjiahe	221.90
229	Xiaozhaizigou	100.14
230	Xinluhai	157.09
231	Queershan	241.08
233	Longxihongkou	456.47
234	Wolong	3,204.28
235	Fengtongzhai (Sichuan)	395.64
236	Labahe	626.62
238	Mangkang	3,332.43
261	Ruergaishidi	1,658.67
262	Yanboyezeshan	3,374.43
263	Riganqiaoshidi	1,260.92
264	Manzetangshidi	4,096.36
265	Wujiao	291.09
266	Nianlong	590.36
267	Xiaohogou	275.20
268	Dugoula	1,233.52
269	Baiyang	737.14
270	Piankou	130.95

Map No.	Protected Area	Coverage (km ²)
272	Minjiangbai	714.26
273	Baodinggou	274.57
274	Dasongdu	149.91
275	Qianfoshan	692.57
276	Jiudingshan	645.04
277	Zhuchanggou	502.81
278	Yuke	1,143.88
279	Ribaxueshan	141.10
280	Baishuihe	331.11
281	WenchuanCaopo	499.71
282	Mosika	292.80
283	A'rengou	87.66
284	Siguliangshan	195.17
285	Youyi	638.87
286	Taizhangou	133.92
287	Heishuihe	414.19
288	Xionglongxi	1,582.39
289	Zhagashenshan	493.28
290	Jintangkongyu	231.58
292	Haizishan	2,990.05
293	Gonggashan (Sichuan)	3,663.64
294	Gexigou	16.31
295	Genieshenshan	533.88
297	Zhubalong	50.28
298	Gemu	171.58
299	Wahuishan	586.61
300	Hongba	358.72
308	Sanjiangyuan	287,076.14
309	Ganligahai-zecha	1,946.01
310	Huangheshouqu	3,050.60
313	Chaqinsongduo	1,459.96
314	Langcun	686.55
315	Gajinxueshan	745.77

Northeast region

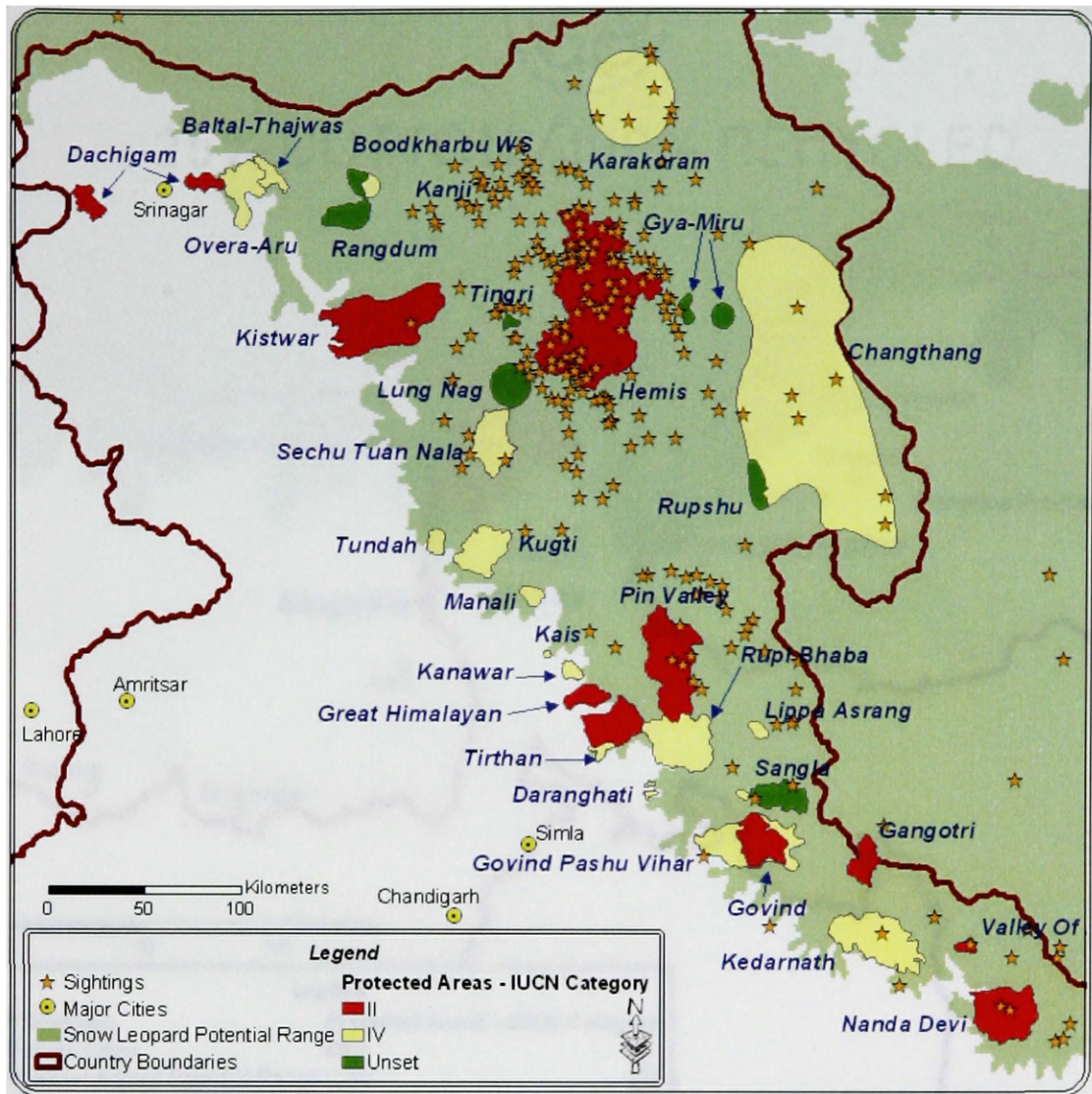


Map No.	Protected Area	Coverage (km ²)
207	Helanshanshuiyuanhanyanglin (Neimeng)	4,597.96
208	Helanshan (Ningxia)	1,060.99
209	Dongdashaan	45.93
210	Longshoushan	21.19
211	Qilianshan	3,874.73
213	Qinghaihuniao	5,584.30
215	Mengda	351.68

Map No.	Protected Area	Coverage (km ²)
216	Guozhagou	24.26
259	Liancheng	1,217.84
260	Gansulianhuashan	158.70
308	Sanjiangyuan	287,076.14
309	Ganligahai-zecha	1,946.01
Total		1,034,926.65

Appendix K: India

Western Region

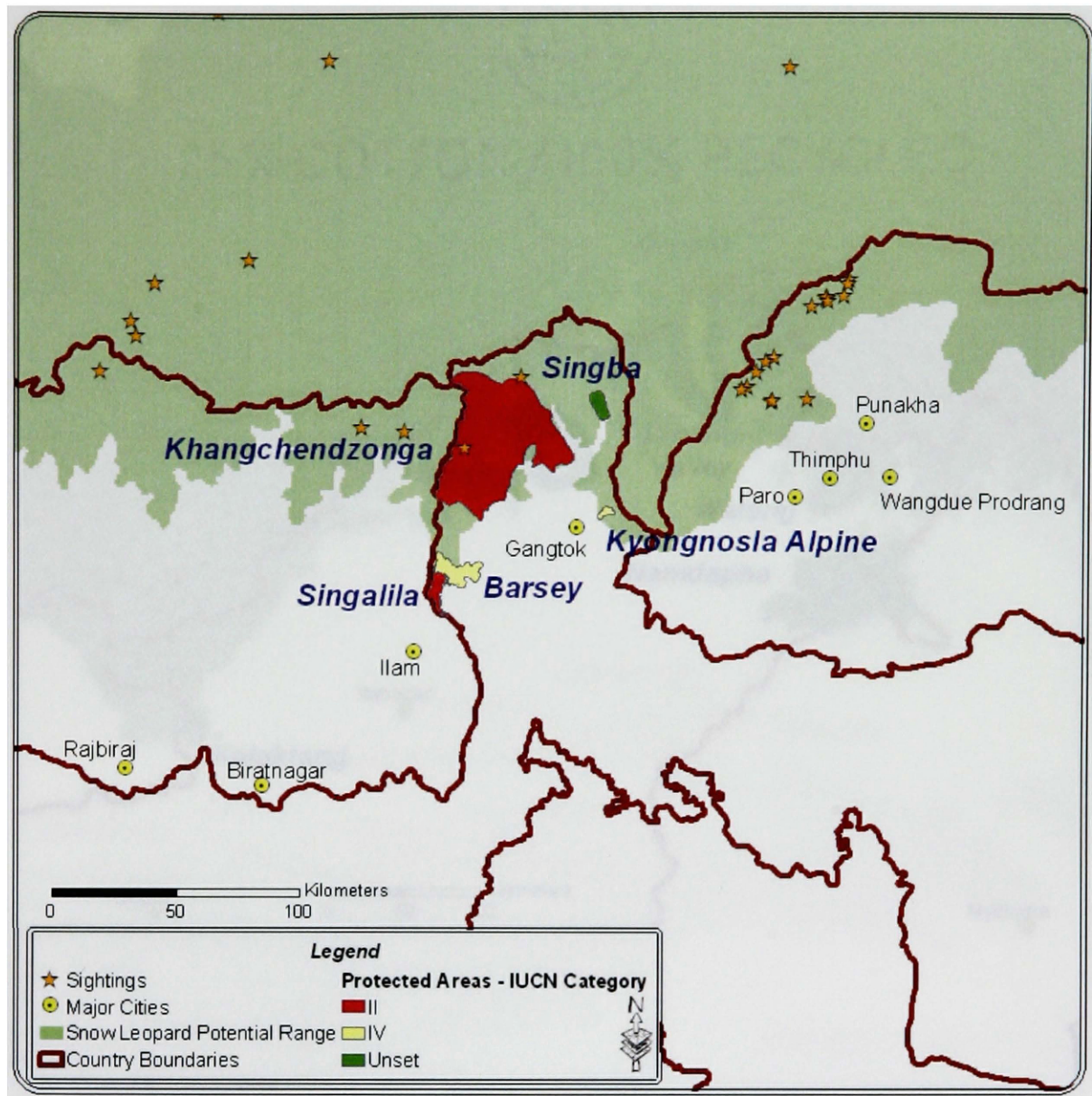


Protected Area	Coverage (km ²)
Baltal-Thajwas	141.05
Boodkharbu	98.19
Changthang	8,238.67
Dachigam	314.89
Daranghati	31.68
Gangotri	255.22
Govind	474.11
Govind Pashu Vihar	573.38
Great Himalayan	710.84
Gya-Miru	196.85
Hemis	3,306.92

Protected Area	Coverage (km ²)
Kais	11.59
Kanawar	77.14
Kanji	83.05
Karakoram	1,692.48
Kedarnath	932.20
Kistwar	1,441.09
Kugti	486.35
Lippa Asrang	60.51
Lung Nag	377.43
Manali	94.04
Nanda Devi	785.32
Overa-Aru	430.92

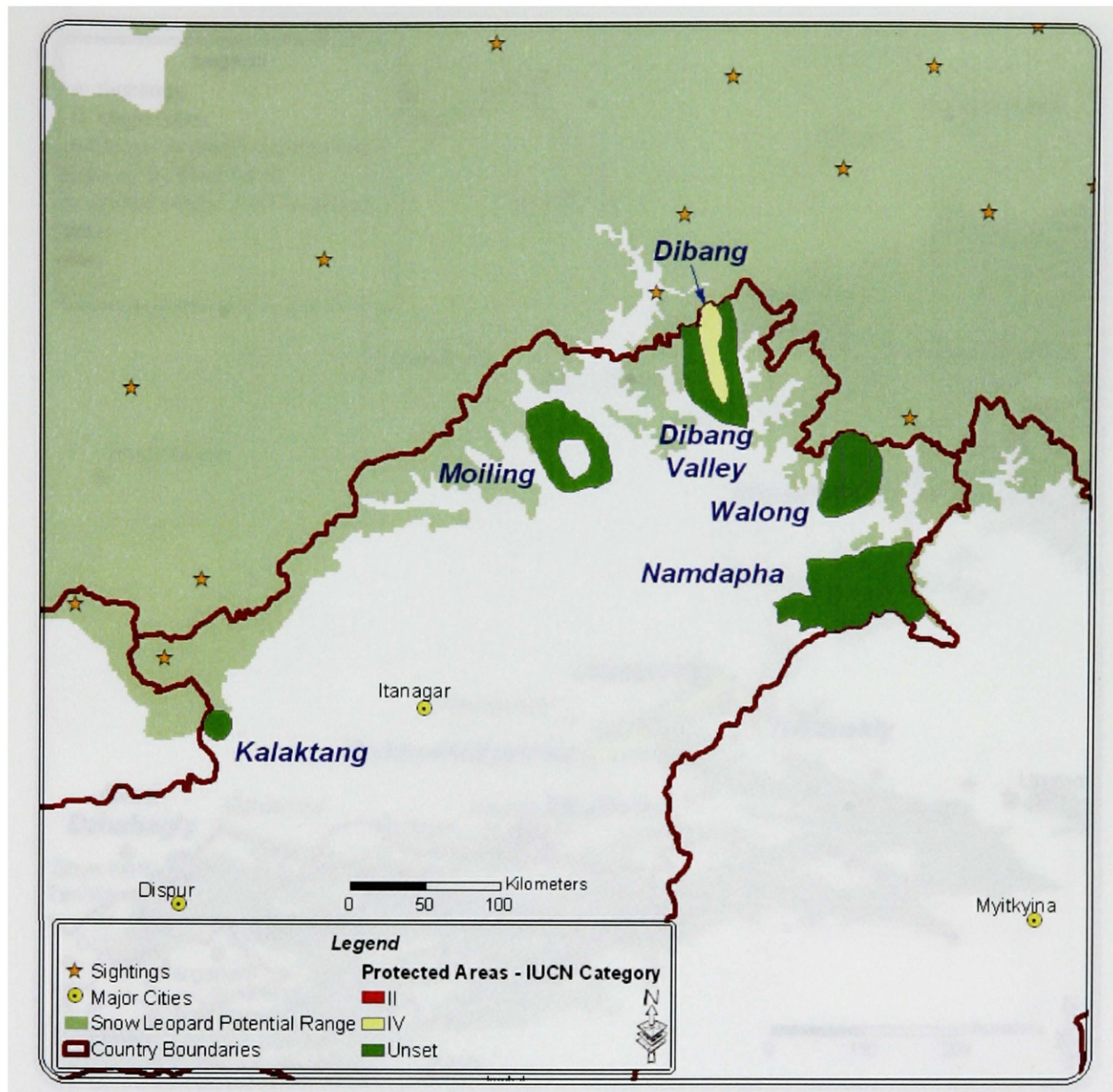
Protected Area	Coverage (km ²)
Pin Valley	1,132.50
Raksham Chitkul	28.32
Rangdum	269.63
Rupi Bhaba	819.16
Rupshu	184.38
Sangla	341.92
Sechu Tuan Nala	524.09
Tingri	44.29
Tirthan	59.02
Tundah	101.34
Valley Of Flowers	62.90
Total	24,381.49

Central Region



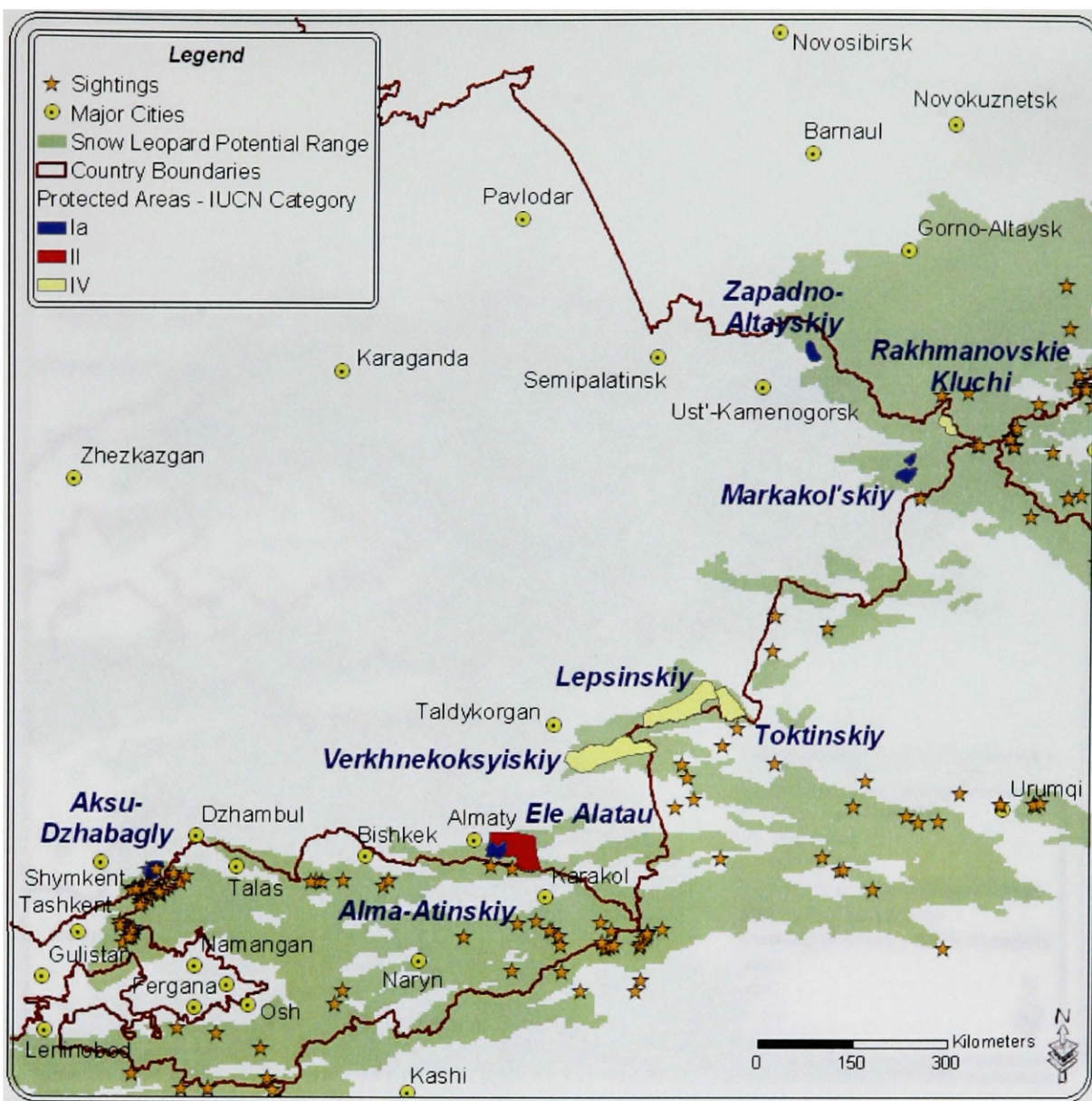
Protected Area	Coverage (km ²)
Barsey Rhododendron	135.60
Khangchendzonga	1,758.75
Kyongnosla Alpine	19.15
Singalila	76.96
Singba	56.69
Total	2,047.16

Eastern Region



Protected Area	Coverage (km ²)
Diband	745.24
Diband Valley	1,765.32
Moiling	1,931.21
Walong	674.11
Walong	1,040.48
Namdapha	3,695.99
Kalaktang	293.54
Total	10,145.87

Appendix L: Kazakhstan



Protected Area	Coverage (km ²)
Aksu-Dzhabagly	695.09
Alma-Atinskiy	674.83
Ele Alatau	2,920.10
Lepsinskiy	3,257.61
Markakol'skiy	761.59
Rakhmanovskie Kluchi	524.82
Toktinskiy	1,374.21
Verkhnekoksyiskiy	3,872.56
Zapadno-Altayskiy	496.30
Total	14,577.12

Appendix M: Kyrgyzstan



Protected Area	Coverage (km ²)
Aksuiski	43.33
Ala-Archa	122.58
Besh-Aral	1,159.84
Beshtash	126.18
Chandalash	494.04
Chatyrkul	186.76
Chychkan	138.79
Dzhardy-Kaindin	129.30
Dzhety-Oguz	268.86
Gulchin	23.70
Issyk-Kul	5,912.82
Issyk-kul Lake	5,764.28
Karakol	152.71
Kara-Shoro	31.30

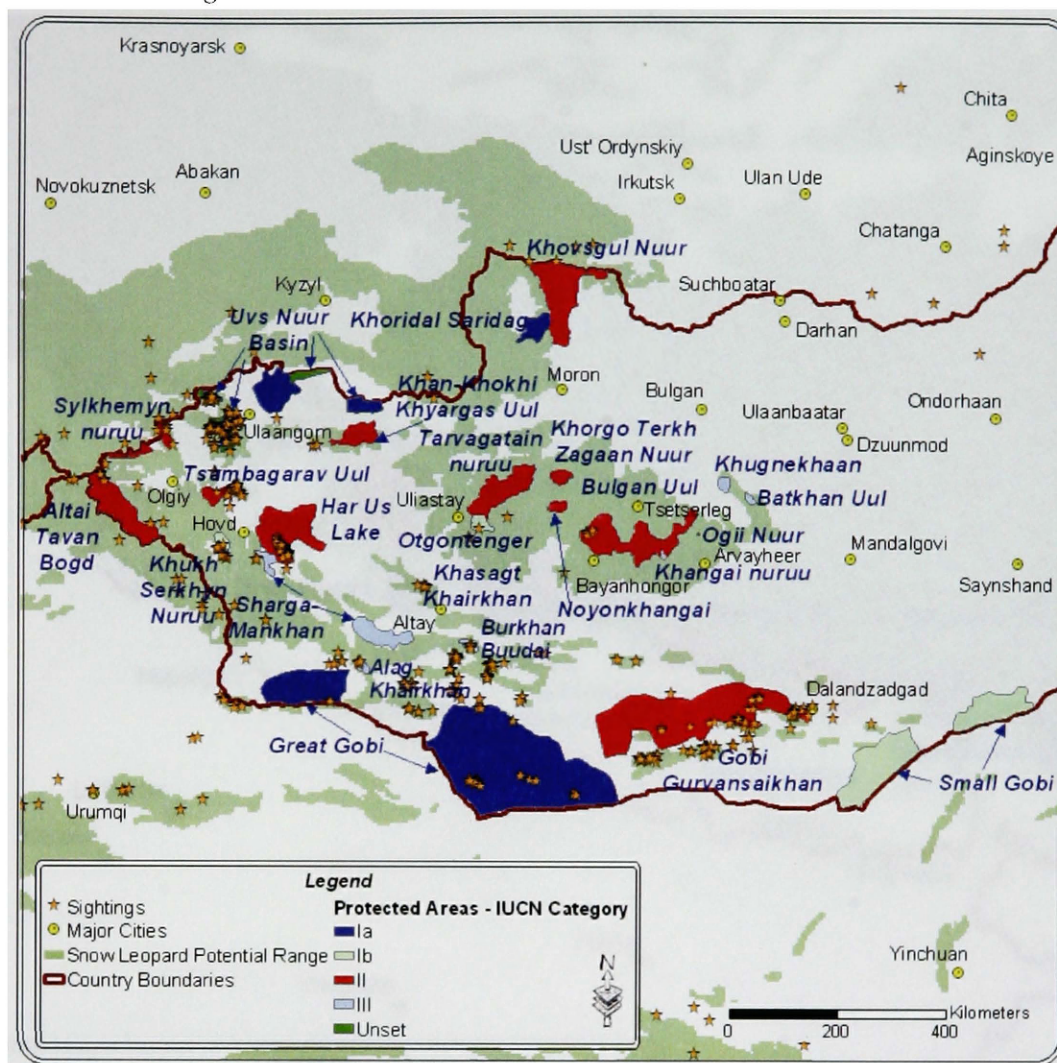
Karatal-Zhapyrk NR	45.07
Kochkor	20.03
Kyrgyz-Ata NP	119.19
Manass	407.46
Naryn	193.63
Naryn NR	275.46
Sarychat-Ertash NR	585.14
Sary-Chelekskiy	199.75
Sonkul	343.37
South Kyrgyz	49.39
Teploklyuchinski	236.79
Toguz-Torouss	284.83
Tyup	155.61
Yassin	29.15
Total	17,499.37

Appendix N: Myanmar



Protected Area	Coverage (km ²)
Ka Kabo Razi	11,630.65
Total	11,630.65

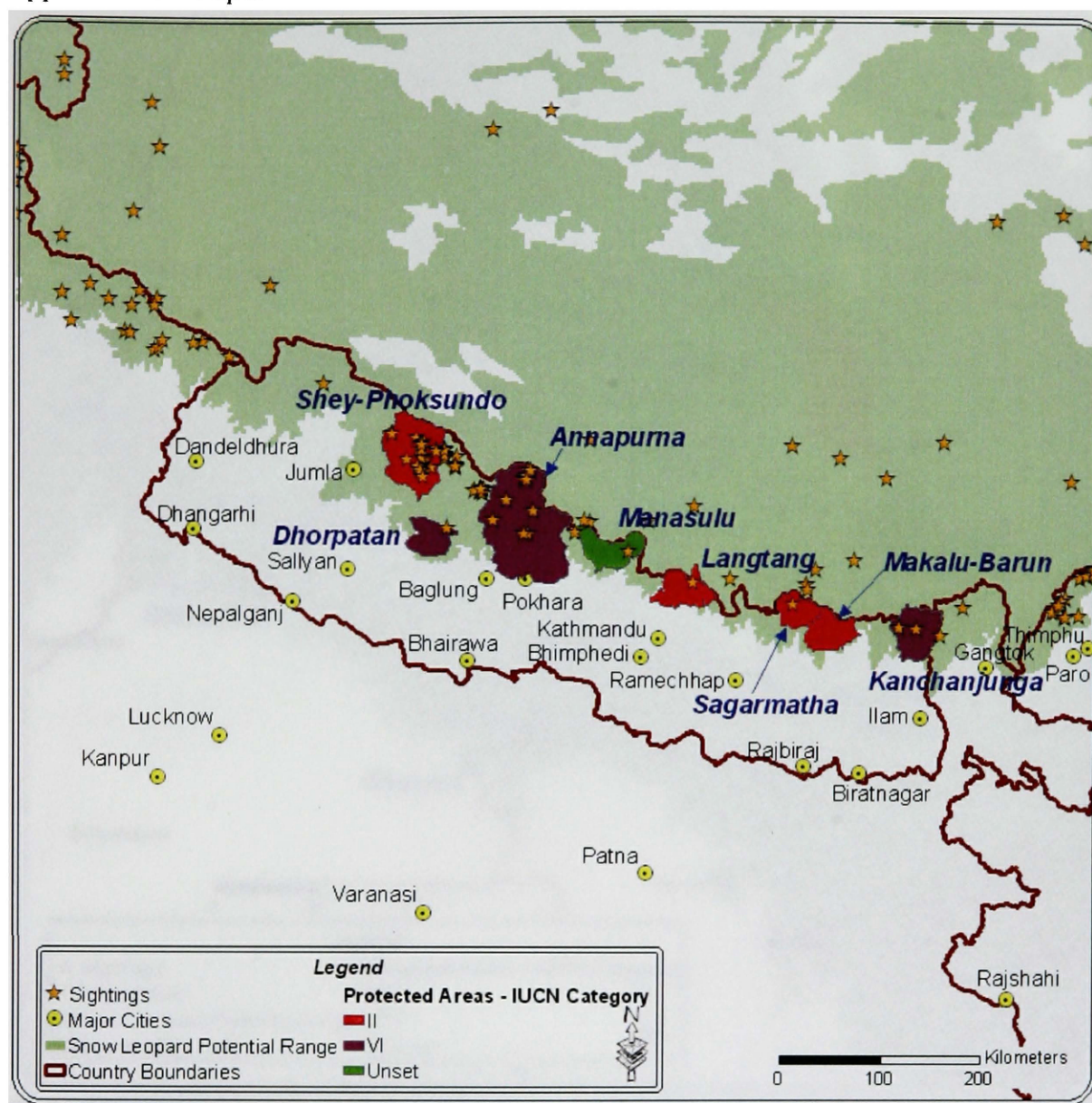
Appendix O: Mongolia



Protected Areas	Coverage (km ²)
Alag Khaikhan	393.79
Altai Tavan Bogd	6,039.99
Batkhaan	238.59
Bulgan Mountain	51.69
Burkhan Buudai	547.73
Gobi Gurvansaikhan	25,932.45
Great Gobi	50,191.97
Great Gobi National Park	50,179.08
Har Us Nuur	8,195.04
Har Us Nuur National Park	8,190.10
Khangai nuruu	8,887.86
Khan-Khokhi Khyargas Mountain	2,330.95
Khasagt Khaikhan	302.94
Khorgo Terkh Zagaan Nuur	809.25
Khoridal Saridag	1,883.09

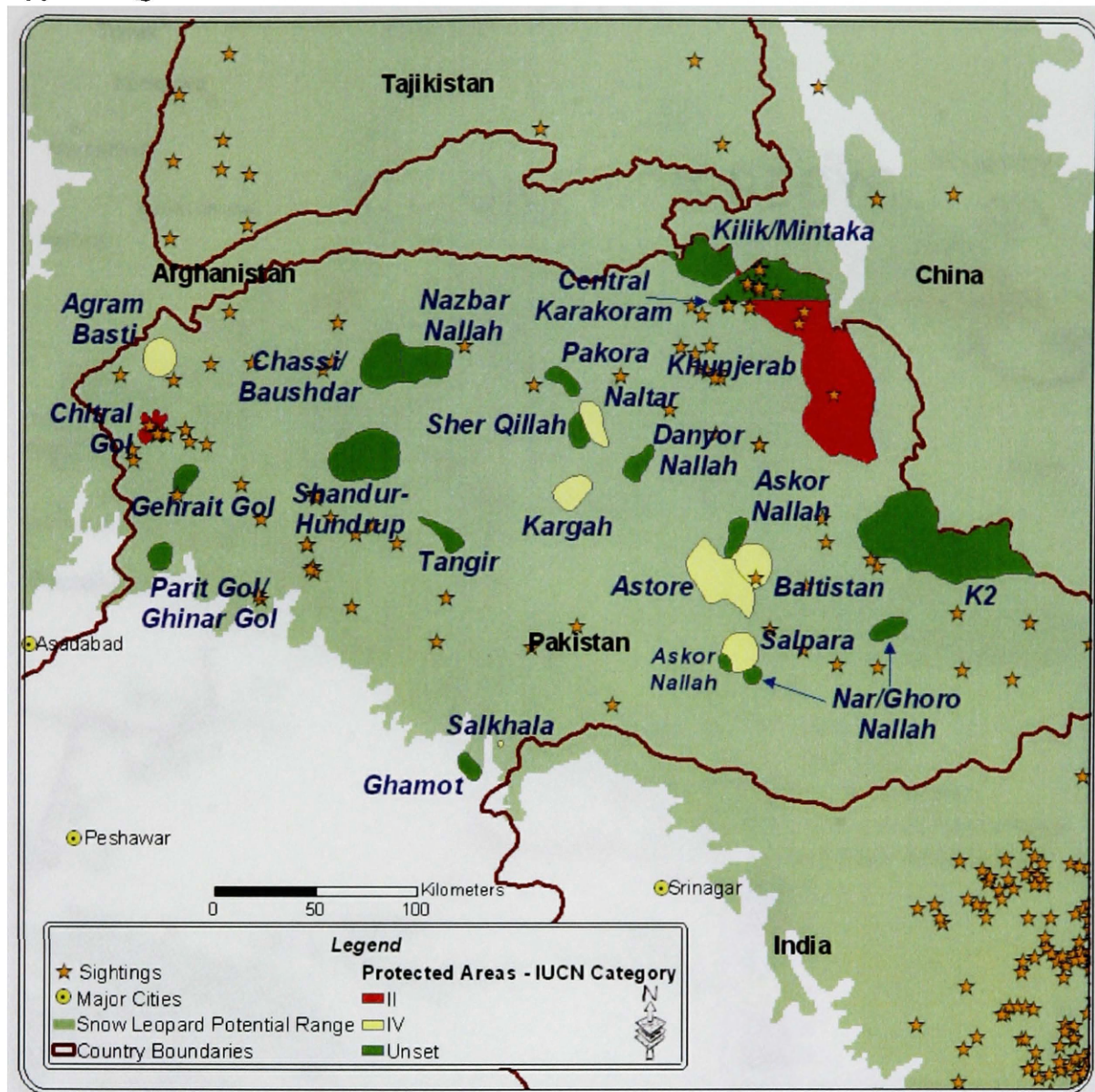
Khovsgol lake	8,384.21
Khugnekhaan	513.84
Khuisyn Naiman Lakes	125.46
Khukh Serkhyn Nuruu	760.00
Noyonkhangai	579.11
Ogii Nuur	12.77
Otgontenger	924.34
Sharga-Mankhan	3,968.84
Small Gobi	16,272.23
Sylkhemyu nuruu	1,496.59
Tarvagatain nuruu	5,267.52
Terhiyn Tsagaan Nuur	806.51
Tsambagarav mountain	1,121.05
Uvs Nuur Basin	9,091.74
Uvs Nuur Basin	7,241.58
Total	220,740.32

Appendix P: Nepal



Protected Area	Coverage (km ²)
Annapurna	7,240.58
Dhorpatan	1,282.50
Kanchanjunga	1,956.95
Langtang	1,597.31
Makalu-Barun	1,467.27
Manasulu	1,629.77
Sagarmatha	1,087.99
Shey-Phoksundo	3,527.80
Total	19,4790.18

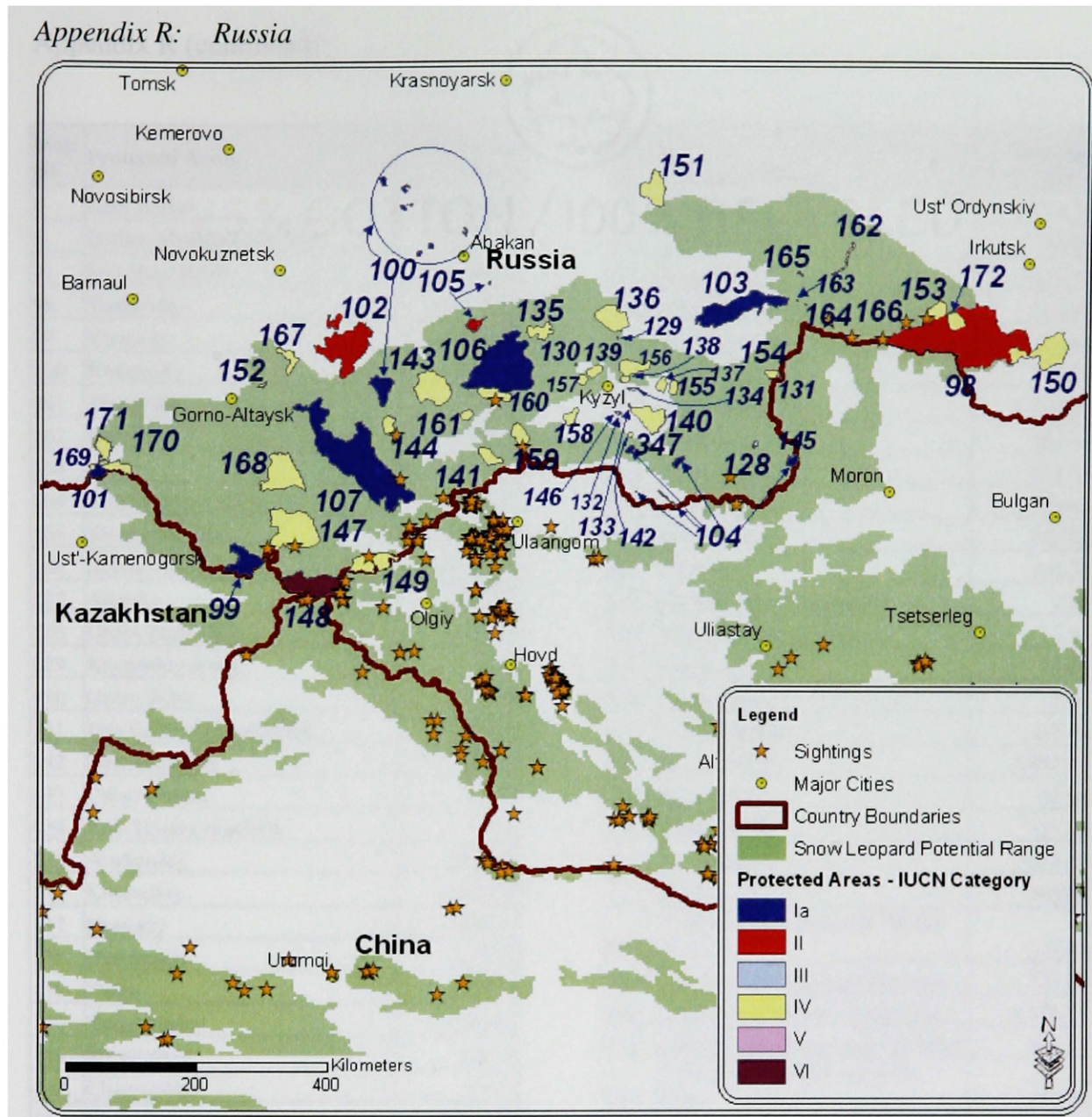
Appendix Q: Pakistan



Protected Areas	Coverage (km ²)
Agram Basti	250.96
Askor Nallah	189.75
Astore	703.10
Baltistan	311.57
Central Karakoram	791.72
Chassi/Baushdar	448.68
Chitral Gol	140.75
Danyor Nallah	148.71
Gehrait Gol	127.89
Ghamot	103.03
K2	2,194.91
Kargah	224.46

Khunjerab	3,134.66
Kilik/Mintaka	472.97
Naltar	198.78
Nar/Ghoro Nallah	215.11
Nazbar Nallah	389.26
Pakora	134.13
Parit Gol/Ghinar Gol	133.31
Salkhala	7.30
Salpara	269.28
Shandur-Hundrup	720.00
Sher Qillah	125.95
Tangir	149.56
Total	11,585.85

Appendix R: Russia

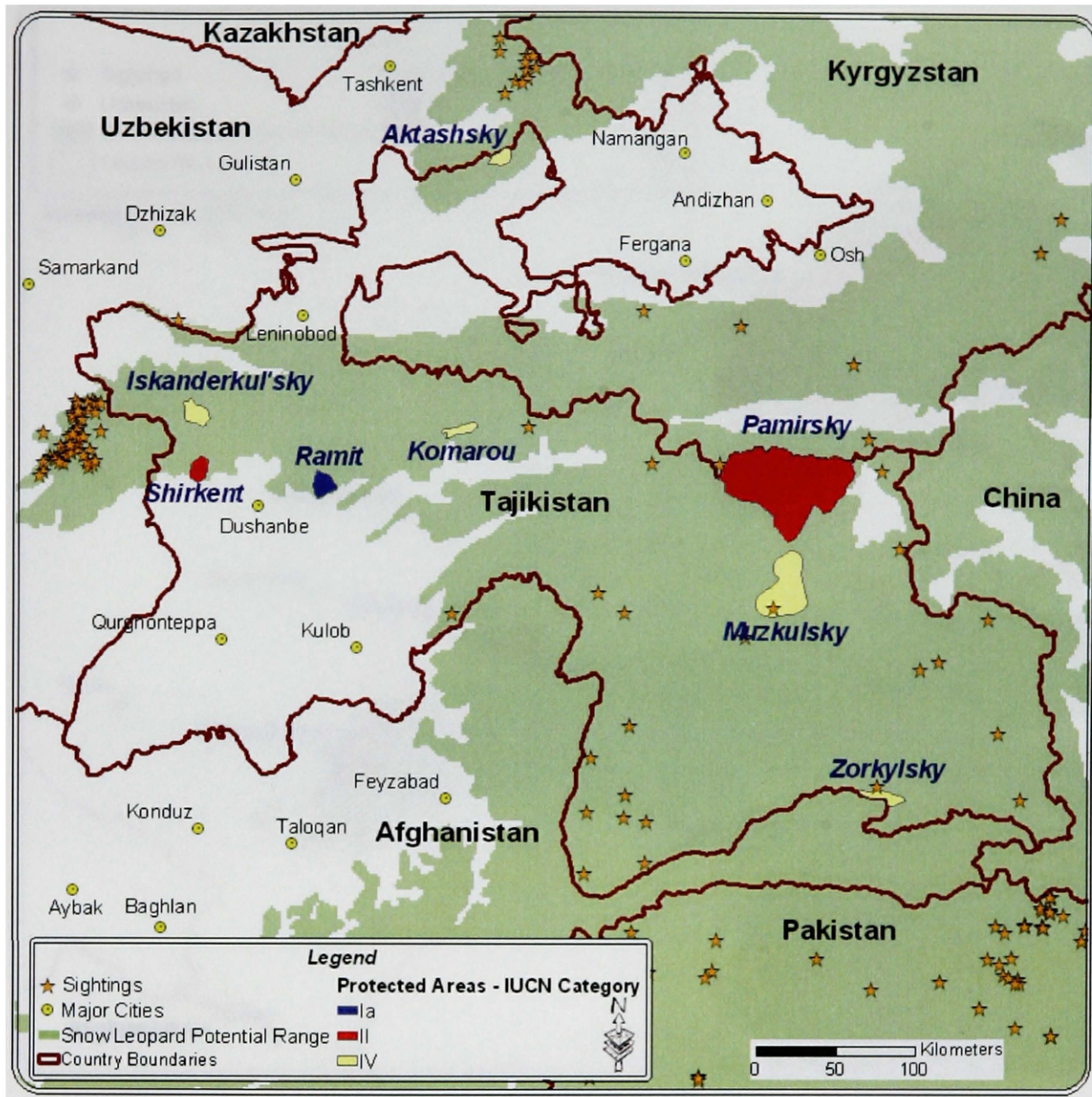


Appendix R (continued)

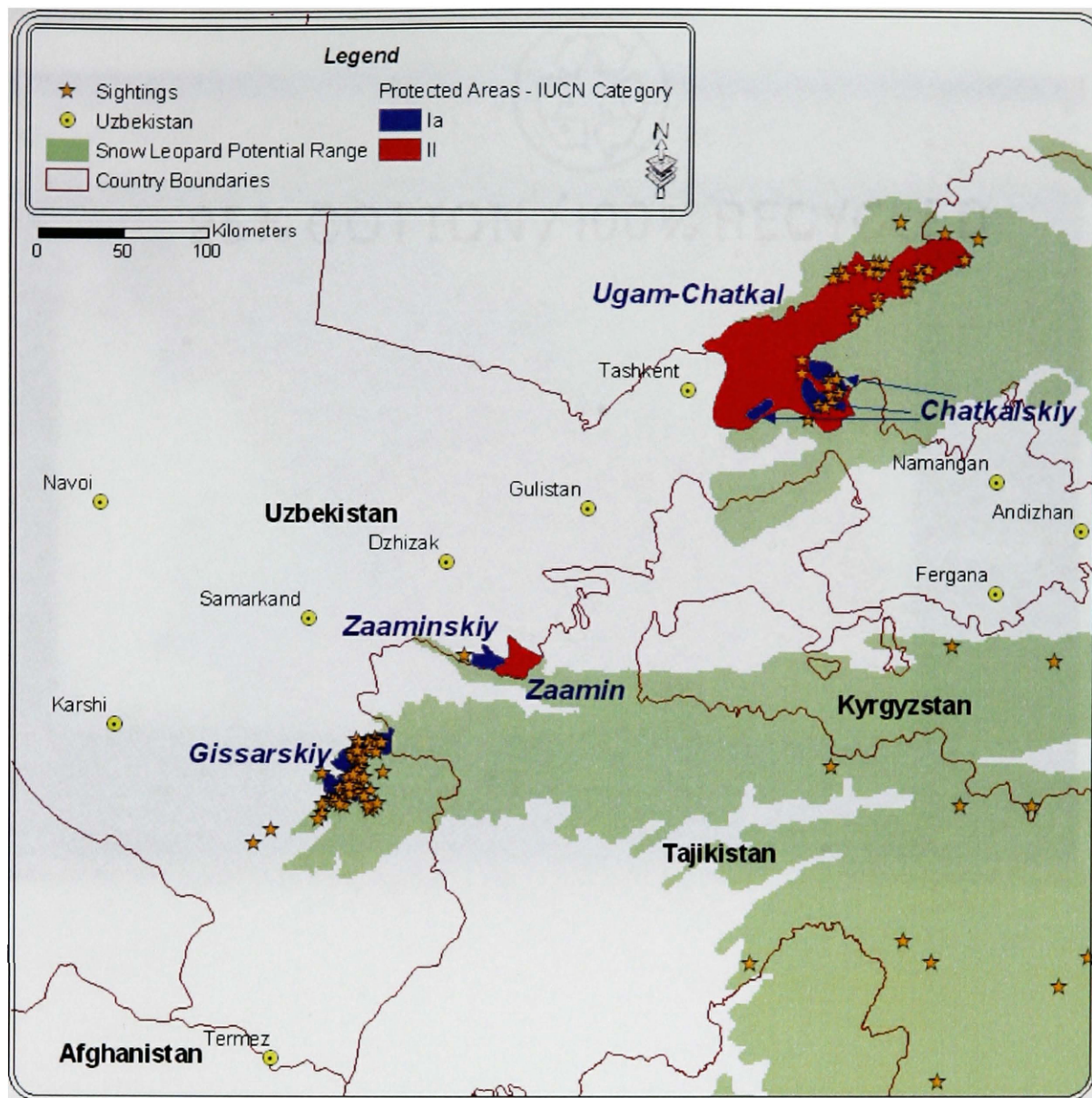
Map ID	Protected Areas	Coverage (km ²)
8	Lake Baikal	81,672.04
9	Golden Mountains of Altai	16,481.27
11	Uvs Nuur Basin	3,008.79
98	Tunkinsky	11,178.86
99	Katunsky	1,468.53
100	Khakassky	1,324.54
101	Tigireksky	426.03
102	Shorsky	3,792.94
103	Azas	3,268.32
104	Ubsunurskaya Kotlovina	582.27
105	Shushensky Bor	314.58
106	Sayano-Shushensky	6,160.54
107	Altaysky	9,187.83
128	Ozero Tere-Khol'	57.80
129	Khutinskiy porog	2.61
130	Ozero Beloe	7.50
131	Ush-Bel'dirskie istochniki	16.09
132	Ozero Khadyn	35.33
133	Ozero Cheder	11.63
134	Kok-Teiskiy istochnik	43.64
135	Aradanskiy	634.06
136	Khutinskiy	1,388.32
137	Shanskiy	280.71
138	Ondumskiy	137.58
139	Taiga	305.55
140	Balgazynskiy	1,306.82
141	Sheminskiy	556.18
142	Chagytayskiy	51.09
143	Khan-Daeer	2,096.98
144	Kara-Khol'skiy	423.23
145	Tarysskie istochniki	29.15
146	Ozero Dus-Khol'	1.24
147	Shavlinskiy	3,531.32
148	Ukok	2,453.45
149	Kosh-Agachskiy	1,432.88
150	Snezhinskiy	2,409.77

Map ID	Protected Areas	Coverage (km ²)
151	Tofolarskiy	1,311.56
152	Mikhailovskiy	54.05
153	Shumakskiy	678.87
154	Ush-Beldirskiy	216.41
155	Derzigskiy	251.83
156	Tapsinskiy	774.07
157	Aeaerbekskiy	197.33
158	Khaakskiy	362.12
159	Chaa-Khol'skiy	593.44
160	Khemchikskiy	749.46
161	Sut-Khol'skiy	226.88
162	Okinskiy	165.53
163	Ledniki pika Topografov	1.84
164	Ozero Shutkhulay-Nur	3.73
165	Ozero Khara-Nur	15.22
166	Ozero Il'chir	3.74
167	Turochakskiy	475.06
168	Sumul'tinskiy	2,471.43
169	Beloretskiy	62.84
170	Charyshskiy	521.76
171	Chinetinskiy	611.19
172	Badary	568.06
347	Ubsunurskaya kotlovina (Buffer Zone)	314.41
348	_N/A No 1 (Krasnoyarskiy kray)	721.08
349	_N/A No 3 (Krasnoyarskiy kray)	1,336.71
350	_N/A No 76 (Krasnoyarskiy kray)	839.12
351	_N/A No 165 (Krasnoyarskiy kray)	634.88
352	Aiskiy	53.60
353	_N/A No 12 (Krasnoyarskiy kray)	151.93
354	_N/A No 6 (Krasnoyarskiy kray)	97.80
355	Tigirekskiy (Buffer Zone)	269.96
356	Tigireksky	2,718.83
357	_N/A No 7 (Krasnoyarskiy kray)	205.16
	Total	173,739.38

Appendix S: Tajikistan

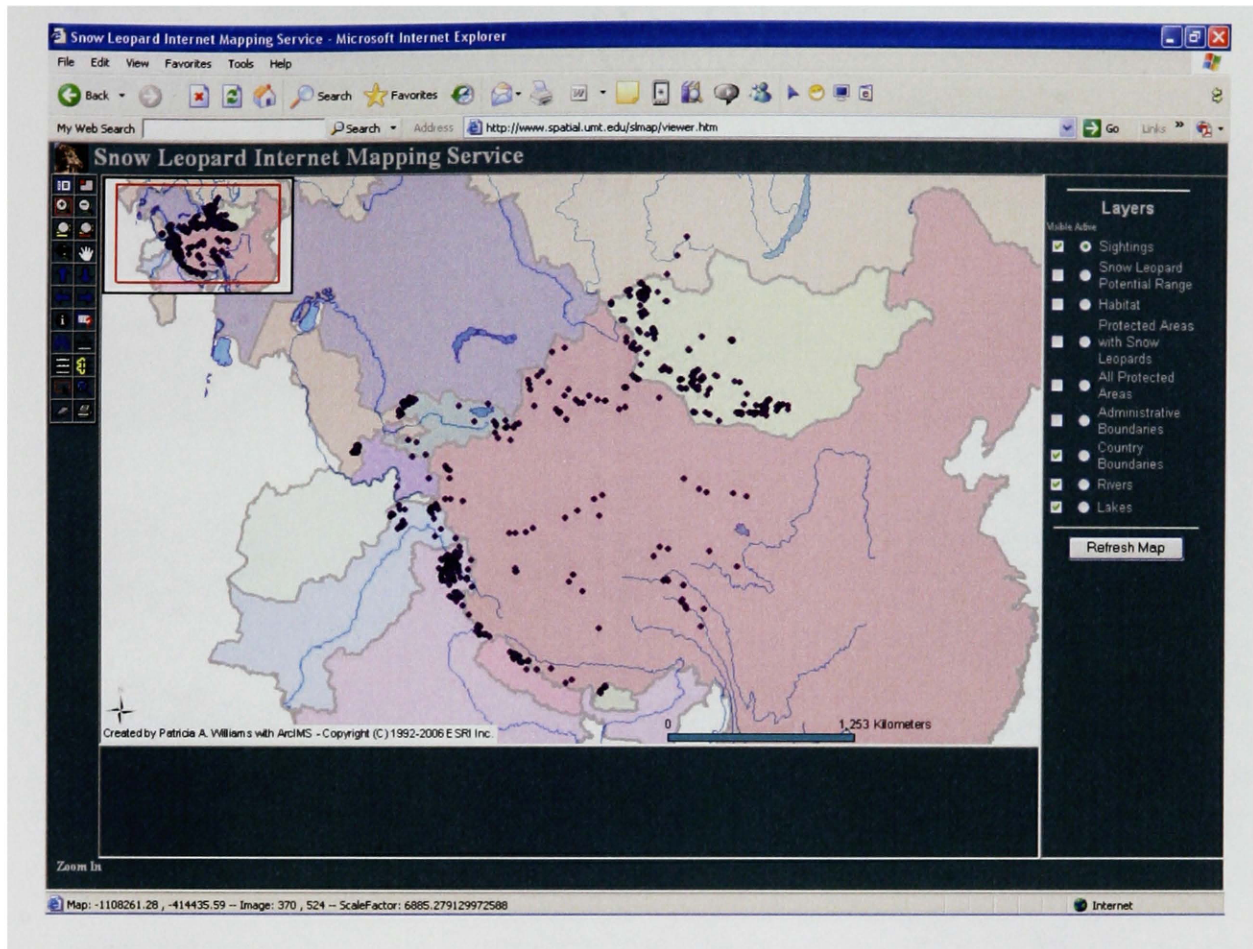


Protected Area	Coverage (km ²)
Aktashsky	101.38
Iskanderkul'sky	179.81
Komarou	106.00
Muzkulsky	850.72
Pamirsky	2,817.96
Ramit	156.44
Shirkent	136.22
Zorkylsky	134.82
Total	4,483.37

Appendix T: *Uzbekistan*

Protected Area	Coverage (km ²)
Chatkalskiy	543.75
Gissarskiy	694.04
Ugam-Chatkal	5,927.66
Zaamin	339.23
Zaaminskiy	165.02
Total	7,669.70

Appendix U: Snow Leopard Internet Mapping Services



Appendix V: Snow Leopard Network participating members list.

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