Living with Carnivores:
Human-Carnivore Conflict in Lao PDR and Amur leopard Restoration in South Korea

By

Jeong Eun (Anya) Lim

A dissertation submitted in partial fulfillment of
The requirements for the degree of

Doctor of Philosophy
(Environment and Resources)

at the

UNIVERSITY OF WISCONSIN-MADISON

2017

Date of final oral examination: 1/30/2017
The dissertation is approved by the following members of the Final Oral Committee:
Paul Robbins, Professor, Nelson Institute for Environmental Studies
Peter Steiner, Assistant Professor, Educational Psychology
Mutlu Ozdogan, Associate Professor, Forest & Wildlife Ecology
Anthony Ives, Professor, Zoology
Arlyne Johnson, Senior Program Officer, Foundation of Success

ACKNOLWEGEMENTS

The Ph.D. study has been an extraordinary life experience which provided me an opportunity to mature both intellectually and personally. In this long enduring process, my research would not have been possible without the generous support of many people in many ways. Firstly, I would like to express my deepest appreciation to my advisor, Dr. P. Robbins, for his excellent guidance, patience, and encouragement. His guidance greatly helped me to broaden my knowledge of the Ph.D. study to consider the socio-political structure of the studying society. I am hugely indebted to Dr. A. Johnson, who is my career role model and a tremendous mentor. She provided me continuous intellectual and emotional support to complete the degree and motivated me to become a conservationist backed-up by solid science and research. I am very grateful to P. Steiner for introducing me the amazing research method which I have enjoyed throughout the research and being available whenever I am stuck on analysis. I also would like to thank T. Ives and M. Ozdogan for their contribution to this study. With generous support and understanding of my advisor and committee members, I could have been staying motivated to complete the degree and overcome hard times.

I also would like to thank the Nam Et-Phou Louey National Protected Area Management Unit and Wildlife Conservation Society – Lao PDR; without their permissions and logistical support, this study would not have been possible. Many thanks to C. Phommachan and B. Soulaxay for your hard work, smiles, and hospitality in Laos; you have made my time in Laos more productive and happy. Without your help, I could not understand the local communities in the Nam Et-Phou Louey National Protected Area as much.

Thank you to Panthera Foundation, Derse Foundation and Tiger & Leopard Conservation Fund in Korea for believing in this research; without your financial support, this work would not have been possible.

Many thanks to T. Mohan and J. Miller for terrific administrative support to complete the degree. Thanks to the writing center for their years of support for improving my writing. My thanks also go to T.Y Choi and D.G. Woo for your sharing information and ideas in developing a conceptual framework for the leopard restoration in South Korea.

To my friends: V. Tripuraneni, N. Jouini, K. Dosa and Pao Vue for being an excellent editor, cheerleader, and companion throughout the long study; J.W. Kim, S.H. Kim and S.S. Shim for your friendship and encouragement during tough times. You have made my time in Madison brighter.

Lastly, thank you to my family and H.B. Park, no word can capture my love and gratitude for your support, encouragement and endless love for me; with your support and love, I could be myself and continue working for wildlife conservation.

Also, thank you to many more people who have supported my research.

Table of Contents

ACKNOLWEGEMENTS .... **i**

Table of Contents .... **iii**

LIST OF FIGURES .... **v**

LIST OF TABLES .... **vi**

LIST OF ABBREVIATIONS **1**

INTRODUCTION TO THE DISSERTATION **1**

Chapter 1 : Ethnicity, perceived risk, and attitudes of human-carnivore conflict in the Nam Et-Phou Louey National Protected Area, Laos **6**

- **1. Introduction** **7**
- **2. Materials and Methods** **9**
  - 2.1. Study area 9
  - 2.2. Data collection 11
  - Data analysis 13
- **3. Results** **15**
  - 3.1 Respondents demographics and socio-economic status 15
  - 3.2. Livestock management 18
  - 3.3. Livestock depredation by carnivores 20
  - 3.4. Attitude towards carnivores 21
- **4. Discussion and Conclusions** **24**

Chapter 2 : Exploring conservation decision-making among local herders in the Nam Et-Phou Louey National Protected Area, Lao PDR **28**

- **INTRODUCTION** **29**
- **STUDY AREA** **32**
- **METHODS** **33**
  - Design of the Experimental Vignette Study 33
  - Implementation of the Vignette Experiment 37
  - Statistical Analysis 39
- **RESULTS** **40**
- **DISCUSSION** **44**

Chapter 3 : Developing a conceptual framework for Amur Leopard restoration in South Korea **48**

- **INTRODUCTION** **49**
- **METHODS** **52**
  - Study Area 52
  - Open Standard Steps 54
- **RESULTS** **58**
  - Project vision and conservation targets 58
  - Viability assessment and goals of conservation targets 59
  - Identify and rank direct threats 62
  - Complete situation analysis 66

Prioritize Conservation Strategies ... 66
DISCUSSION ... **69**

Literature Cited ... **73**

APPENDICES ... **87**
Appendix A. A questionnaire survey ... **87**
Appendix B. A randomized block confounded factorial design of 32 vignettes ... **93**
Appendix C. Parameter estimates for the preference of grazing areas in the random-slope model ... **94**
Appendix D. Criteria for threat rankings* ... **96**
Appendix E. Criteria for strategy prioritization* ... **97**

LIST OF FIGURES

FIGURE 1.1 LOCATIONS OF SANAMS AND VILLAGES IN THE NAM ET-PHOU LOUEY NATIONAL PROTECTED AREA 11

FIGURE 1.2 SANAM CHARACTERISTICS OF THREE ETHNIC GROUPS 21

FIGURE 1.3 MOST PROBLEMATIC WILDLIFE FOR LOCAL HERDERS 22

FIGURE 2.1 STUDY AREA, SHOWING THE VILLAGES AND GRAZING AREAS IN THE NAM ET-PHOU LOUEY NATIONAL PROTECTED AREA 30

FIGURE 2.2 AN EXAMPLE OF A SKETCH VIGNETTE SET 1. VIGNETTE 1 ON THE TOP LEFT PICTURE PRESENTS A GRAZING AREA WITH POOR QUALITY OF GRASS, NEAR TO A VILLAGE, AGRICULTURAL LAND AND PREY, AND FAR FROM CARNIVORES. 36

FIGURE 3.1 A POTENTIAL LEOPARD HABITAT SOUTH EAST OF THE KOREAN DEMILITARIZED ZONE (DMZ) 54

FIGURE 3.2 A CONCEPTUAL MODEL OF THE AMUR LEOPARD RESTORATION IN SOUTH KOREA 65

LIST OF TABLES

TABLE 1.1 LIVELIHOOD ACTIVITIES AND MAIN INCOME SOURCES OF LOCAL HERDERS IN THE NEPL NPA.17

TABLE 1.2 SANAM CHARACTERISTICS OF THREE ETHNIC GROUPS 19

TABLE 1.3 PARAMETER ESTIMATES FOR ATTITUDE MODELS OF TIGERS AND DHOLES 24

TABLE 2.1 VIGNETTE FACTORS AND FACTOR LEVELS USED IN THE VIGNETTE EXPERIMENT........ 34

TABLE 2.2 PARAMETER ESTIMATES FOR THE PREFERENCE OF GRAZING AREAS IN THE RANDOM-SLOPE MODEL........ 43

TABLE 3.1 VIABILITY ASSESSMENT OF THREE CONSERVATION TARGETS 61

TABLE 3.2 THREAT RATING FOR CONSERVATION TARGETS........ 64

TABLE 3.3 PRIORITIZATION OF STRATEGIES........ 68

LIST OF ABBREVIATIONS

AIC	Akaike Information Criterion
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
CCZ	Civilian Control Zone
CMP	Conservation Measures Partnership
CUZ	Controlled Use Zone
DMZ	Demilitarized Zone
FOS	Foundation of Success
GoL	Government of Laos
GPS	Global Positioning System
IUCN	International Union for Conservation of Nature and Natural Resources
SSC	Species Survival Commission
KEA	Key Ecological Attribute
NEPL	Nam Et-Phou Louey
NPA	National Protected Area
NTFP	Non-Timber Forestry Product
OS	Open Standards for the Practice of Conservation
TPZ	Totally Protected Zone
VIF	Variance Inflation Factor
WCS	Wildlife Conservation Society

INTRODUCTION TO THE DISSERTATION

Across the globe, large carnivores are widely considered charismatic and naturally attain a lot of people's attention. In many cases, they are a symbol of various entities, including countries, sports teams, and universities. For example, national animals are tigers in Bangladesh, India, Malaysia and Vietnam; snow leopards in Afghanistan; gray wolves in Turkey; and jaguars in Guyana (Worldatlas 2015). Carnivores not only are culturally important but also ecologically play a significant role. As an umbrella species and apex consumer, they regulate ecosystems and promote biodiversity (Prugh et al. 2009; Camargo-Gamboa et al. 2010; Estes et al. 2011; Ritchie et al. 2012). Tropic cascade in the Yellow stone National Park following the wolf reintroduction demonstrates an excellent example of the critical ecological function of a large carnivore. Returning wolves improved both terrestrial and riparian ecosystems and species relying on those ecosystems which suffered from overgrazing by elks (Ripple et al. 2001; Ripple & Beschta 2003, 2012).

Given their endangered status along with the cultural and ecological importance, carnivore conservation and management are one of the major conservation concerns (Weber & Rabinowitz 1996; Linnell et al. 2001; Camargo-Gamboa et al. 2010; Ritchie et al. 2012). However, populations of large carnivores have plummeted in the past two centuries, and the majority of remaining populations are still being threatened (Weber & Rabinowitz 1996; Morrison et al. 2007; Walston et al. 2010; IUCN 2014). The main reasons for the population plunge are habitat loss and fragmentation as well as overhunting of carnivores and their prey due to the demand for Chinese medicine and food and conflict between people and carnivores (Woodroffe 2000; Check 2006; Dinerstein et al. 2007;

Chapron et al. 2008; Harihar et al. 2009; Walston et al. 2010; Wikramanayake et al. 2011; Barber-Meyer et al. 2013; Mohsanin et al. 2013; Rosenblatt et al. 2014). Particularly, the conflict between human and carnivores exacerbates the decline of carnivore populations. The conflict, often due to competition between human and carnivores over the land and prey, negatively affects people's livelihood and safety and in turn promotes retaliatory killing or persecution of the carnivores (Macdonald & Sillero-zubiri 2002; Treves & Karanth 2003; Thirgood et al. 2005; Goodrich 2010). Especially, the larger body-sized carnivores, the higher the chance of conflict with humans and the harder to escape from the risk of extirpation (Ripple et al. 2014).

To secure viable populations of endangered carnivores, conservationists either protect the existing populations in current ranges or more increasingly are trans-locating populations to the current or indigenous ranges (Bangs & Fritts 1996; Bottrill et al. 2006; Forder 2006; Hayward et al. 2007; Miller et al. 2011; Johnson et al. 2012). However, large carnivore conservation is tremendously complicated and challenging in a human-dominated landscape, and by far failures outnumber successes (Weber & Rabinowitz 1996; Breitenmoser et al. 2001; Dickman 2010; Fontúrbel & Simonetti 2011; Barua et al. 2013). Still, without acceptance and support from the people living with them, long-term survival of large carnivores is not feasible. Therefore, finding "coexistence recipes," which involves prevention and mitigation of human-carnivore conflict, is inevitable in carnivore conservation (Miquelle et al. 2005; Hemson et al. 2009; Goodrich 2010; Zimmermann et al. 2010; Rigg et al. 2011). To improve the efficiency and effectiveness, the coexistence recipes need a systematic approach. Developing coexistence solutions requires the understanding of socio-cultural, political and ecological factors underlying human-carnivore entanglement.

Therefore, in this dissertation, I demonstrate two case studies to facilitate the coexistence between local people and carnivores. One case study was investigating current on-going human-carnivore conflict in local people's perspective in the Nam Et-Phou Louey National Protected Area (NEPL NPA) in Lao PDR to search for conflict mitigation strategies. The other case study was planning for the potential leopard restoration in South Korea to prevent the potential conflict between people and the restored carnivores and thus to increase the success of the coexistence. Through these case studies, this dissertation aimed to: 1) assess the local people's perceived risk and attitudes toward tigers and dholes as well as associated drivers affecting the attitudes in the NEPL NPA; 2) examine the factors that influence the selection of grazing areas where human-carnivore conflict usually occurs in the NEPL NPA, and 3) develop a conceptual framework for Amur leopard restoration in South Korea.

Chapter 1, "Ethnicity, perceived risk and attitudes of human-carnivore conflict in the Nam Et-Phou Louey National Protected Area, Laos," investigates local herders' perceived risk of livestock depredation by tigers and dholes, their attitudes toward these carnivores, and demographic and socio-economic factors influencing the attitudes. I further compare the perceived risk and attitudes among three ethnic groups in the NEPL NPA. I interviewed 203 herders whose grazing areas were in and around the Totally Protected Zone of the NEPL NPA. My finding confirms the difference in the perceived risk and attitudes toward dholes, but not tigers, among three ethnic groups. The study also demonstrates that the attitudes toward tigers and dholes are largely shaped by the previous experience of livestock loss by the target species, which comes from different livestock management system and main livelihoods. My hope is that this study can inform conservationists seeking to develop human-carnivore conflict mitigation strategies where local participation is weak.

Chapter 2, "Exploring conservation decision-making among local herders in the Nam Et-Phou Louey National Protected Area, Lao PDR," exemplifies a vignette experiment with respect to human-tiger conflict in the NEPL NPA. A pictorial vignette experiment investigates the relative importance of five relevant selection factors: the grazing area's distance to carnivores, prey, agricultural land, and a village, and the quality of grass to understand factors that influence local people's selection of grazing areas. The good quality of grass and distance to carnivores were the most important factors for herder's decision-making. The results from the vignette experiment help to design effective protected area management strategies for reducing human-tiger conflict that also consider local herders' concerns. This research also confirms the utility and potential application of a vignette experiments in wildlife conservation research, especially when dealing with sensitive topics.

Chapter 3, "Developing a conceptual framework for Amur Leopard restoration in South Korea," demonstrates step-by-step procedures of planning for Amur leopard restoration in South Korea by using the Open Standards for Practice of Conservation. Starting with defining the geographical scope and conservation targets of the project, I assessed the viability of the conservation targets, identified and ranked direct threats to conservation targets, and prioritized strategies to maximized the effectiveness of the restoration. The framework not only examined the current status of the target, which implicates the feasibility of the restoration but also, uncovered research gaps that need to be addressed. Through this case study, I hope to introduce a systematic conservation planning tool that can consider complex ecological, political and socio-economic situations for conservationists and policy makers and facilitate communication among stakeholders.

These three chapters each contribute to our understanding of human-carnivore entanglement, and provide possible solutions to reduce or prevent the conflict in various situations, in the NEPL NPA in northern Laos where the conflict is present and human population density is relatively low and in South Korea where the conflict is expected and people are highly populated. Furthermore, I hope this research helps provide the framework for policies and conservation projects that promote the coexistence between people and carnivores worldwide.

Chapter 1 : Ethnicity, perceived risk, and attitudes of human-carnivore conflict in the Nam Et-Phou Louey National Protected Area, Laos

1. Introduction

Conflict between humans and carnivores is prevalent worldwide where both species co-occur: lions in Africa, lynxes in Europe, wolves in North America, and tigers in Asia (Ruid et al. 2009; Liberg et al. 2011; Rigg et al. 2011; Ahmed et al. 2012; Pettigrew et al. 2012; Dickman et al. 2014). Livestock depredation is the most frequent form of the conflict. In general, livestock loss is not only debilitating to rural livelihood, but also prompts retaliatory killing or persecution of carnivores (Treves & Karanth 2003; Quigley & Herrero 2005; Thirgood et al. 2005; Johnson et al. 2006; Goodrich 2010; Inskip et al. 2013). Moreover, such conflict can result in negative attitudes towards the carnivores that eventually lead to little or no support for carnivore conservation among the local people. Therefore, to ensure the long-term survival of carnivores in a human-dominated landscape, human-carnivore conflict should be promptly and appropriately resolved.

It is, however, not simple to develop effective conflict mitigation strategies. This requires careful understanding of the complexities of the conflict, because local people's responses to the conflict will differ based on personal experiences as well as socio-economic, cultural, and political factors (Kleiven et al. 2004; Dickman 2010; Lescureux & Linnell 2010; Thorn et al. 2012; Inskip et al. 2013; Dickman et al. 2014). Interventions that do not consider these factors will likely be only a temporary remedy that treats the symptoms, not the causes of human-carnivore conflict and, therefore, are less sustainable and less likely to be locally acceptable. Despite the importance of understanding the complexities of the conflict, studies that attend to underlying factors are still lacking in many regions, including Nam Et-Phou Louey National Protected Area (NEPL NPA) in northern Laos.

The NEPL NPA has a long history of human-carnivore conflict. Local herders in the NEPL NPA have occasionally lost livestock to carnivores including tigers (*Panthera tigris*) and dholes (*Cuon alpinus*) (Johnson et al. 2006; Kamler et al. 2012). Although the frequency of large livestock loss in the area is not high (2.1 livestock per village per year), even a single large livestock loss (about $ 600 per cattle, $850 per buffalo in 2012) poses a burden on the local livelihood in the NEPL NPA, which is one of the poorest regions in Laos with less than $1,408 GDP per capita (World Bank 2015). At the same time, tigers in the region are on the brink of extinction due to continuous poaching, primarily for illegal wildlife trade and, to a lesser degree, in retaliation for livestock loss (Johnson et al. 2006). The three indigenous ethnic groups in this region include *Lao Loum* (Lowlander; Tai-Kadai speaking family including Tai Lao, Tai Dam, and Tai Deng), *Lao Theung* (Midlander; Mon-Khmer speaking family including Khmu and Lao Khaa), and *Lao Sung* (Highlander; Tibeto-Burman speaking family including Hmong and Mien) based on their traditional residence schemes —all of whom have unique culture and livelihood practices. While there is no ethnic majority, *Lao Loum* are numerically and socially dominant (Ireson & Ireson 1991). Among these groups, the *Lao Sung,* more specifically *Hmong,* are the most frequently labeled as tiger poachers by other ethnic groups and conservation organizations in this region (Schlemmer 2001; Satoshi 2004). Despite these anecdotes, it is still unclear whether *Lao Sung* have more negative attitudes towards carnivores than other ethnic groups in the NEPL NPA. In the early 2000s, the NEPL NPA Management Unit and the Wildlife Conservation Society (WCS) tried to systematically monitor the conflict and investigated the feasibility of a livestock insurance program to respond to human-tiger conflict. However, both attempts were not completed due to the lack of human and financial resources to continue the monitoring, and a lack of interest and understanding among local people in the insurance scheme (Johnson et al. 2006). In addition to tigers, dholes, also listed as endangered by the International Union for Conservation of Nature (IUCN), are in conflict with local herders; however, information about human-dholes interactions is sorely lacking (Kamler et al. 2012; IUCN 2014). Moreover, there remains a lack of information about how local herders perceive these carnivores and what factors influence their attitudes, which are fundamental components of understanding the conflict.

Given these conditions, our research aimed to understand the complexities of human-carnivore conflict in the NEPL NPA. To understand the complexities of the conflict, we measured local herders' attitudes towards major carnivores – tigers and dholes – and assessed local herders' perceived risk of these carnivores and associated factors influencing their attitudes. Based on this understanding, our research will not only help to identify effective conflict mitigation strategies that are relevant for each ethnic group in the NEPL NPA, but also provide a guide to approaching human-carnivore conflict in other places where such conflicts negatively affect both carnivore conservation and local livelihood.

2. Materials and Methods

2.1. Study area

The Nam Et-Phou Louey National Protected Area (NEPL NPA) is well-known for its exceptional biodiversity, especially diverse carnivore species including tigers, dholes, leopards (*Panthera pardus*), Asian golden cats (*Pardofelis temminckii*) and clouded leopards (*Neofelis nebulosa*) (Duckworth et al. 1999; Johnson et al. 2006, 2009), although recent research indicates a decline in the tiger population (Johnson et al. 2016). Mostly composed of mixed evergreen-deciduous forest, the NEPL NPA is divided into two zones: a 3,206km^2 Totally Protected Zone (TPZ) where access and extraction of natural resources are strictly forbidden, and an 1862km^2 Controlled Use Zone (CUZ) where subsistent hunting and gathering are allowed (Johnson et al. 2016). The NEPL NPA traverses three provinces and nine districts (Figure 1.1). Our study focused on Viengthong district (divided into Xone and Hiem districts in 2014), which covers 67% of the TPZ and had the highest number of livestock depredation reported. Among the total of 34 villages within the boundary of the NEPL NPA, 24 villages are located in Viengthong district, of which three are inside of the TPZ. Each village is composed of a single ethnic group. In addition to those official villages, there are unofficial settlements for raising livestock, called a “sanam” in the local language. Sanams are typically located within grazing areas which have no definite boundaries marked in the forest. Settlements in those sanams are mostly temporary and small (one or two hut-like structures), but they can be permanent and large. For instance, one sanam in our study has over twenty permanent settlements inside the TPZ. Permission to use sanams in this region are generally granted by district agricultural office (even the ones in the TPZ), although some of them are contrary to the NEPL NPA regulations developed by the district government in accordance with the Forestry Law (GoL 2007, 2008). Sanam users may come from either the same village or different villages.

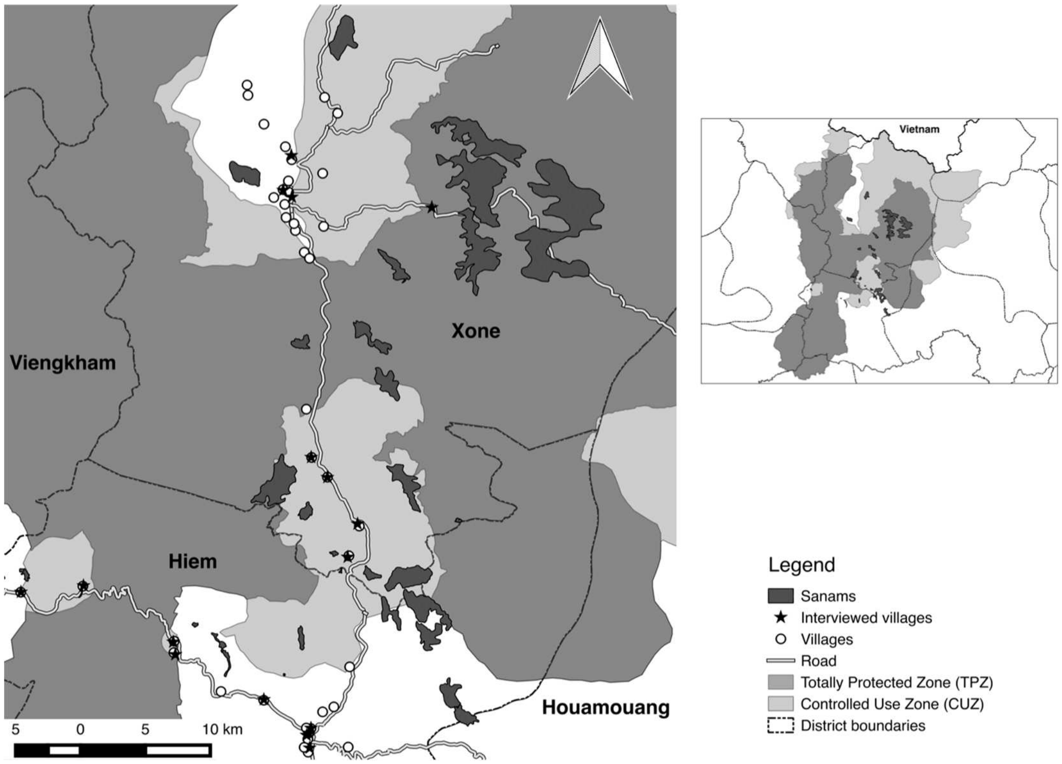

Figure 1.1 Locations of sanams and villages in the Nam Et-Phou Louey National Protected Area

2.2. Data collection

To assess local herders' attitudes of carnivores as well as associated drivers of human-carnivore conflict in the NEPL NPA, we used a face-to-face interview with a structured questionnaire due to high adult illiteracy (43%) in this region (Gebbie et al. 2008). The target population was livestock breeding families who raise large livestock, such as cattle and buffalos, in and around the NPA's TPZ. We only focused on large livestock herders because they are the primary users of sanams where livestock depredation commonly takes place and are therefore the main stakeholders of human-carnivore conflict in the NEPL NPA. Among family members, we restricted a respondent to an adult over 18 years old who is actually engaged in large livestock management. After the pilot survey with eight local herders in the NEPL NPA to ensure the clarity of the survey questions, two trained Lao research assistants from National University of Laos conducted the survey in Lao language between May and August 2012. These two research assistants interviewed 203 herders from 16 villages in Viengthong district. As different sanams in the NPA have an uneven risk of carnivore attack on livestock, we used stratified sampling with sanams as a subpopulation unit to fairly represent local herders across different sanams in the NPA. Then, we interviewed at least eight herders per sanam. In 15 cases fewer than eight users in a sanam were available, and we interviewed all available ones. The interviews covered 35 sanams, including all eight currently used sanams inside the TPZ (Figure 1.1).

Our survey obtained information about 1) the demographic and socio-economic status of respondents including affluence and livelihood activities; 2) the livestock management system such as characteristics of sanams and seasonal change of grazing practice; 3) interactions with wildlife especially focusing on livestock predation by carnivores; and 4) attitudes towards tigers and dholes (See Appendix A for the full questionnaire). We particularly targeted dholes and tigers because these two carnivores are responsible for large livestock depredation (Johnson et al. 2006). Compared with dholes, tigers are a very sensitive topic in our study area due to the strict law enforcement about poaching and illegal trade. Due to the sensitivity, we expected respondents to be less forthright with their answers about tigers for fear of being politically incorrect. Therefore, we asked more questions on tigers (6 questions) than dholes (2 questions) to assess local herders' attitudes. In this way, we improved the validity of the answers about attitudes towards tigers. Unlike other socio-economic information, we acquired information on the ethnicity of each village from the Viengthong district agricultural office to avoid possibly politically sensitive questions to local people (Viengthong District Agricultural Office 2011).

We did not ask about education level because most of our target population did not receive any education. To estimate the wealth, we asked herders ownership of 17 fixed assets including dwelling construction instead of asking them the annual income.

In addition to the interviews, we collected Global Positioning System (GPS) coordinates of each village and sanam using a Garmin GPS Map 62s handheld GPS and CuuB Location Plus A1 GPS. Because sanams had no defined boundaries, we recorded the locations where congregated cows and buffalos were observed.

Data analysis

We recorded all interview responses in a spreadsheet. We used dummy coding for categorical responses such as presence/absence of livestock loss and livelihood activities, and used continuous numbers for numerical responses such as age and number of livestock owned. To estimate the wealth, we converted fixed assets owned by respondents to monetary value (dollars) based on average market value of the products. We calculated attitude scores based on six questions for tigers and two questions for dholes, which were coded 1 (positive), 0 (neutral) or -1 (negative), and then combined. Therefore, the possible attitude scores ranged between -6 and 6 for tigers and -2 and 2 for dholes. To obtain the spatial attributes of sanams, we measured the distance between villages and sanams using ArcGIS 10.2. We estimated the size of sanams using GPS tracks collected from the field as well as satellite images from Google Earth version 7.1.2.2041 because sanams did not have officially defined boundaries. We layered collected GPS tracks and points on Google Earth, and estimated boundaries of sanams by reviewing terrain.

We analyzed the interview and spatial data using R version 3.1.1 (R Core Team 2014). To assess differences among ethic groups, we used Chi-square tests, Fisher's exact tests, Kruskal-Wallis tests, and one-way Analysis of Variance (ANOVA) depending on data types, with a significance level of $p<0.05$. To assess factors affecting local herders' attitudes towards tigers and dholes, we used multilevel regression with two levels because respondents were nested in sanams due to our survey design using a stratified sampling. The level-one unit was respondents, and the level-two unit was sanams.

$$Y_{ij} = \beta_{0j} + X_{ij}\beta_{1j} + r_{ij} \text{ with}$$

$$\beta_{0j} = \gamma_{00} + S_j\gamma_{01} + u_{0j},$$

where Y_{ij} is the attitude score of respondent *i* who use sanam *j*. In our study, Y_{ij} represents either attitude score of tigers or attitude score of dholes. X_{ij} is the design vector containing the selected respondent characteristics, and β_1 is the corresponding coefficient vector. The error term r_{ij} is assumed to be independent and normally distributed with mean zero and variance σ_r^2, $r_{ij} \sim NID(0, \sigma_r^2)$. In the level-two equation for the random intercepts, γ_{00} is the average intercept across sanams and S_j is the vector of selected sanam characteristics with coefficient vector γ_{01}. Finally, to account for multiple measurements on the same sanam, u_{0j} is an independent and normally distributed error term, $u_{0j} \sim NID(0, \sigma_u^2)$.

We selected covariates firstly according to our research interest (ethnic group) and theoretical consideration such as age and wealth (Williams et al. 2002; McClanahan et al. 2005; Røskaft et al. 2007; Smith et al. 2014; Thapa Karki & Hubacek 2015). We additionally reviewed covariates which were statistically significant from univariate regression ($p<0.05$). We then checked the collinearity among the selected covariates and sequentially deleted variables with the variance inflation factor (VIF) over 10. To compare the models for tigers and dholes, we kept the same covariates in the basic models. After completing the variable selection, we checked the interactions among selected variables and added significant interactions to our models (Zuur et al. 2010). Then, we selected a parsimonious model with the lowest Akaike Information Criterion (AIC) through the likelihood ratio test with lme4 package in R.

3. Results

3.1 Respondents demographics and socio-economic status

Among 203 respondents, 32.5% were *Lao Loum*, 50.7% were *Lao Sung*, and 16.7% were *Lao Theung*. The average age of respondents was 42.9 ± 12.7 (SD) years old with a range of 18~78 years old, and *Lao Sung* (38.5 ± 12.2) were significantly younger than *Lao Loum* (48.5 ± 10.7) and *Lao Theung* (45.6 ± 13.1) (ANOVA, df=2, p-value < 0.001). The majority of respondents (95.1%) were males because they normally take charge of large livestock management. The household size ranged from 3 to 25 people with a mean of 8.10 ± 3.6, and *Lao Sung* had notably larger family size (9.6 ± 4.0) than *Lao Loum* (6.9 ± 2.4) and *Lao Theung* (5.9 ± 1.8) (Kruskal-Wallis test, p-value < 0.001). 57% of respondents held a special social position within their communities, such as a head of a village, village policeman or village militia, and there was no difference among the ethnic groups.

While all respondents raised livestock, many of them also engaged in other livelihood activities, such as cultivating paddy rice and cash crops in upland fields, fishing, collecting Non-Timber Forestry Products (NTFPs), and gardening vegetables (Table 1.1). To a lesser extent, some respondents received a regular salary, engaged in hunting, and traded vegetables and NTPFs in a market. Regardless of multiple livelihood activities, the main income of all ethnic groups came from raising livestock and cultivating cash crops in upland fields. Among the three ethnic groups, *Lao Loum* were more actively participated in receiving a salary and fishing while *Lao Theung* engaged in gardening and *Lao Sung* focused more on hunting and agriculture in upland fields. The level of dependency on their major income sources was also different. *Lao Sung* heavily relied on raising livestock, cultivating crops in upland field, and collecting NTFPs. However, *Lao Loum* and *Lao Theung* had more diverse income sources. The estimated median household wealth was USD 9,939 with significant variance among the ethnic groups (Kruskal-Wallis test, df=2, p-value < 0.001). *Lao Loum* were the wealthiest (Median = USD 15,922) followed by *Lao Sung* (Median = USD 9,809) and *Lao Theung* (Median = USD 6,124).

Table 1. 1 Livelihood activities and main income sources of local herders in the NEPL NPA

Livelihoods engaged (%)						Main income sources (%)					
Livelihoods	*Lao Loum* (n=66)	*Lao Sung* (n=103)	*Lao Theung* (n=34)	Total (n=203)	*p*-value[a]	Livelihoods	Lao Loum (n=66)	Lao Sung (n=103)	Lao Theung (n=34)	Total (n=203)	*p*-value
salary	0.36	0.14	0.15	0.21	<0.01	salary	0.26	0.08	0.12	0.14	<0.01
trade	0.15	0.17	0.32	0.19	0.09	trade	0.09	0.07	0.03	0.07	0.52
paddy field	0.98	0.89	0.88	0.92	<0.05	paddy field	0.17	0.01	0.09	0.07	<0.001
upland field	0.64	0.90	0.79	0.80	<0.001	upland field	0.32	0.50	0.59	0.45	<0.05
gardening	0.71	0.58	0.82	0.67	<0.05	gardening	0.15	0.06	0.29	0.13	<0.01
NTFP collection	0.76	0.68	0.68	0.70	0.52	NTFP collection	0.02	0.17	0.15	0.12	<0.01
hunting	0.14	0.30	0.29	0.25	<0.05	Livestock grazing	0.52	0.88	0.24	0.66	<0.001
fishing	0.83	0.60	0.76	0.70	<0.01						

[a] *p*-values are based on Fisher's exact Test

3.2. Livestock management

Herders in the NEPL NPA raised, on average, 20.8 ± 26.2 chickens, 1.1 ± 3.0 goats, 4.3 ± 4.2 pigs, 6.6 ± 6.8 cows and 1.8 ± 2.6 buffalos per household. Particularly, *Lao Loum* raised fewer goats (0.45 ± 2.0) than *Lao Theung* (1.5 ± 4.4) and *Lao Sung* (1.4 ± 2.9), and *Lao Sung* had significantly more cows (8.2 ± 8.0) than *Lao Loum* (6.3 ± 5.2) and *Lao Theung* (1.9 ± 2.3) (Kruskal-Wallis Test, df=2, p-value < 0.01). To raise large livestock, 55.7% respondents changed grazing locations from sanams to paddy fields in a dry season from November through to April, while 42.4% respondents raised their livestock in the same sanams all year round. This livestock husbandry practice varied among the ethnic groups (Fisher's exact test, p-value < 0.001). While the majority of *Lao Sung* (60.2%) raised their livestock only in the sanams, only 30.3% of *Lao Loum* and 11.8% of *Lao Theung* used the sanams all year round.

Not only livestock management but also attributes of sanams differed among the ethnic groups (Table 1.2). On average, sanams of *Lao Sung* were the largest and had the fewest numbers of users, the most number of large livestock, and thus significantly higher density of large livestock than sanams of *Lao Loum* and *Lao Theung*. Furthermore, *Lao Sung* used sanams closest to the TPZ and had the most livestock depredation by both tigers and dholes.

Table 1. 2 Sanam characteristics of three ethnic groups

Sanam Characteristics	*Lao Loum*	*Lao Sung*	*Lao Theung*	Total	p-value[a]
Number of users	19.76 (7.72)[b]	16.89 (8.22)	20.21 (11.20)	18.38 (8.73)	0.031
Size (ha)	148.12 (93.24)	614.34 (718.79)	30.59 (20.63)	365 (574.15)	2.20E-16
Distance to the village (km)	3.22 (1.69)	5.16 (2.95)	2.0 (1.43)	4.0 (2.69)	1.93E-10
Number of large livestock	155.56 (95.80)	185.99 (117.15)	60.21 (40.43)	155 (110)	2.29E-10
Large livestock density (livestock/ha)	1.17 (1.07)	4.02 (4.93)	0.77 (0.76)	2.55 (3.87)	8.32E-12
Distance to the TPZ (km)	2.46 (1.56)	0.72 (1.71)	1.85 (1.19)	1.47 (1.77)	2.20E-16
Number of livestock loss by tiger/sanam	0.74 (0.66)	1.22 (3.49)	0.00	0.86 (2.55)	8.30E-07
Number of livestock loss by dhole/sanam	17.78 (22.89)	24.83 (20.50)	0.24 (0.43)	18.41 (21.39)	3.31E-12

[a] *p*-values are based on Kruskal-Wallis Test (df=2)
[b] Mean value (Standard Deviation)

3.3. Livestock depredation by carnivores

52.7% respondents reported the livestock loss by six carnivores, including tigers, dholes, leopards, clouded leopards, golden cats and civets, between 2007 and 2012. On average, each household lost 2.6 cattle and buffalos (range: 0~30), 0.4 pigs (range: 0~18), 0.3 goats (range: 0~13) and 1.0 poultry (range: 0~30) per year by eight wildlife including the six carnivore species. 44.8% respondents experienced the large livestock loss between 2007-2012, and except one case of a snake attack, local herders lost their large livestock by tigers and dholes. Between the two species, the respondents reported that dholes were responsible for 88.2% incidents of large livestock attack, while tigers were responsible for 11.8%. Reported livestock loss was different among the ethnic groups (Kruskal-Wallis Test, df=2, p-value < 0.01). While 59.2% of *Lao Sung* and 42.4% of *Lao Loum* experienced large livestock loss, only 2.9% of *Lao Theung* lost large livestock between 2007 and 2012. Moreover, 61.2% of *Lao Sung*, 39.4% of *Lao Loum*, and 2.9% of *Lao Theung* experienced dhole attacks on their livestock, while 3.4% of *Lao Sung*, 7.6% of *Lao Loum*, and no *Lao Theung* experienced tiger attacks in the 5 years of the time period. *Lao Sung* lost, on average, 3.6 ± 5.6 large livestock from carnivore attack between 2007 and 2012, while *Lao Loum* and *Lao Theung* lost 2.4 ± 4.9 and 0.03 ± 0.17 large livestock, respectively.

In all cases (n=12), local herders ascribed the attacks on their livestock to tigers based on tracks. Local herders identified the dhole attacks mostly based on tracks (51.6%), but also on observation of depredation (38.3%), and guesses (2.0%) or hearing from other people (8.1%). The grounds ascribing attacks to dholes were different among ethnic groups (Fisher's exact test, p-value < 0.05). While *Lao Loum* primarily used tracks (60.0%), for Lao

Sung actual observation of depredation (44.9%) was as important as tracks (48.6%) to infer dhole attacks on their livestock (Figure 1.2).

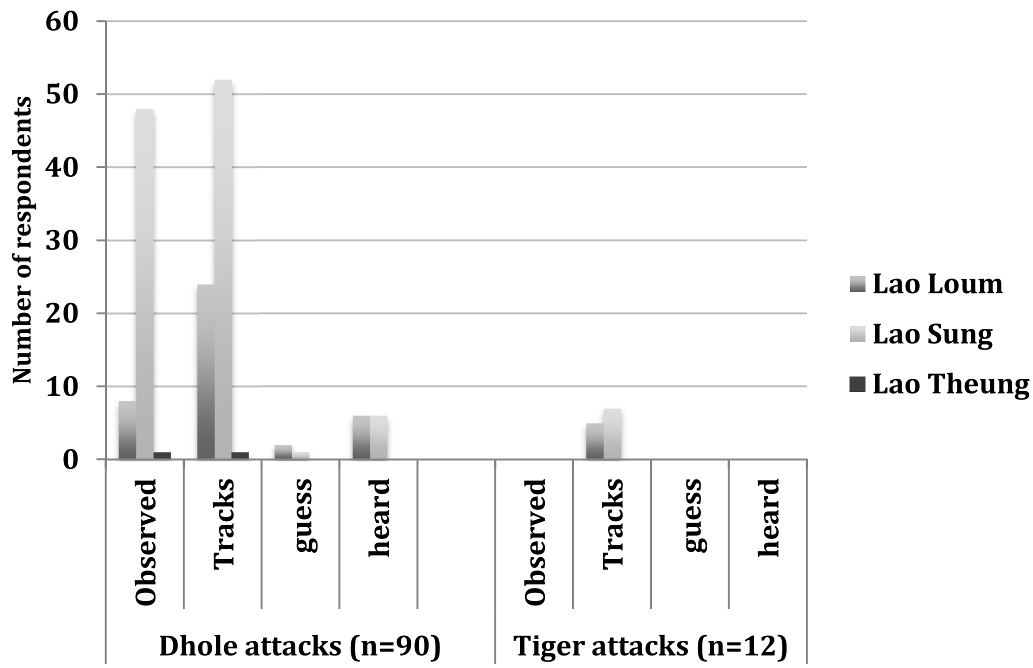

Figure 1.2 Evidence of major carnivore attacks perceived by local herders

3.4. Attitude towards carnivores

The top-ranked problematic wildlife to the local herders were dholes, followed by wild boars, tigers, and deer (Figure 1.3). However, differences among the ethnic groups were strong. While dholes were the primary concern to *Lao Sung*, both *Lao Loum* and *Lao Theung* ranked wild boars more negatively than dholes (Fisher's exact test, p-value < 0.001). Furthermore, deer were not a concern to *Lao Sung* but were identified as a significant problem to *Lao Theung* (Fisher's exact test, p-value < 0.001). However, opinions about tigers were not different among the three ethnic groups (Fisher's exact test, p-value = 0.51).

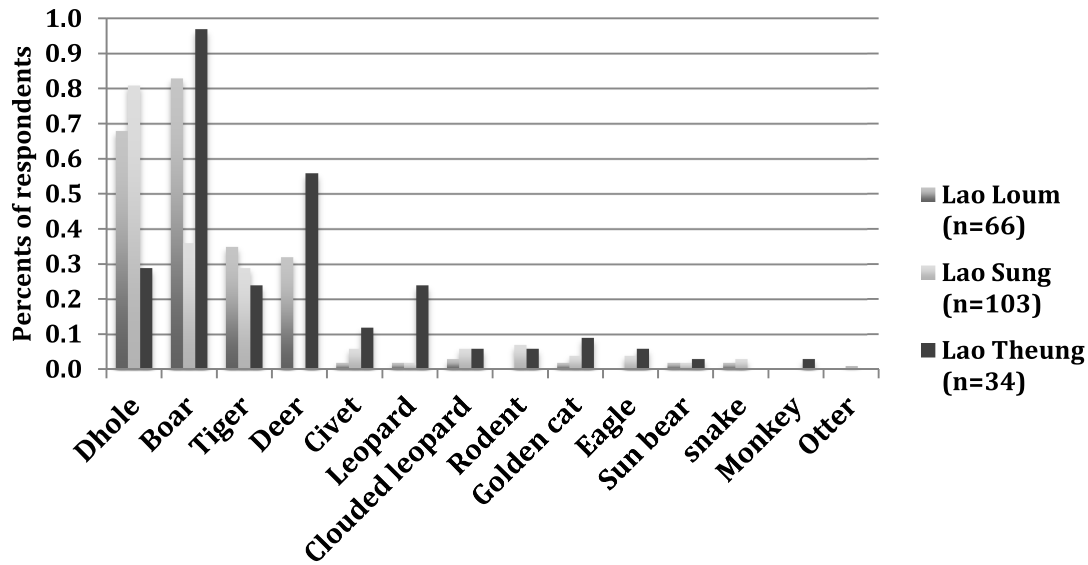

Figure 1.3 Most problematic wildlife for local herders

Attitude scores of tigers and dholes reflected this perception. The respondents' attitude scores of tigers ranged from -4 to 6 with average score of 3.36 (SD = 2.98), and the attitude scores of dholes ranged from -2 to 2 with average score of -0.80 (SD = 1.72). The attitude score of 0 referred to neutral attitude in both cases. On average, *Lao Theung* had the most positive attitudes towards tigers, with a mean attitude score of 4.86 (SD = 2.50), while *Lao Loum* and *Lao Sung* showed similar attitude scores of 3.05 (SD = 2.79) and 3.08 (SD = 3.11) respectively (ANOVA, df=2, p-value < 0.01). Furthermore, *Lao Theung* had relatively positive attitudes towards dholes, with a mean attitude score of 0.67 (SD = 1.82), while *Lao Loum* and *Lao Sung* had similar negative attitude scores of -0.92 (SD = 1.56) and -1.20 (SD = 1.52) (ANOVA, df=2, p-value < 0.01).

Basic attitude models of tigers and dholes were composed of five level 1 predictor variables and one level 2 predictor variable (Table 1.3). Among the six predictor variables, ethnic group, wealth of the respondents, previous experience of livestock loss by tigers and perception that problem wildlife should be reduced were significant (p-value < 0.05) for the tiger basic model while ethnic group, age of respondents, previous experience of livestock of by dholes, perception that problem wildlife should be reduced and number of users in sanams were significant for the dhole basic model. Adding an interaction between ethnic group and experience of livestock loss only slightly improved (lower AIC) the basic dhole model but not the tiger model. According to the tiger model, attitude toward tigers was positively associated with *Lao Theung* compared to *Lao Loum* in ethnic group and wealth, and negatively associated with experience of livestock loss by tigers and negative perception on problem wildlife. On the other hand, attitude toward dholes was only positively associated with *Lao Theung,* and negatively associated with the age, experience of livestock loss by dholes, negative perception on problem wildlife, and the number of sanam users.

Table 1.3 Parameter Estimates for attitude models of tigers and dholes

	Tiger basic		Tiger with interactions		Dhole basic		Dhole with interactions	
	Estimate (SE)	p-value	Estimate (SE)	p-value	Estimate (SE)	p-value	Estimate (SE)	p-value
Level 1								
Intercept	-0.12 (3.03)	0.97	-0.38 (3.09)	0.90	2.50 (1.54)	0.11	2.28 (1.53)	0.14
Ethnic_*Lao Sung*	-0.20 (0.59)	0.74	0.09 (0.66)	0.89	-0.55 (0.25)	0.03	-0.31 (0.47)	0.51
Ethnic_*Lao Theung*	1.77 (0.76)	0.03	1.99 (0.87)	0.03	1.10 (0.31)	<0.001	1.68 (0.41)	<0.001
Age	-0.02 (0.02)	0.26	-0.02 (0.02)	0.25	-0.02 (0.01)	0.01	-0.02 (0.01)	<0.01
Wealth	0.67 (0.28)	0.02	0.68 (0.29)	0.02	-0.02 (0.15)	0.88	-0.03 (0.15)	0.85
Livestock loss *	-1.07 (0.43)	0.01	-0.41 (0.77)	0.60	-0.97 (0.24)	<0.001	-0.54 (0.37)	0.15
Perception on Problem wildlife**	-1.66 (0.49)	<0.001	-1.68 (0.49)	<0.001	-1.04 (0.26)	<0.001	-1.08 (0.27)	<0.001
Level 2								
Sanam User	-0.02 (0.03)	0.39	-0.03 (0.03)	0.39	-0.03 (0.01)	0.01	-0.03 (0.01)	<0.01
Interactions								
Ethnic_*Lao Sung* : Livestock loss			-1.01 (0.96)	0.29			-0.36 (0.52)	0.48
Ethnic_*Lao Theung* : Livestock loss			-0.88 (1.40)	0.53			-1.40 (0.63)	0.03
AIC***	994.08		996.98		726.43		725.46	

* Livestock loss refers to the previous experience of livestock loss by respective carnivores for each model
** Perception on Problem wildlife refers to a belief that problem wildlife should be reduced
*** AIC: Akaike Information Criterion

4. Discussion and Conclusions

Local herders' perceived risk of carnivores was high in the NEPL NPA, as more than half of them said they experienced livestock loss to carnivores. Compared to the previous study of livestock depredation (2.1 cattle and buffalos per village per year) (Johnson et al. 2006), our study showed much higher livestock depredation rate (2.6 cattle and buffalos per household per year). This escalated livestock depredation possibly came from different purpose of the survey rather than actual increased in depredation. While the previous study focused on tiger attacks only, our study expanded depredation scope to all carnivore attacks and dholes accounted 88% of the attacks. Consequently, perceived risk of dholes exceeded the risk of tigers and other carnivores. With relatively low perceived risk of tigers, local herders, across all three ethnic groups, showed the positive attitude toward tigers.

However, a level of concern to the risk was different among three ethnic groups, and their attitudes towards target carnivores were also different. *Lao Theun*g perceived the least risk of tiger and dhole attacks and had the most positive attitudes towards both carnivores, while *Lao Loum* and *Lao Sung* showed the higher perceived risk and less positive attitudes towards tigers and negative attitudes towards dholes. There was no significant attitude difference between *Lao Loum* and *Lao Sung* for either tigers or dholes*.* This ethnic difference was clear in the attitude models.

According to the tiger attitude model, (i) more affluent livestock herders who (ii) are *Lao Theung* (iii) without previous experience of tiger attack, (iv) do not believe that problem wildlife should be reduced, have more positive attitudes towards tigers. The wealthier local herders would have a higher tolerance because their livestock loss by tigers would lead to less economic hardship. As *Lao Theung* did not have tiger attacks between 2007-2012, they would have the significantly more positive attitude toward tigers than *Lao Loum* or *Lao Sung*. Because tiger attacks have been infrequent in recent years, the negative opinion about problematic wildlife would shape the herders' attitude as much as the actual experience of tiger attacks.

Similar to attitude towards tigers, attitudes towards dholes were negatively associated with the perceived risk (previous experience of livestock depredation by dholes) and negative perception (a perception that problem wildlife should be reduced). To a lesser degree, age and the number of users in a sanam also negatively influenced the attitudes towards dholes. Ethnicity affected the attitudes differently. Compared with *Lao Loum*, *Lao Theung* had positive attitudes while *Lao Sung* had negative attitudes. However, in case of having livestock depredation by dholes, *Lao Theung* showed significant intolerance. This could imply that increasing livestock depredation of dholes in sanams of *Lao Theung* would easily turn their current positive attitudes to negative. Notably, however, wealth did not influence the attitudes towards dholes. This difference could come from different frequencies of livestock loss by the two carnivores. Reported livestock loss from dholes was far more frequent than loss from tigers, and within these high incidents of livestock loss, wealth no longer seems to attenuate the intolerance.

In sum, attitudes toward carnivores are largely shaped by a perceived risk of carnivore attacks and a negative perception about problem wildlife. Positive attitudes of *Lao Theung* would come from the experience of the least livestock loss while negative attitudes of *Lao Sung* would come from the experience of the most livestock loss. This different risk could be explained by different livelihoods and livestock management styles. *Lao Theung* had the fewest large livestock and raised them in small grazing areas near to the villages. Previous research confirmed that the risk of tiger attack increases with the distance from villages (Johnson et al., 2006). Therefore, the livestock husbandry practice of *Lao Theung* is less vulnerable to carnivore attacks. In addition, because their main livelihood was agriculture in upland fields, the perceived risk of deer and wild boar was higher than other ethnic groups. In summary, different livelihoods among the ethnic groups lead to different livestock management practices, and this difference further leads to exposure of different risk of carnivore attacks, which drives different attitudes towards the carnivores in conflict.

As the ethnic groups demonstrated clear differences with respect to livelihoods, perceived risk and attitudes, conservation strategies should consider these differences to improve the attitudes towards the carnivores and local engagement in conservation actions for mitigating human-carnivore conflict. For example, *Lao Sung* would be a good starting point to implement preventative measures to reduce the risk of carnivore attacks on large livestock such as improving livestock husbandry practice and raising livestock near to the village (Johnson et al. 2006). Because large livestock is the most important income source to *Lao Sung*, they would be more willing to try the method. During the interview with local herders in this study, some of *Lao Sung* expressed this inclination. On the contrary, a conservation strategy to *Lao Theung* can focus on encouraging them to continue the current livestock husbandry practice and implementing an outreach to emphasize the role of carnivores in regulating the prey populations which raid crops. Furthermore, considering the importance of perception of local herders about the problematic wildlife from both attitude models, a community outreach program that provides information of non-lethal methods for human-carnivore conflict would be an effective approach.

As such, our research considers complexities of human-carnivore conflict by investigating socio-economic structure of local communities in conflict and suggests alternative approaches which reflect ethnic differences as well as other factors shaping local herders' attitudes towards carnivores. We expect that our study provides a good example of how the understanding human-carnivore conflict in a local context could help to develop effective mitigation strategies, which can be applied to other conservation projects worldwide.

Chapter 2 : Exploring conservation decision-making among local herders in the Nam Et-Phou Louey National Protected Area, Lao PDR

INTRODUCTION

Understanding factors shaping preferences, beliefs, perceptions and attitudes with regard to wildlife is critical for designing effective conservation actions, especially when there are human-wildlife conflicts, as these factors directly or indirectly influence people's decision-making and behavior (Dickman 2010; Barua et al. 2013; Suryawanshi et al. 2013; Dickman et al. 2014). Survey questionnaires and interviews have been traditionally used to assess these factors (Kellert 1985; Wywialowski 1994; Conforti & De Azevedo 2003; Røskaft et al. 2007; Lescureux et al. 2011; Karanth & Nepal 2012; TREVES et al. 2013; Dickman et al. 2014). Although standard surveys enable the effective collection of quantitative data, their internal validity is sometimes questionable, particularly with respect to socially or politically sensitive topics. Similarly, self-reporting and inconsistent interpretations of questions by respondents can also lead to invalid and unreliable measurements (Frechtling 2002; Johnson & Christensen 2004).

Hunting of legally protected wildlife is often a sensitive topic to local communities living in and around protected areas in developing countries, especially when community members are involved in poaching. Tigers (*Panthera tigris)* in the Nam Et-Phou Louey National Protected Area (NEPL NPA) in northern Laos are no exception (Fig. 2.1). Although tigers are globally and nationally protected animals, the tiger population in the NEPL NPA has declined due to commercial poaching and prey depletion (Johnson et al. 2016). Conservation actions, such as law enforcement and public outreach, have focused on protection of tigers in the NPA. Given the strictly protected status of tigers and the active law enforcement to stop illegal hunting, issues with respect to tigers have become an extremely sensitive topic in this area. Despite the conservation efforts, it has been reported that local people may use livestock carcasses as bait for poaching tigers and use access to livestock grazing areas inside the NPA as a means for bringing guns into the area for hunting (Johnson et al. 2006). The reports suggest a close relationship between grazing and tiger poaching. To date, research has not been sufficient to understand this relationship. It is unlikely that local people will comfortably reveal their negative experience or views on tiger conservation in such a political setting. Thus, a traditional survey questionnaire is likely to be less reliable for eliciting local people's opinions or experiences about using grazing areas for poaching tigers because corresponding questions might produce only politically correct answers.

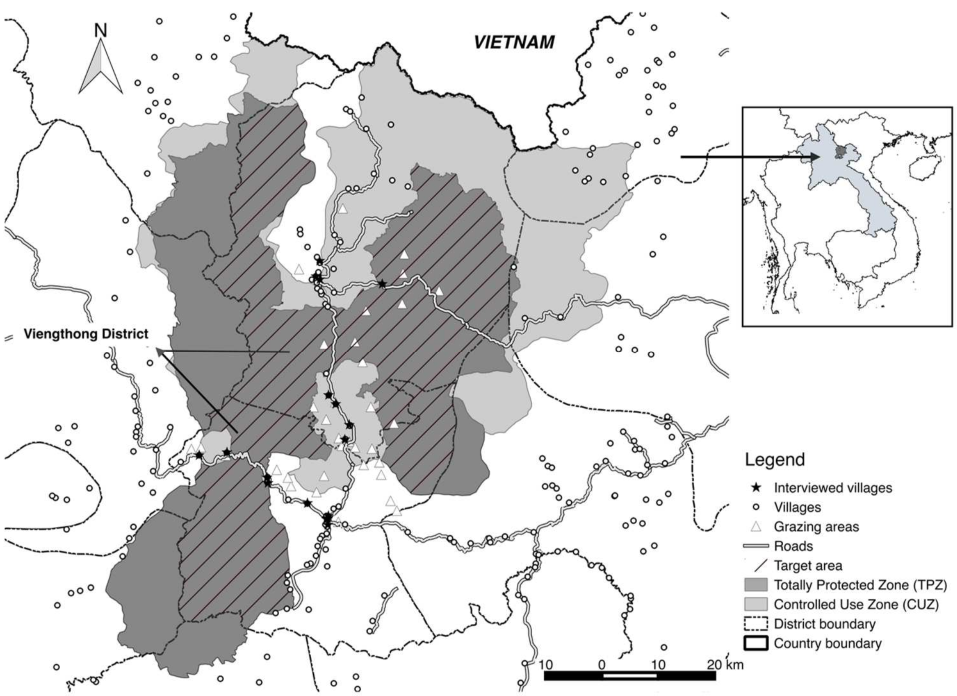

Figure 2.1 Study Area, showing the villages and grazing areas in the Nam Et-Phou Louey National Protected Areas

As an alternative to the traditional questionnaires in survey research, vignette experiments have been a prominent tool in the social sciences and in nursing research to elicit respondents' beliefs and judgments (Alexander & Becker 1978; Hox et al. 1991; Sniderman & Grob 1996; Ludwick & Zeller 2001; Hughes & Huby 2002; Taylor 2005; Jasso 2006; Atzmüller & Steiner 2010; Auspurg & Hinz 2015). A vignette is a short description of a hypothetical scenario constructed from predetermined attributes that are of interest to the researcher. A vignette experiment employs a whole population of vignettes, which is generated by factorially varying the values of all attributes. Sets of vignettes are then presented to respondents in order to elicit their preferences, judgments, or anticipated behaviors with respect to hypothetical scenarios (Alexander & Becker 1978; Rossi 1979; Atzmüller & Steiner 2010). Compared with traditional survey questionnaires, vignette experiments are frequently considered as better suited for assessing attitudes and beliefs because they allow for a simultaneous assessment of multiple factors in a highly contextualized setting. In this sense, vignettes are less abstract than standard survey questions (Alexander & Becker 1978; Rossi 1979; Ludwick & Zeller 2001; Hughes & Huby 2002; Atzmüller & Steiner 2010). Vignette experiments also have the potential to minimize social desirability bias because, if properly implemented, respondents are less likely to discern the researcher's intention (Alexander & Becker 1978; Ludwick & Zeller 2001). Furthermore, vignettes are frequently more effective for the investigation of sensitive topics because responding to a hypothetical scenario is less intimidating than being directly asked about one's own actual behaviors, experiences, or opinions. The presentation style for vignettes is also highly flexible. Depending on the study's goal and the experimental situation, vignettes can be presented as texts, pictures, cartoons, audios, or videos (Burstin et al. 1980; Atzmüller & Steiner 2010; Rungtusanatham et al. 2011; Caro et al. 2012; Atzmüller & Kromer 2013, 2014; Hillen et al. 2013; van Vliet et al. 2013). Regardless of these numerous advantages, vignette experiments have been rarely if ever used in wildlife conservation research.

In this article we describe a vignette experiment that investigates human-tiger conflict in the NEPL NPA. Our research aimed to understand factors that influence local people's selection of grazing areas. We particularly focus on the design and analysis of a vignette experiment for assessing people's preference for grazing areas that are in close proximity to tigers and their prey. We illustrate how the results from the vignette experiment increased our understanding of grazing area preferences, and thus can help conservationists to design more effective and locally acceptable strategies to prevent human-tiger conflict.

STUDY AREA

The Nam Et-Phou Louey National Protected Area (NEPL NPA), established in 1993, is composed of two management units including a 3,206 km^2 Totally Protected Zone (TPZ) and a 1,862 km^2 Controlled Use Zone (CUZ; Fig. 2.1). The NPA regulations prohibit any human activity in the TPZ in order to protect the source populations of endangered wildlife, especially tigers, while subsistence agriculture and hunting of less threatened wildlife are allowed in the CUZ (GoL 2007). There are approximately 127 villages with a total of 30,000 people in and adjacent to the CUZ (World Bank 2012). Although the Lao government has actively relocated remote villages in the NPA closer to roads outside the TPZ (Schlemmer 2002; World Bank 2012), the original grazing areas around old village sites within the TPZ have remained in use due to a lack of suitable grazing land in the relocated areas. Under this situation, local people have reportedly lost 2.1 large livestock on average per village per year to tigers (Johnson et al. 2006). This livestock depredation, which is the result of unsupervised livestock grazing in tiger habitats, has led to retaliatory killing of tigers and may also have provided opportunities for poaching tigers (Johnson et al. 2006).

METHODS

Design of the Experimental Vignette Study

Designing a vignette experiment first requires the identification of the vignette factors (also called situation characteristics) and the corresponding factor levels that are relevant for the research question. After consultation with local people and community experts in the NEPL NPA about the local livestock management, we selected three factors that strongly determine local people's grazing area preference and two factors representing the relationship between grazing areas and wildlife. The five factors were 1) quality of grass in the grazing area (G), 2) distance between the grazing area and agricultural land (A), 3) distance between the grazing area and a village (V), 4) distance between the grazing area and tiger prey (P), and 5) distance between the grazing area and large carnivores (C). Each factor had two levels: 'good' and 'poor' for the grazing quality, and 'close' and 'distant' for the four distance-related factors A, V, P, and C (Table 2.1). Thus, with two factor levels for each factor, the full factorial combination of all five factors resulted in a vignette population of $2^5 = 32$ vignettes describing 32 different types of grazing areas.

Table 2.1 Vignette factors and factor levels used in the vignette experiment

Factors	**Factor levels**	
Quality of grass in the grazing area (G)	Poor	Good
Distance between agricultural land and the grazing area (A)	Near	Distant
Distance between village and the grazing area (V)	Near	Distant
Distance between prey and the grazing area (P)	Near	Distant
Distance between carnivores and the grazing area (C)	Near	Distant

If each respondent would assess all 32 vignettes, then we could estimate all five main and 26 two-way and higher-order interaction effects of the five factors. However, 32 vignettes are too many to be reliably assessed by a respondent. Thus, in order to reduce the number of vignettes per respondent, we systematically partitioned the vignette population into eight subsets of four vignettes according to a randomized block confounded factorial design (Atzmüller & Steiner 2010). Appendix B contains the assignments of vignettes to sets. Respondents can easily assess four vignettes, while we still can estimate all five main effects and most of the two-way and higher-order interaction effects. Only two two-way interactions (A×P and G×C) and five higher-order interactions (A×G×V, A×C×V, G×P×V, C×P×V, and A×C×G×P) were confounded with the set effect. Due to the confounding, these interaction effects cannot be separated from potential set effects (i.e., context effects induced by the specific combination of the four vignettes). Given that we were mostly interested in the main effects, the confounding of two-way and higher-order interaction effects does not compromise the investigation of our research question.

Considering the rate of adult illiteracy (43%) in the area (Gebbie et al. 2008) and local people's apathy to repeated conventional questionnaire-based interviews by different conservation and rural development organizations working in this region, we decided to use a visual-based form of vignettes instead of text. We employed sketch vignettes drawn by local students that, as we found out, were better understood by local people than realistic photos or more abstract pictograms with which they are unfamiliar. Since the sketches reflected the actual local environment, such as the shape of houses, types of crops in the agricultural land, and the local species of carnivores and prey, they minimized the discrepancy between the respondents' actual situations and the hypothetical scenarios represented in the vignettes. Since four of our factors represented distal relations with respect to the grazing area, we set up the sketch vignettes as symbolic maps. Figure 2.2 shows the four vignettes of set 1. The first vignette (top left) represents the scenario where the grazing area, represented by the cow grazing, is distant to carnivores but close to a village, prey and agricultural land. The quality of the grazing area is poor as symbolized by the few tufts of grass. In the second vignette (top right) the grass quality is good, while the grazing area is close to the village but also close to carnivores and distant to agricultural land and prey. As can be seen from the sketch vignettes, they also encode distal relationships other than the one to the grazing area, for instance, the distance between the village and carnivores or the agricultural land and prey. Since these distal relationships were not of importance to us, we did not systematically vary them. Although these relations might have affected the assessment of the vignettes, corresponding effects are presumably small because the interviewers verbally explained each vignette, particularly the grazing area's distal relationships, while all other distal relationships (unrelated to the grazing area) were not mentioned. Although we were primarily investigating the relationship between local people's grazing area preference and tigers, we included both dhole (*Cuon alpinus*) and tiger in the sketches instead of tiger alone. The reasons for this were: i) to avoid the possibility that respondents could easily guess the intention of our study's focus and, thus, provide socially desirable answers, and ii), to more realistically represent the situation in the NPA where dholes are a relatively abundant large carnivore (Duckworth et al. 1999; Kamler et al. 2012).

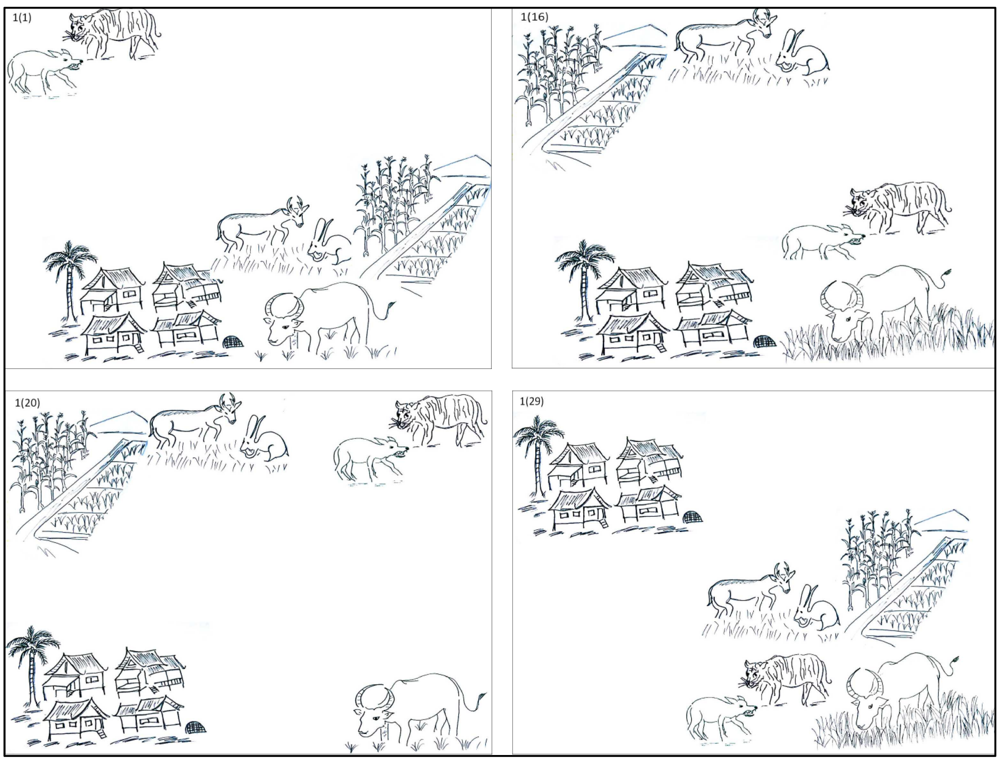

Figure 2.2 An example of a sketch vignette set 1. Vignette 1 on the top left picture presents a grazing area with poor quality of grass, near to a village, agricultural land and prey, and far from carnivores.

Implementation of the Vignette Experiment

Between May and August, 2012, we conducted the vignette experiment with livestock breeding families raising cattle or buffaloes in and around the TPZ of the NEPL NPA in Viengthong district, which covers 68.9% of the TPZ (Fig. 2.1). Our target population of herding families has had conflicts with tigers, which can greatly affect the outcomes of tiger conservation actions. Because grazing areas are the main location of this conflict, we stratified the herding families according to the different grazing areas to obtain a good representation of our target population. The strata refer to 35 grazing areas, including all eight identified grazing areas inside the TPZ and 27 grazing areas in close proximity to the TPZ (Fig. 2.1). For each stratum (grazing area), we aimed at sampling eight herding families because this allowed us to have all eight vignette sets represented in each subpopulation. However, 43% (15/35) of grazing areas had less than eight herding families. In these areas, we interviewed all the herding families (ranging from 1 to 9 families, with a median of 6). In order to approximately balance the number of observations per vignette set, we started the vignette experiment in an area either with vignette set 1 or set 8 and then worked through the sets forwards or backwards, respectively. Since we neither had a list of herding families nor knew the number of families in each stratum, we used snowball sampling instead of random sampling (Goodman 1961). That is, after the end of an interview, the interviewed respondent named another family of the village who used the same grazing area. Once a family was identified for an interview, the interviewers selected a volunteering respondent, either male or female, among the family members who had to be at least over 18 years of age and actually engaged in large livestock management.

In our vignette experiment, we used both ranking and rating to assess respondents' preference for a hypothetical grazing area. At the beginning of the vignette experiment, each respondent received all four vignettes of the assigned set in random order. Then, the interviewer asked the respondent to rank the four vignettes according to the preference. After the respondent completed the ranking, the interviewer recorded the ranks, shuffled the vignettes, provided one vignette at a time, and asked the respondent to rate the vignette on a continuous rating scale. We separated the ranking and rating procedure in order to prevent respondents from immediately recalling their rank order, and thus to verify the consistency of the ranking and rating outcomes. Since local people are not familiar with expressing their opinions on a numerical scale for rating, we provided respondents with a picture of an empty ruler with smileys at the endpoints of the scale: a sad face at one end and a smiling face at the other end. For each vignette, interviewers asked the respondents to pick one point in between according to their preference. Later, we scaled the continuous measure to a range from 0 to10, with 0 referring to the least preferred (sad face) and 10 to the most preferred grazing area (smiling face).

Before conducting the vignette experiment, interviewers collected background information on respondents, including their socio-economic status and their previous experience of wildlife-caused damage. In addition, we acquired information about the ethnicity of each village from the Viengthong district agricultural office (Viengthong District Agricultural Office 2011). Collecting respondent characteristics is important for the analysis of the experimental vignette data because they help in explaining differences across subgroups of respondents.

We had two Lao research assistants from National University of Laos who conducted the interviews and implemented the vignette experiment in Lao language. The two research assistants were trained over two weeks (half-days) until they fully understood the goal and the process of the experiment and survey. The training included basic interviewing skills for the survey, assigning vignette sets to respondents, and explaining the vignettes experiment including the ranking and rating tasks. In a small pilot study, we tested the eight vignette sets with eight herders from one of the villages in the NEPL NPA. In particular, we assessed the respondents' understanding of the vignettes to ensure the experiment's validity. All eight respondents easily understood the sketches and comfortably ranked and rated the vignettes.

Statistical Analysis

The analysis of vignette data typically involves an Analysis of (Co)Variance (ANCOVA) or a multilevel regression (Rossi 1979; Farrow 1987; Carlson 1999; Atzmüller & Steiner 2010; Caro et al. 2012). In our study, we used multilevel regression with vignettes as level-one units and respondents as level-two units which takes care of the multiple measurements per respondent (i.e., the correlated error structure). Multilevel regression provides a parameter estimates for the vignette factors and their interactions as well as corresponding significance tests. We first estimated the following random intercept model:

$$Y_{ij} = \beta_{0j} + X_{ij}\beta_{1j} + r_{ij} \text{ with}$$

$$\beta_{0j} = \gamma_{00} + set_j\gamma_{01} + S_j\gamma_{02} + Z_j\gamma_{03} + u_{0j},$$

where Y_{ij} is the grazing area preference for vignette *i* judged by respondent *j*. In our study, Y_{ij} represents either the ranked preference or the rated preference of the grazing area. X_{ij} is the design vector containing the vignette-related predictors for all main and interaction effects (except the confounded ones), and β_1 is the corresponding coefficient vector. The error term r_{ij} is assumed to be independent and normally distributed with mean zero and variance σ_r^2, $r_{ij} \sim NID(0, \sigma_r^2)$. In the level-two equation for the random intercepts: γ_{00} is the average intercept across respondents; set_j is the vector of set indicators with coefficient vector γ_{01}; S_j is the vector of stratum dummies (grazing areas) with coefficient vector γ_{02}; and Z_j is the vector of selected respondent characteristics with coefficient vector γ_{03}. Finally, to account for multiple measurements on the same respondent, u_{0j} is an independent and normally distributed error term, $u_{0j} \sim NID(0, \sigma_u^2)$.

In addition to the random intercept model, we also tested a random intercept and slope model for two vignette factors, distance to carnivores (C) and distance to prey (P). Compared with the random intercept model, the random slope model has an additional error term for each random slope, $\beta_{1j} = \gamma_{10} + u_{1j}$ where $u_{1j} \sim NID(0, \sigma_{u1}^2)$. The random slopes allowed us to assess the heterogeneity of people's preferences. In both models, we used deviation coding for the five vignette factors and used dummy coding for the vignette sets. A value of -0.5 was assigned to the level "Near" and "Poor", and a value of 0.5 was assigned to the level "Distant" and "Good" of the respective vignette factors. Thus, positive coefficients indicate the preference for grazing areas that are distant to a village, agricultural land, carnivores, and prey, and the preference for a good grass quality. For estimating the effects we used the lme4 package in R (R Core Team 2014).

RESULTS

A total of 203 herding families using 35 grazing areas participated in the vignette experiment without any refusal. Altogether, respondents rated 203 × 4 = 812 vignettes. The random intercept and slope model fitted the data better than the random intercept model (ANOVA, p-value <0.001), and the multilevel models for the ranked preference and rated preference showed consistent results for both main and interaction effects. Therefore, we only present the estimated random intercept and slope model for the rated preference (Table 2.2). Our final multilevel model did not contain any respondent characteristics because no such variables were statistically significant (t-value < 2). Our model demonstrates that local people preferred grazing areas having good quality grass (G), in close proximity to a village (V), but far away from agricultural land (A) and carnivores (C) (Table 2.2). Especially, the quality of grass (G) and distance to carnivores (C) influenced the preference. On the preference scale from 0 to 10, the quality of grass and the distance to carnivores significantly affected the preference of the grazing area by 2.62 and 2.30 points, respectively. To a lesser extent, local people favored grazing areas far from agricultural land (A, 0.42 points) and close to the village (V, -1.37 points). Distance to prey (P), which showed a slightly negative effect on preference, failed to reach statistical significance (t value < 2). One three-way interaction (GxCxV) and one four-way interaction (AxPxGxV) showed marginal significance, indicating that herders would be willing to accept a larger distance between the grazing area and the village if the grass quality is good and tigers are far away (GxCxV), and similarly for the four-way interaction. For the random effects of our model, the standard deviation of the slopes for distance to carnivores (C) and distance to prey (P) were 1.86 and 0.47, respectively. This indicates that the importance of the grazing area's distance to carnivores varies considerably across respondents (the 95% probability interval for the slope of distance to carnivores includes negative, -1.42, to strongly positive slopes, 6.02). Among the eight vignette sets, the preference score was slightly higher in vignette set 6 and 7 by 0.86 and 0.84 respectively, than vignette set 1 (reference set). In addition, some grazing areas (13 out of 35) had significantly lower preference scores compared to the reference grazing area. (See the Appendix C for the parameter estimates of grazing areas in the random slope model)

Table 2.2 Parameter estimates for the preference of grazing areas in the random-slope model.

	Coef.[a]	SE	*t* value
Intercept	6.92	0.84	8.22 *
Set2	0.60	0.34	1.77
Set3	-0.32	0.34	-0.94
Set4	0.39	0.34	1.17
Set5	0.60	0.33	1.79
Set6	0.86	0.33	2.57*
Set7	0.84	0.34	2.45*
Set8	0.54	0.33	1.63
A[b]	0.42	0.16	2.55 *
V[b]	-1.37	0.16	-8.48 *
P[b]	-0.24	0.16	-1.46
C[b]	2.30	0.21	11. 07*
G[b]	2.62	0.21	12.62 *
A x V	0.13	0.42	0.32
V x P	-0.22	0.42	-0.54
A x C	0.02	0.32	0.07
V x C	0.48	0.33	1.47
P x C	-0.07	0.32	-0.23
A x G	-0.15	0.32	-0.45
V x G	0.23	0.33	0.69
P x G	0.19	0.32	0.60
A x V x P	-0.64	0.65	-0.99
A x P x C	0.42	0.83	0.50
A x P x G	0.99	0.83	1.19
A x C x G	0.57	0.66	0.86
V x C x G	1.57	0.65	2.43 *
P x C x G	0.58	0.66	0.88
A x V x P x C	-0.84	1.32	-0.64
A x V x P x G	3.12	1.32	2.37 *
A x V x C x G	-1.05	1.66	-0.63
V x P x C x G	-0.24	1.66	-0.14
A x V x P x C x G	4.20	2.58	1.63
SD of Random intercept	0.07		
SD of Random Slope for C	1.86		
SD of Random Slope for P	0.47		
SD of Level-one	2.30		

The stratum effects for the grazing areas are not shown in the table, but some are significant

[a] Abbreviation: Coef., Coefficients of the model

[b] Abbreviation: *A*, Distance between agricultural land and grazing area; *V*, Distance between village and grazing area; *P*, Distance between prey and grazing area; *C*, Distance between carnivores and grazing area; *G*, Quality of grass in grazing area

* Significant *t* value of two-tailed *t*-test with 0.05 significance level (*t* value > 2).

DISCUSSION

Livestock depredation by carnivores is the most common type of human-carnivore conflict worldwide. It is often associated with inadequate livestock management, such as unattended livestock grazing in protected areas (Breitenmoser 1998; Wang & Macdonald 2006; Kinnaird & O'Brien 2012; Soh et al. 2014). Especially, when grazing areas overlap carnivore habitats, livestock depredation is inevitable and pastures become a core of the conflict. However, implementation of methods preventing livestock loss by carnivores is not simple in practice because actual implementation and maintanance of such methods are largely dependent on livestock owners' willingness to adopt those methods (Breitenmoser et al. 2005; Goodrich 2010). Yet, regardless of the risk of carnivore attacks on livestock, local people can be reluctant to change their livestock husbandry practices for reasons such as hesitancy to try unfamiliar methods or to add more labor to livestock management. Therefore, in order to change the local people's livestock management practices, comprehensive understanding of local people's grazing area preferences is fundamental.

The findings from our vignette experiment provide us with a clearer understanding of the relative importance of factors that local herders consider when selecting grazing areas. This understanding is critical for designing effective NPA management strategies to reduce human-tiger conflict. In contrast to our research hypothesis, our results suggest that local herders in the NEPL NPA did not favor grazing areas with large carnivores in close proximity. Furthermore, accessibility of prey in grazing areas did not significantly influence the local herders' grazing area selection. These results imply that in general local people tend to avoid large carnivore depredation of livestock and largely do not intend to use grazing areas to hunt tigers, dholes or their prey. Nonetheless, these average effects do not imply that all local herders are inclined to avoid carnivores in their grazing areas nor that all do not prefer grazing areas having carnivores and prey nearby. The large standard deviation of the random slope for distance to carnivores in the random slope model demonstrated that some herder groups would indeed prefer carnivores close to their grazing areas. This result supports current conservation strategies in the NEPL NPA to relocate grazing areas in TPZ to areas outside of the TPZ as well as active law enforcement to stop poaching. Particularly, more intensive patrolling is recommended around grazing areas where herders chose grazing areas in the proximity of carnivores.

In addition, improving current livestock husbandry practices is critical in order to prevent carnivore attacks on livestock. When current efforts to remove livestock from the TPZ have limited success due to a lack of herders' cooperation, the results of our vignette experiment provide alternative approaches that may increase their acceptance. The most important component of these approaches is successful demonstrations by local herders of how new practices can improve the quality of livestock forage and protect livestock from carnivore attacks by keeping livestock near villages. These approaches will prevent local herders from needing to go back to their livestock grazing areas in the TPZ because of inadequate grazing conditions in relocated grazing areas. During the survey, we observed a few families who independently began to graze large livestock in close proximity to their villages due to frequent livestock loss by carnivores but who may possibly encounter a problem of insufficient forage in the near future. These families could be an excellent target group for piloting the new livestock management practices and serve as a role model to other herders.

While vignette experiments are a powerful survey tool to increase the credibility of responses in sensitive topics, the design and implementation of the experiment needs care. One of the major issues arises from the hypothetical setting that mimics the real world. Vignette experiments try to assess respondents' real-life behavior using hypothetical scenarios of real-life situations. Yet, it is possible that the responses to the hypothetical scenarios differ from the actual judgments in real-life events (Ludwick & Zeller 2001). Also, if vignettes fail to appropriately represent reality, the results of the vignette experiment would not be valid. Therefore, researchers must carefully select vignette factors to fit real-world decision-making processes (Ludwick & Zeller 2001). Our sketch vignettes seemed to well represent the local environment, and all respondents easily understood the context of each vignette. The analysis of the vignette data confirmed the consistency of the results with local people's real-life decisions. The preference for grazing areas that are far from agricultural cropland is consistent with the current agricultural practices that we observed - separating livestock from cropland to protect crops from livestock. Moreover, preference for good quality grass is also well reflected in concerns about overgrazing in the current grazing areas, which respondents expressed during the field study. The consistencies of our results with the herders' real-life decisions support our belief that the results with regard to the distance of tigers and their prey are valid.

In our study design, however, presence of a dhole in the sketches together with a tiger could possibly have affected the local people's grazing area preference regarding the proximity to tigers. Previous studies revealed that the main diet of dholes in the NEPL NPA is wild ungulates (Kamler et al. 2012), but a significant number of herders reported livestock loss by dholes during the interview. That is, fear of dhole attack on livestock could hinder the favor to the presence of tiger in close proximity. However, we believe that it would not significantly influence the herders' preferences regarding distance to tigers because the potential economic gain from tiger poaching is far greater than the opportunity costs of losing livestock to dholes. Some exploratory analysis of the vignette data also showed that previous experience of livestock loss by dholes, one of the measured respondent characteristics, did not affect the preference for grazing areas.

Despite the above-mentioned concerns, our results strongly suggest that vignette experiments are a promising instrument to understand people's preferences and judgments. With careful design and implementation, a vignette experiment embedded in a traditional survey can increase both external and internal validity. Vignette experiments are especially useful for research that involves socially and politically sensitive topics such as wildlife consumption, poaching, and trafficking. They also can serve as an effective alternative to traditional survey questionnaires, particularly when respondents have difficulties in understanding abstract (less contextualized) questions than context-rich representations of hypothetical real-life scenarios. Due to the flexibility and efficiency of vignette experiments, vignettes are widely applicable to wildlife conservation research, from assessing people's judgments on species or conservation policies to assessing potential behaviors in response to conservation management and interventions.

Chapter 3 : Developing a conceptual framework for Amur Leopard restoration in South Korea

INTRODUCTION

In the 20th century, all large carnivores, except Asiatic black bears (*Ursus thibetanus ussuricus)*, vanished from South Korea primarily due to massive overharvesting and habitat destruction, especially during the Japanese colonial era (1910-1945) and the Korean War (1950-1953) (Ministry of Environment 2006; Endo 2009; Lee et al. 2013). Among predators, *Bum*, which collectively refers to both tigers and leopards in the Korean language due to their similar appearances, particularly has had a special relationship with Koreans. Reflecting 5000 years of coexisting history, *Bum* can be found from the origin myth of Korea as well as in hundreds, if not thousands, of folk tales, old sayings, sculptures and paintings (Lee et al. 2013). Probably, *Bum* has been one of the most popular subjects in Korean culture and society. Despite their ecological absence (tigers since 1924 and leopards since 1970), their cultural importance has not diminished. For example, the mascot of the 1988 Seoul Olympics was a tiger, and Koreans still describe the shape of the Korean peninsula as a tiger roaring at the continent. Regardless of their long absence, both species are still listed in the Korean endangered species list (Ministry of Environment 2005).

Although Korean tigers and leopards no longer exist in South Korea, they have not been completely wiped out in the wild. They are the same species as the currently endangered Amur tiger (*Panthera tigris altaica*) and Amur leopard (*Panthera pardus orientalis*), which survive in the Russian Far East and Northeast China (Lee et al. 2012; IUCN 2014; Miquelle 2015; Qi et al. 2015). This fact has led some politicians and advocates to unsuccessful attempts to reintroduce wild tigers in South Korea, mostly motivated by nostalgia, potential economic benefit, and the desire of political popularity but with little evidence (Cho 2008; Kim 2010; Seeley & Skabelund 2015). But a recent feasibility study of tiger reintroduction tentatively concluded that tiger restoration in South Korea is extremely difficult due to the lack of suitable habitat to accommodate viable tiger populations and the high potential of human-tiger conflict (Lee et al. 2013). The Lee's study, instead, opened the discussion regarding leopard restoration in South Korea. Unlike Amur tigers that retain extensive and exclusive home ranges (384km^2 for tigress), Amur leopards keep nonexclusive and smaller home ranges (33~139km^2 for a female leopard) (Salmanova 2008; Goodrich et al. 2010; Lee et al. 2013; Spitzen et al. 2013). Amur leopards are also expected to cause less conflict with humans than Amur tigers due to their smaller body size and lower energy requirements (Goodrich et al. 2011; Spitzen et al. 2013). Furthermore, the critically endangered status of Amur leopards calls for compelling conservation actions (IUCN 2014).

Reintroduction is a useful conservation tool to rebuild a viable population of (locally) extinct species in their original ranges. However, it can be very challenging (IUCN/SSC 2013). The reintroduction of large carnivores is highly complex, requires immense financial, human and technical resources and time, and has had a low chance of success so far (Breitenmoser et al. 2001; Hayward et al. 2007; Jule et al. 2008; Macdonald 2009; IUCN/SSC 2013). Therefore, reintroduction should be carefully considered and planned. For a reintroduction to be successful, it requires a systematic approach in its planning to thoroughly review potential ecological and social factors influencing the reintroduction as well as to disclose uncertainties underlying those factors in order to maximize success with limited resources (Pressey et al. 2007; Rondinini & Boitani 2007; Margoluis et al. 2009;

Grantham et al. 2010). To facilitate the selection and design of effective conservation strategies, conservation researchers and practitioners have developed several strategic planning frameworks in recent decades (Margules & Pressey 2000; Salafsky et al. 2002; Sutherland et al. 2004; Stem et al. 2005; McCarthy & Possingham 2007; Pressey et al. 2007; Kapos et al. 2008). One of these comprehensive frameworks is the Conservation Measures Partnership (CMP)'s Open Standards for the Practice of Conservation (OS) (CMP 2013). The OS is a strategic conservation planning tool that uses an adaptive management approach to enhancing effectiveness and efficiency of conservation projects (Schwartz et al. 2012; CMP 2013). The Miradi Software Program (Miradi) was developed to visualize and document the OS process.

Although reintroduction of Amur leopard in South Korea has been considered, there has been no comprehensive effort to systematically review the potential or process of the reintroduction. This resulted in insufficient understanding of the current situation and futile discussions. Therefore, with the urgent need of a systematic approach, we developed a conceptual framework using the OS and Miradi in this study to assess the current and future situations and thus to increase the success and effectiveness of Amur leopard restoration in South Korea (Miradi 2016). To develop a conceptual framework, we 1) clarified the scope, vision, and conservation targets of the restoration project, 2) assessed the current status of the targets, 3) assessed direct threats to the targets and identified associated contributing factors, 4) developed a diagram-based conceptual model to graphically illustrate the planning rationale and process, and 5) prioritized restoration strategies to mitigate major direct threats. We use the results from this conceptual framework to define research gaps, such as status of targets and direct threats, that need to be addressed in the process of restoration; to facilitate the communication among project stakeholders including decision makers, donors and partners to explicitly understand the overall perspective and complexities of the leopard restoration; to carefully estimate the feasibility of the restoration; and to determine parameters of what is needed to successfully restore Amur leopards in a systematic way. Furthermore, the framework also provides a good example of the systematic planning process to other potential and current conservation and restoration projects worldwide.

METHODS

Study Area

The geographic scope of our project was the potential leopard habitat around the southeast region of the Korean Demilitarized Zone (DMZ) in South Korea (Figure 3.1). The DMZ has served as the de facto border between South and North Korea since the Korean War. According to the agreement, the DMZ is supposedly about 4km wide, 2km north and south from the Military Demarcation Line, which is about 992km^2, but its current width is as small as 0.7km. Although little is known about the ecology of the DMZ due to its inaccessibility, there has been a high expectation for the DMZ's potential as a reservoir of biodiversity in Korea. The DMZ region of South Korea includes the DMZ, Civilian Control Zone (CCZ) and 10 neighboring counties. It is divided into 5 different landscapes – eastern coastal area, eastern mountainous area, central wetland area, western plain area, and western Han River estuary area. In our study, however, we excluded the DMZ from the project scope due to the current inaccessibility and high uncertainty of the future condition of this area even though we still call our study area the DMZ region. No action is allowed within the DMZ without agreement between North and South Korea, and it is unlikely that the tense political situation will improve in the near future.

To determine the scope, we initially determined the potential habitat of the leopards based on previous potential leopard habitat models and then divided it into two zones, 687 km^2 of core zone and 1,883 km^2 of buffer zone according to its suitability based on expert knowledge and spatial attributes such as the locations of roads, human settlements and dams (Choi 2005; Jeon et al. 2008; National Institute of Environmental Research 2013). The core zone showed the highest habitat suitability with a high potential to become a protected area, while the buffer zone showed moderate habitat suitability and needs improvement of ecological conditions in order to support a viable leopard population. In addition, human population density is very low in our study area compared to the average density of South Korea (509.2/km^2). The core zone contains very limited human settlements, and the human population density of the buffer zone is about 25.6/km^2 (Korean Statistical Information Service 2015). Most local communities are farmers or livestock breeders in the study area and occasionally collect Non-Timber Forestry Products (NTFPs) in nearby forests.

Our study area encompasses the mid-eastern mountainous area and eastern coastal area of the DMZ region, which is a part of the major ecological network of the Korean Peninsula. Characterized by high mountains and dense temperate forest, this area is home to endangered wildlife, such as long-tailed gorals (*Naemorhedus caudatus*) and Siberian musk deer (*Moschus moschiferus*). It has a continental climate with cold and snowy winters, and hot and humid summers. The eastern coastal area has heavy snow in the winters. The average temperature is 10.2 (range -5.5~23.8) with 1391 mm of annual precipitation.

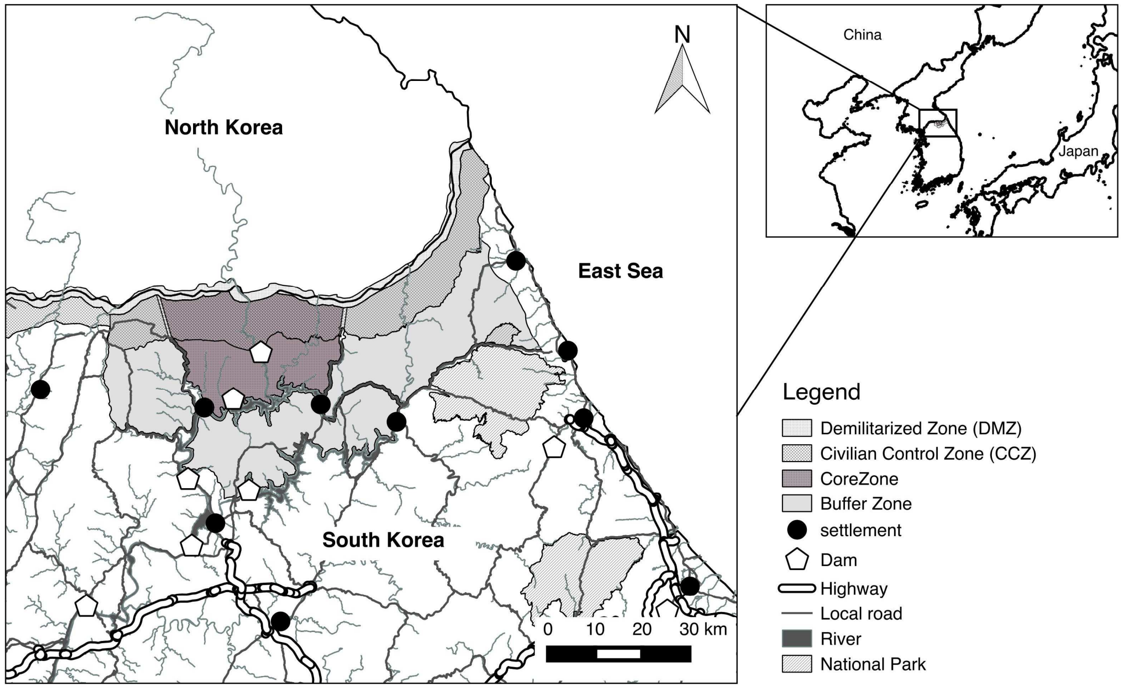

Figure 3.1 A potential leopard habitat south east of the Korean Demilitarized Zone (DMZ)

Open Standard Steps

The Open Standard (OS) has a five-step project management cycle which are 1) Conceptualize the Project Vision and Context, 2) Plan Actions and Monitoring, 3) Implement Actions and Monitoring, 4) Analyze Data, Use the Results, and Adapt, and 5) Capture and Share Learning (Margoluis et al. 2009; CMP 2013). In our study, however, we largely focus on Step 1 and the first part of Step 2 of the Open Standard to develop a conceptual model for Amur leopard restoration planning.

Project vision and conservation targets

After defining the project scope, we developed a project vision, which is relatively general and brief (CMP 2013). It presents a broad direction and purpose of our project. Next we identified conservation targets of our project. Conservation targets are typically ecosystems or species that explicitly show what to conserve or where to focus conservation efforts among all components of biodiversity within the project's scope. (Salafsky et al. 2002; Margoluis et al. 2009; Groves & Game 2016). In addition to conservation targets, we also identified human wellbeing targets and related ecosystem services that demonstrate the effect of conservation work on people. Human wellbeing targets are affected by the status of conservation targets and ecosystem services which are dependent upon biodiversity conservation (McShane et al. 2011; CMP 2012).

Assessing viability of targets and define goals

Once we determined where and what to focus our conservation efforts on, we evaluated the health and current status of our conservation targets. In this process, we identified the Key Ecological Attributes (KEAs) for each conservation target, which define the health of the targets in aspects of biology and ecology. KEAs were divided into three types, size (e.g. area and abundance), condition (e.g. biological composition, structure and biotic interactions), and landscape context (e.g. ecological processes and connectivity) (Parrish et al. 2003; FOS 2009). We then determined associated indicators for each KEA, which provide a specific measurement over time, to monitor and evaluate changes in KEAs. Indicators measure the status of KEAs with four scales: Poor, Fair, Good, and Very Good (FOS 2009; CMP 2013). Very Good refers to ecologically desired status which needs little conservation intervention; Good refers to status within acceptable range which requires some intervention; Fair indicates status outside of acceptable range which requires human intervention; and Poor describes status that restoration is difficult (FOS 2009). The measurement units of the indicators were either quantitative (e.g. number of leopards) or qualitative (e.g. moderately fragmented) depending on the available information. We identified at least one indicator per KEA as well as the reference ranges, which are a set of thresholds or boundaries for the four scale classification, for each indicator based on the information from the literature and expert knowledge. We especially referred to the guideline of Amur leopard reintroduction in the Russian Far East to estimate the reference ranges of the indicators for the Amur leopard and prey in our study area (Hebblewhite et al. 2011; Kelly et al. 2013; Spitzen et al. 2013). Then, we reviewed governmental reports and research papers, normally written in Korean, to gather data regarding the current status of prey density and habitat. After selecting measurement range and current status, we then developed goals that reflect the desired future status of KEAs for our conservation targets. A good goal should be directly linked to targets, impact oriented, measurable, achievable within a specific time period, and specific enough to have the same understanding among the people involved in the project (Parrish et al. 2003; FOS 2009).

Identify and rank direct threats

Every conservation project confronts multiple threats. Threats often hinder achieving conservation goals. However, tackling all the threats is impossible with limited time and resources. Therefore, conservation practitioners often focus on a handful of direct threats that are a human activity that instantly degenerate the health of conservation targets (Salafsky et al. 2008; FOS 2009; Aziz et al. 2013). To select key direct threats to our conservation targets, in collaboration with four experts who understand the DMZ region and wildlife ecology in South Korea we identified all possible threats for each conservation target and then rated those threats based on the three criteria of scope, severity and irreversibility by using a four-point scale: Low, Medium, High, and Very high (See Appendix D for detailed criteria of the four-point scale for threat ranking). The scope refers to the spatial extent of damages; severity describes the level of damage to conservation targets within the scope; and irreversibility indicates the degree to which threats can be reversed and targets can be restored (FOS 2009). In our study, we used Miradi to calculate the summary threat rating by combining the scales from three criteria and distinguishing the threats as Low, Medium, High, and Very high (See Appendix B of (FOS 2009) for the Miradi calculation scheme of threat rating). Then, we selected threats with the highest ratings. We also recognized stresses that explain the negative biophysical impact of the threats.

Complete situation analysis

In addition to identification of direct threats, we determined contributing factors, which are composed of indirect threats, opportunities and other important variables that influence direct threats either positively or negatively in order to complete the situation analysis. Indirect threats are a driver of direct threats, and opportunities refer to a factor which potentially has a positive effect on conservation targets either directly or indirectly. Contributing factors often provide an intervention point for conservation actions(FOS 2009). With the selected targets, key direct threats, associated contributing factors, we developed a conceptual model, a diagram depicting the problem analysis. While arrows describe the assumed relationship between factors in the problem analysis, each component was presented with different colors and shapes, such as targets in a green rectangle, direct threats in a red rectangle, and strategies in a yellow hexagon.

Prioritize strategies

We used the conceptual model to identify potential intervention points and strategies to mitigate the threats and to achieve the goals. A good strategy is directly linked to critical factors, focused, feasible and appropriate to fit site-specific cultural, social, and biological norms (FOS 2009). We then assessed each strategy based on the potential impact and feasibility. The potential impact is the likelihood to mitigate a threat and to restore a target, and feasibility refers to the likelihood to implement the strategy within time, ethical, technical, and financial restraints (Salafsky et al. 2008; FOS 2009). Similar to threat rating, we evaluated both potential impact and feasibility with a four-scale system from Low to Very High. Then, we used the Miradi to categorize our strategies into Less Effective, Effective and More Effective based on roll-up rating (FOS 2009; Miradi 2016). See the Appendix E for the detailed criteria for prioritizing strategies.

RESULTS

Project vision and conservation targets

Within the project scope, our vision was the restoration of viable Amur leopard population in South Korea for improved biodiversity and ecosystems and the benefit of future generation. In our study, we selected three critical conservation targets, which reflect our project vision while representing the biodiversity in the potential leopard habitat.
Our targets were Amur leopards, leopard prey, and their habitat that are the essential components of the restoration. The Amur leopard is our focal species, and currently, only about 50 individuals are left around the Sino-Russian border (Spitzen et al. 2013). Prey and habitat, fundamental for the survival of the leopards, determine their population size and viability (Stoneking et al. 2002; Hebblewhite et al. 2011; Brooke et al. 2014). In addition to these three biological conservation targets, we identified three human wellbeing targets that demonstrate the effect of the leopard restoration on people. They were economic improvement, cultural cohesion, and spiritual and physical health which provided

regulating and cultural services. Human wellbeing targets are especially important for local people utilizing the potential leopard habitat because they can increase local people's tolerance and acceptance of the reintroduced leopards. However, as human wellbeing targets do not exclusively influence people within the project scope, the scope of human wellbeing targets included not only local people within the potential habitat but also the general public of South Korea who will experience *Bum* culture.

Viability assessment and goals of conservation targets

In our viability assessment, the selected KEAs were population size, reproductive success, and survival for the Amur leopard; major prey density, prey biomass, and distribution for the leopard prey; and habitat fragmentation and forest fire occurrence for the habitat mainly based on the Amur leopard reintroduction program in the Russian Far East (Spitzen et al. 2013). Each KEA had one to four indicators. In our study, because Amur leopards have not been restored yet, current status of Amur leopard was noted as not available for now. On the other hand, current status of the prey was Good in the four scale classification. Among indicators of the major prey density, water deer (*Hydropotes inermis argyropus*) density and wild boar (*Sus scrofa*) density were especially high, while no information is available for the roe deer (*Capreolus pygargus*) density and goral (*Naemorhedus caudatus*) density was low. The high density of water deer and wild boar mostly contributed to the Very Good status of total prey biomass and thus of the major prey density. The current status of habitat was Fair. Large forest fires of over 30 ha occurred relatively frequently, about every 8 years, which led to Poor status, but the connectivity of our study area was Good (Table 3.1).

After understanding the current status of each conservation target, our goals of the Amur leopard restoration reflected desired future status of each indicator. In 15 years the core area and buffer zone could support over 30 Amur leopards with a survival rate of over 0.7 per annum, including at least 10 breeding females which have a reproduction frequency of 2~3 years (Spitzen et al. 2013). Secondly, we maintained a Very Good status of major prey density (see Table 3.1 for the specific species and their density measures) and at least 820,000 kg of total prey biomass with over 90% of prey presence in the study area (Han et al. 2013; Spitzen et al. 2013). Lastly, we kept the habitat with little fragmentation and reduced large forest fire occurrence to at least 15 years in the same time period (Lee et al. 2004; Choi 2005; Lee & Lee 2006; Jeon et al. 2008; Korea Forest Serive 2015).

Table 3.1 Viability Assessment of three conservation targets

Item	Current status	Unit	Measurement Range				Sources
			Poor	Fair	Good	Very Good	
KEA1: population size							
I-1: number of total leopards	NA	number	<15	15 - 29	30 - 50	>50	S[1]
I-2: number of breeding females	NA	number	<7	7 - 9	10 - 15	>15	S[1]
KEA2: reproductive success							
I: reproduction frequency	NA	years	every >4	every 3~4	every 2~3	every 2	S[1]
KEA3: survival							
I: survival rate	NA	%	<0.5	0.5-0.6	0.7 – 0.9	1	S[1]
KEA1: major prey density							
I-1: goral density	0.14	$/km^2$	<0.11	0.11 - 0.15	0.16 - 0.20	>0.20	
I-2: roe deer density	NA	$/km^2$	<1.0	1.0 - 1.9	2.0 - 3.0	>3.0	
I-3: water deer density	5.9	$/km^2$	<1.0	1.0 - 2.9	3.0 - 5.0	>5.0	S[1], H[2]
I-4: wild boar density	4.5	$/km^2$	<1.0	1.0 - 1.9	2.0 - 3.0	>3.0	S[1], H[2]
KEA2: prey biomass							
I: total prey biomass	>820,858	kg	<250,000	250,000 - 489,999	490,000 - 820,000	>820,000	C[3]
KEA3: prey distribution							
I: prey occupancy	0.9-0.99	%	<0.80	0.80-0.89	0.9-0.99	1	E[4]
KEA1: habitat fragmentation							
I: connectivity	little fragmented	landscape context	highly fragmented	moderately fragmented	little fragmented	not fragmented	E[4], C[5],J[6]
KEA2: forest fire occurrence							
I: frequency of large forest fire (>30ha)	8	years	<10	10 - 14	15-20	<20	L[7], L[8], K[9]

I: indicator

NA: information Not Available

S[1]: (Spitzen et al. 2013), H[2]: (Han et al. 2013), C[3]: (Stoneking et al. 2002), E[4]: Expert knowledge, C5: (Choi 2005), J[6]: (Jeon et al. 2008), L[7]: (Lee et al. 2004), L[8]: (Lee & Lee 2006), K[9]: (Korea Forest Serive 2015)

Identify and rank direct threats

We identified eight potential direct threats that are likely to pose a risk to our conservation targets. Those threats were: 1) removing unsuited leopards from the habitat, 2) illegal hunting of leopards and prey (Spitzen et al. 2013; Robinson et al. 2015), 3) disease from domestic animals and other wildlife to leopards and prey (Sung et al. 2010; Cha et al. 2012; Seimon et al. 2013; Cho et al. 2015), 4) greenhouse gas emissions (Post & Stenseth 1999; Im et al. 2011; Shin et al. 2016), 5) road kill of leopards and prey (Choi et al. 2008), 6) uncontrolled intensive forest fire of over 30 ha in the habitat (Lee et al. 2004; Lee & Lee 2006), 7) buried mines in the CCZ (Dudley et al. 2002), and 8) building roads and cable cars within the habitat (Kerley et al. 2002). Among the eight potential threats, we rated the first four threats to pose a medium threat to our conservation targets, while we rated the other threats as low (Table 3.2). Especially, removing unsuited leopard, illegal hunting, and disease from domestic animals and other wildlife posed a high threat to the Amur leopard. For the prey, only greenhouse gas emissions, which lead to heavy snowfall (Post & Stenseth 1999; Im et al. 2011; Shin et al. 2016), posed a medium threat while all other threats were rated as low. Among the eight potential threats, three of them, greenhouse gas emissions, uncontrolled intensive forest fire, and building roads and cable cars, were related to the habitat and posed a medium threat. This threat rating indicated that the first four threats have higher priority to intervene. Therefore, we determined to focus on those four threats to identify contributing factors and develop strategies (Figure 3.2). During this process, the habitat as a conservation target was discarded for further consideration. Although it was still important, the four high priority threats did not influence the habitat. Therefore, no conservation action was required at this time.

Unlike other direct threats, which used contributing factors to explain drivers, Greenhouse gas emissions causing climate change used stresses instead to describe the result of greenhouse gas emissions to our conservation targets because drivers of Greenhouse gas emissions were rather broad and often beyond the scope of our project. That is, the expected result of climate change was changes in precipitation, especially frequent heavy snowfall during the winter in our study area. This deep snow cover would make both leopards and prey hard to find food in winter by restricting their movement and thus increase their mortality (Post & Stenseth 1999; Spitzen et al. 2013; Choi 2014) (Figure 3.2). In addition, as assessed in the threat rating, Greenhouse gas emissions were expected to more negatively affect to prey than leopards (Post & Stenseth 1999; Choi 2014; Luo et al. 2015).

Table 3.2 Threat rating for conservation targets

	Amur leopard				Prey				Habitat				Summary threat rating
	Scope	Severity	Irreversibility	Threat rating	Scope	Severity	Irreversibility	Threat rating	Scope	Severity	Irreversibility	Threat rating	
Removing unsuited leopards	H	H	M	H									M
Illegal hunting	H	V	M	H	M	L	L	L					M
Disease from domestic animals and wildlife	H	V	H	H	M	L	L	L					M
Greenhouse gas emission	V	M	H	M	V	M	H	M	V	M	H	M	M
Road kill	M	H	M	M	M	L	L	L					L
Uncontrolled intensive forest fire	L	L	L	L	L	M	L	L	M	M	M	M	L
Mines	M	H	M	M	M	L	L	L					L
Building roads and cable cars	L	M	L	L	L	M	M	L	M	M	H	M	L

L Low, M – Medium, H- High, V- Very high

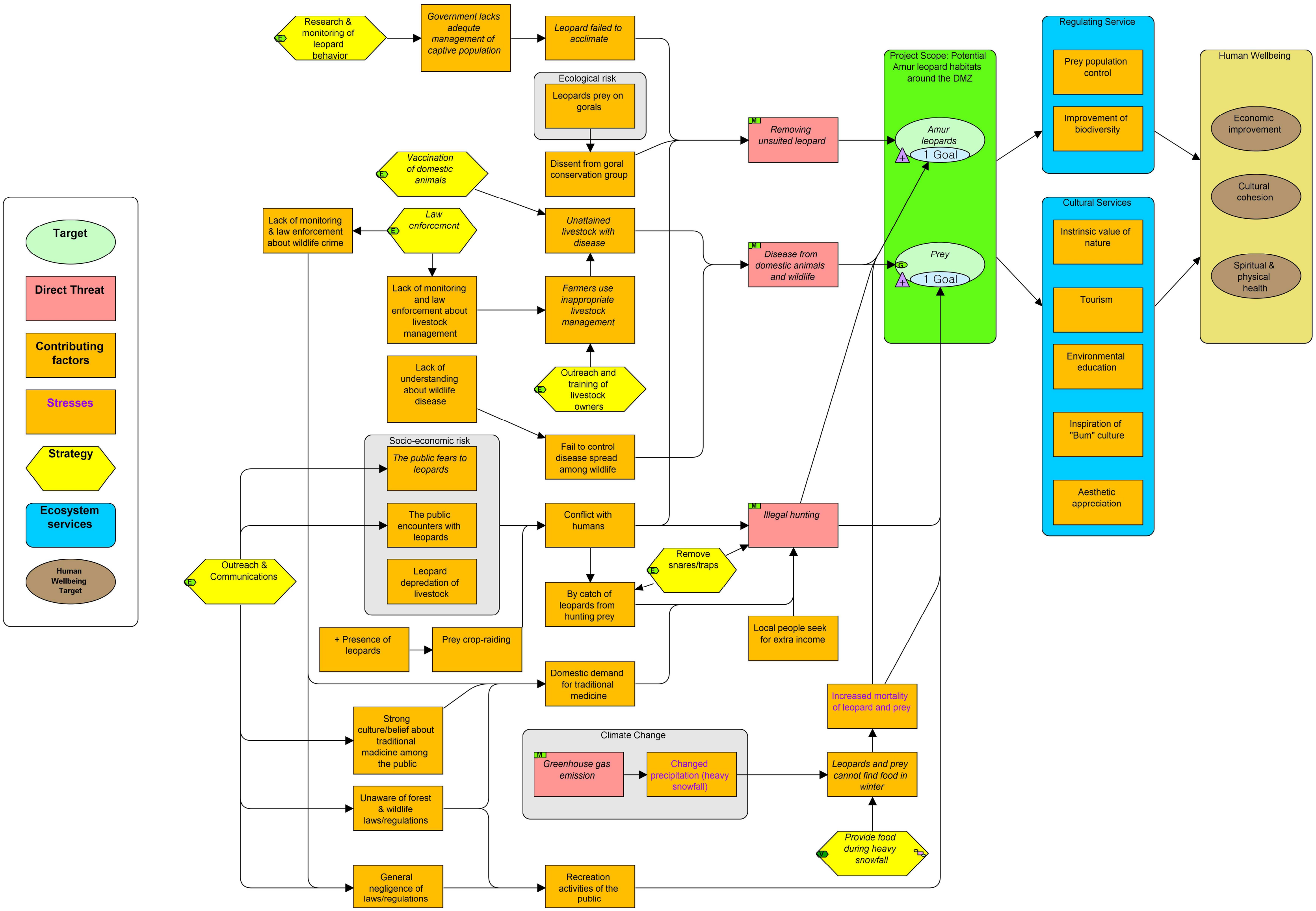

Figure 3.2 A Conceptual Model and strategies for Amur leopard restoration in South Korea

Complete situation analysis

We identified 22 contributing factors composed of 21 indirect threats and one opportunity (Figure 3.2). One or more contributing factors influenced the direct threats and other contributing factors. For example, conflict with humans is expected to be an indirect threat leading to two direct threats, removing unsuited leopard and illegal hunting of leopard and prey, and another indirect threat, by-catch of leopards from hunting prey (Treves et al. 2006; Barlow et al. 2013; Becker et al. 2013; Saif et al. 2016). The conflict with humans is expected as the result of direct interactions with leopards (e.g., encounter with leopards and livestock depredation) as well as indirect interaction (e.g., fear to leopards) (Inskip & Zimmermann 2009; Goodrich 2010). We grouped these three contributing factors as socio-economic risks, which comply with the socio-economic aspect of the risk assessment in the IUCN's reintroduction guide (IUCN/SSC 2013). Likewise, leopards preying on gorals, the first class endangered species by Korean Wildlife Conservation and Management Law, were classified as ecological risk due to the habitat overlap between the two protected species (Ministry of Environment 2005; IUCN/SSC 2013; Spitzen et al. 2013). The opportunity of prey's crop raiding was the presence of Amur leopard as they control prey population, one of regulating services of ecosystem services (Figure 3.2). This opportunity provided a positive feedback loop of the leopard reintroduction.

Prioritize Conservation Strategies

Based on this situation analysis, we identified 13 strategies to potentially reduce the direct threats and improve the condition of the leopard and prey (Table 3.3). Evaluation of the potential impact and feasibility for each strategy concluded that seven strategies were considered effective: 1) providing food during heavy snowfall (Post & Stenseth 1999), 2) research and monitoring of leopard behaviors (Jochum et al. 2014; Trolliet et al. 2014) , 3) law enforcement regarding wildlife crime and inappropriate livestock management (Goodrich 2010; Linkie et al. 2015; Johnson et al. 2016), 4) outreach and training of livestock owners (Goodrich 2010; Pettigrew et al. 2012), 5) vaccination of domestic animals (Goodrich et al. 2012), 6) public conservation outreach and communication (Jenks et al. 2010; Saypanya et al. 2013), and 7) removing snares and traps (Becker et al. 2013; Soh et al. 2014). Those effective strategies had higher priority to implement. Providing food during heavy snowfall was particularly rated to be very effective because it can directly decrease the morality of leopards and prey (Very high in potential impact) with relatively low cost and technique (Very high in feasibility).

Combining all critical components - two conservation targets, four direct threats, 21 contributing factors, one opportunity, two stresses as well as three human wellbeing targets and associated seven ecosystem services - the conceptual model provided overall perspective of the Amur leopard restoration in South Korea. In addition, seven effective strategies identified using the conceptual model showed intervention points (Figure 3.2).

Table 3.3 Prioritization of strategies

Strategy	Evaluation Criteria		Priority	Involved threats
	Potential Impact	Feasibility		
Provide food during heavy snowfall	Very High	Very High	Very effective	F
Research & monitoring of leopard behavior	High	Very High	Effective	Rm
Law enforcement	High	Very High	Effective	I, D
Outreach and training of livestock owners	High	Very High	Effective	D
Vaccination of domestic animals	High	High	Effective	D
Outreach & communication	High	Very High	Effective	I, Rm
Remove snares & traps	High	High	Effective	I
Research & monitoring of wildlife health	High	Medium	Less effective	D
Vaccination of wildlife (disease carriers)	High	Medium	Less effective	D
Prevention and compensation	Medium	Very High	Less effective	I
Ecological risk assessment	Medium	Very High	Less effective	Rm
Additional income	Medium	High	Less effective	I
Improve rehabilitation program	Medium	Medium	Less effective	Rm

F: Leopards and prey cannot find food in winter, I: Illegal hunting, Rm: Removing unsuited leopard, D: Disease from domestic animals and wildlife

DISCUSSION

Systematic planning can increase the success of conservation projects by explicitly laying out their structure and context, which reflects the dynamic and complex project conditions to the stakeholders and provides a guidance to efficiently evaluate the project progress (Carroll et al. 2003; Rondinini & Boitani 2007; Margoluis et al. 2009; Grantham et al. 2010; Stephenson & Ntiamoa-Baidu 2010; Schwartz et al. 2012; Aziz et al. 2013; Johnson et al. 2016). In our study, using the OS for planning the Amur leopard restoration was particularly useful for explicating what the current situation is and what the next step should be.

The target viability assessment indicated a Good status for the leopard prey and Fair status for the habitat, and threat rating showed low-to-medium level of threats affecting these targets. These results can imply the positive sign of ecological feasibility for the leopard restoration in South Korea, and are consistent with the opinions of experts who participated in the discussion about the restoration of large predators in South Korea coordinated by Korean Ministry of Environment. However, fair status of habitat due to high frequency of large forest fires seemed to need adjustment. As forest statistics did not provide exact spatial coordinates, actual large forest fire frequency in our study area could be fewer.

During the viability assessment, however, we recognized some critical knowledge gaps, one of which is the lack of data regarding roe deer density. The diet of Amur leopards is largely constituted of ungulates (over 50%), such as roe deer and sika deer (*Cervus nippon*) in the Russian Far East (Kerley & Borisenko 2007; Spitzen et al. 2013). In South Korea, sika deer no longer exist in the wild but roe deer do. Therefore, although total prey biomass, which included secondary prey such as hares, badgers, and raccoon dogs that the Amur leopards prey on, was sufficient to support a viable leopard population (Kerley & Borisenko 2007; Spitzen et al. 2013), it is still necessary to understand the status of the primary prey species for the long-term survival of the leopards. In this way, our viability assessment helped to identify knowledge gaps that provide a guideline for future actions for the Amur leopard restoration.

In addition to the ecological feasibility, the conceptual model also highlighted the importance of socio-economic aspects as contributing factors for the leopard restoration. The socio-economic aspect is as important as the ecological aspect in a highly human-dominated landscape of South Korea because human-carnivore conflict is one of the most critical issues in large carnivore conservation (Treves & Karanth 2003; Treves & Naughton-Treves 2005; Barlow et al. 2010; Wieczorek Hudenko 2012; Inskip et al. 2016). Without addressing potential conflicts between reintroduced leopards and people, leopard restoration would be nearly impossible. As recommended strategies in our study, preventative measures including training livestock owners and outreach to local communities and the public were considered to be more effective than compensation or providing additional income. However, a prioritizing system of the OS based on two criteria of potential impact and feasibility was not a very rigorous and could be improved.

No matter how thoroughly people plan, every conservation project contains uncertainties from various sources, such as lack of information, policy changes, and financial changes. Likewise, although we carefully followed the systematic planning approach, uncertainties regarding the leopard restoration still remained due to insufficient data on the current status and threats of our conservation targets. For example, the baseline data used to estimate the major prey density and prey distribution were rather coarse and might not be accurate enough to reflect the situation of our study area. The geographical scope for the density estimation covered a much larger area than our study area and most baseline sampling units did not include our study area. Furthermore, little research has been done on the wildlife diseases in South Korea. Consequently, the threat rating about the disease from domestic animals and wildlife was solely made by veterinarian's empirical knowledge and is subject to change as more study is conducted. These uncertainties should be appropriately addressed in conservation planning.

The OS uses an adaptive management which allows making changes and improvement easy even during the project cycle to handle uncertainties (McCarthy & Possingham 2007; Barlow et al. 2008; Fontaine 2011; Schwartz et al. 2012). We also acknowledged uncertainties in our restoration planning. In the case that major prey density is overestimated, it is inevitable to re-review the feasibility of the restoration and selected strategies accordingly. We can also calibrate our scope to include the DMZ or buffer zones when the political situation between North and South Korea becomes better or reintroduced leopards disperse from the core zone. Accordingly, we can add more prey species, such as musk deer (*Moschus moschiferus parvipes*), to the KEA and can also include new threats that could affect the conservation targets. Our prioritized strategies involved law enforcement, monitoring of prey and conservation outreach based on current available information. However, the priorities can be changed if the current situation changes or we use more thorough rating criteria. For example, under increasing conflict between reintroduced leopard and people, implementing prevention and compensation could have higher priority.

Based on the knowledge gaps and uncertainties identified during the restoration planning process, we recommend the thorough research on major prey density in the potential restoration site in preparation of the Amur leopard restoration. A clear understanding of prey status will help to assess the restoration feasibility more accurately and develop appropriate conservation strategies. Moreover, high prioritized strategies in our analysis revealed the needs of developing community outreach programs to reduce the potential socio-economic risk and increase the local tolerance; implementing law enforcement to stop illegal activities; and vaccinating domestic animals to prevent possible disease spread from domestic animals to Amur leopards and their prey to prepare the Amur leopard restoration in South Korea.

In the planning process, we explicitly defined where the restoration project is and what we try to accomplish, and identified and prioritized what to focus on, and where and how to intervene based on specifically defined criteria for each stage. This clarity will help to avoid possible confusion and miscommunication among multiple stakeholders from different disciplines, including ecologists, veterinarians, and conservation practitioners, in the decision-making process. Although necessary information is not all available at this moment, our conceptual framework provides a good starting point to understand and prepare for Amur leopard restoration in South Korea. Follow-up research is needed to focus on information gaps found during this study.

Literature Cited

Ahmed RA, Prusty K, Jena J, Dave C, Vihar SC. 2012. Prevailing Human Carnivore Conflict in Kanha-Achanakmar Corridor , Central India Department of Wildlife and Conservation Biology , North Orissa University ,. Journal of Zoology **7**:158–164.

Alexander CS, Becker HJ. 1978. The Use of Vignettes in Survey Research. The Public Opinion Quarterly **42**:93–104.

Atzmüller C, Kromer I. 2013. Peer Violence: Gewalt unter Jugendlichen aus der Perspektive von Mädchen und Burschen. Vienna, Austria.

Atzmüller C, Kromer I. 2014. Peer Delinquency: Wahrnehmung und Bewertung typischer Jugenddelikte aus der Sicht Jugendlicher als Grundlage für Präventionsmaßnahmen. Vienna, Austria.

Atzmüller C, Steiner PM. 2010. Experimental Vignette Studies in Survey Research. Methodology **6**:128–138. Available from http://econtent.hogrefe.com/doi/abs/10.1027/1614-2241/a000014.

Auspurg K, Hinz T. 2015. Factorial Survey Experiments. SAGE Publications, Inc.

Aziz A, Barlow AC, Greenwood CC, Islam A. 2013. Prioritizing threats to improve conservation strategy for the tiger Panthera tigris in the Sundarbans Reserve Forest of Bangladesh. Oryx **47**:1–9. Available from http://journals.cambridge.org.ezproxy.library.wisc.edu/production/action/cjoGetFulltext?fulltextid=8956866%5Cnhttp://journals.cambridge.org.ezproxy.library.wisc.edu/action/displayFulltext?type=1&fid=9016201&jid=ORX&volumeId=47&issueId=04&aid=9016199&bodyI.

Bangs EE, Fritts SH. 1996. Reintroducing the Gray Wolf to Central Idaho and Yellowstone National Park. Wildlife Society Bulletin **24**:402–413.

Barber-Meyer SM et al. 2013. Influence of prey depletion and human disturbance on tiger occupancy in Nepal. Journal of Zoology **289**:10–18.

Barlow ACD, Ahmad I, Smith JLD. 2013. Profiling tigers (Panthera tigris) to formulate management responses to human-killing in the Bangladesh Sundarbans. Wildlife Biology in Practice **9**:30–39.

Barlow ACD, Ahmed MIU, Rahman MM, Howlader A, Smith AC, Smith JLD. 2008. Linking monitoring and intervention for improved management of tigers in the Sundarbans of Bangladesh. Biological Conservation **141**:2032–2040.

Barlow ACD, Greenwood CJ, Ahmad IU, Smith JLD. 2010. Use of an action-selection framework for Human-carnivore conflict in the bangladesh sundarbans. Conservation Biology **24**:1338–1347.

Barua M, Bhagwat SA, Jadhav S. 2013. The hidden dimensions of human-wildlife conflict: Health impacts, opportunity and transaction costs. Biological Conservation **157**:309–316. Elsevier Ltd. Available from http://dx.doi.org/10.1016/j.biocon.2012.07.014.

Becker M, McRobb R, Watson F, Droge E, Kanyembo B, Murdoch J, Kakumbi C. 2013. Evaluating wire-snare poaching trends and the impacts of by-catch on elephants and large carnivores. Biological Conservation **158**:26–36. Available from http://linkinghub.elsevier.com/retrieve/pii/S0006320712003722.

Bottrill M, Didier K, Baumgartner J, Boyd C, Loucks C, Oglethorpe J, Wilkie D, Williams D. 2006. Selecting conservation targets for landscape-scale priority setting : A comparative assessment of selection processes used by five conservation NGOs for a landscape in Samburu, Kenya. Washington, DC, USA.

Breitenmoser U. 1998. Large predators in the Alps: The fall and rise of man's competitors. Biological Conservation **83**:279–289.

Breitenmoser U, Angst C, Landry J., Breitenmoser-Wursten C, Linnell JDC, Weber J-M. 2005. Non-lethal techniques for reducing depredation. Pages 49–71in R. Woodroffe, S. Thirgood, and A. Rabinowitz, editors.People and Wildlife, Conflict or Co-existence? Cambridge University Press, Cambridge.

Breitenmoser U, Breitenmoser-Wursten C, Carbyne LN, Funk SM. 2001. Assessment of carnivore reintroductions. Pages 241–281in J. L. Gittleman, S. M. Funk, D. Macdonald, and R. K. Wayne, editors.Carnivore Conservation. Cambridge University Press, Cambridge.

Brooke ZM, Bielby J, Nambiar K, Carbone C. 2014. Correlates of research effort in carnivores: Body size, range size and diet matter. PLoS ONE **9**:1–10.

Burstin K, Doughtie EB, Raphaeli A. 1980. Contrastive Vignette Technique: An indirect Methodology Designed to Address Reactive Social Attitude Measurement1. Journal of Applied Social Psychology **10**:147–165. Available from http://doi.wiley.com/10.1111/j.1559-1816.1980.tb00699.x.

Camargo-Gamboa G, Huerta-Quintanilla R, Rodrguez-Achach M. 2010. Ecological competition and the role of an apex predator. Physica A: Statistical Mechanics and its Applications **389**:4075–4080. Elsevier B.V. Available from http://dx.doi.org/10.1016/j.physa.2010.05.039.

Carlson BE. 1999. STUDENT JUDGMENTS ABOUT DATING VIOLENCE : A Factorial Vignette Analysis. Research in Higher Education **40**:201–220.

Caro FG, Yee C, Levien S, Gottlieb AS, Winter J, McFadden DL, Ho TH. 2012. Choosing Among Residential Options: Results of a Vignette Experiment. Research on Aging **34**:3–33. Available from http://roa.sagepub.com/cgi/doi/10.1177/0164027511404032.

Carroll C, Noss RE, Paquet PC, Schumaker NH. 2003. Use of population viability analysis and reserve selection algorithms in regional conservation plans. Ecological Applications **13**:1773–1789. Available from isi:000187616400021.

Cha S-Y, Kim E-J, Kang M, Jang S-H, Lee H-B, Jang H-K. 2012. Epidemiology of canine distemper virus in wild raccoon dogs (Nyctereutes procyonoides) from South Korea. Comparative Immunology, Microbiology and Infectious Diseases **35**:497–504. Elsevier Ltd. Available from http://dx.doi.org/10.1016/j.cimid.2012.04.006.

Chapron G, Miquelle DG, Lambert A, Goodrich JM, Legendre S, Clobert J. 2008. The impact on tigers of poaching versus prey depletion. Journal of Applied Ecology **45**:1667–1674. Available from http://www.blackwell-synergy.com/doi/abs/10.1111/j.1365-2664.2007.01428.x.

Check E. 2006. Conservation biology: the tiger's retreat. Nature **441**:927–930.

Cho A, Roh Y, Lee H, Cho H, Lim C, Kang S, Kim H-Y, Kim J, Kim B. 2015. Case report : Canine distemper virus infection in a wild Korean raccoon dog. Journal of the Preventive Veterinary Medicine **39**:29–32. Available from http://jpvm.kr/journal/article.php?code=25376.

Cho M. 2008, November. Release tigers into the forest? Maeilshinmun.

Choi J-Y. 2005. A Study on the international environmental cooperation for establishment of North East Asia ecological network. Seoul National University, Seoul, Rep. of Korea.

Choi S. 2014, February. Wildlife suffering from heavy snowfall. The Kyunghyang Shinmun. Rep. of Korea.

Choi T, Yang B, Yoo B. 2008. Overview of Measures and Research Reports to Mitigate Road-kills. Korean Journal of Nature Conservation **2**:85–90.

CMP. 2012. Addressing social results and human wellbeing targets in conservation projects. Draft Guidance. June 27. Available from http://cmp-openstandards.org/wp-content/uploads/2014/03/Guidance-on-HWT-and-Social-Results-in-Conservation-Projects-v2012-06-27.pdf.

CMP. 2013. Open Standards for the Practice of Conservation. Version 3.0.

Conforti VA, De Azevedo FCC. 2003. Local perceptions of jaguars (Panthera onca) and pumas (Puma concolor) in the Iguaçu National Park area, south Brazil. Biological Conservation **111**:215–221.

Dickman AJ. 2010. Complexities of conflict: The importance of considering social factors for effectively resolving human-wildlife conflict. Animal Conservation **13**:458–466.

Dickman AJ, Hazzah L, Carbone C, Durant SM. 2014. Carnivores, culture and "contagious conflict": Multiple factors influence perceived problems with carnivores in Tanzania's Ruaha landscape. Biological Conservation **178**:19–27. Elsevier Ltd. Available from http://dx.doi.org/10.1016/j.biocon.2014.07.011.

Dinerstein E et al. 2007. The Fate of Wild Tigers. BioScience **57**:508.

Duckworth JW, Salter REE, Khounboline K. 1999. WILDLIFE IN LAO PDR 1999 Status report. IUCN-The World Conservation Union/ Wildlife Conservation Society/ Centre for Protected Areas and Watershed Management, Vientiane.

Dudley JP, Ginsberg JR, Plumptre AJ, Hart J a, Campos LC. 2002. Effects of War and Civil Strife on Wildlife and Wildlife Habitats\nEfectos de la Guerra y Conflictos Civiles Sobre la Vida Silvestre y Sus Hábitats. Conservation Biology **16**:319–329. Available from http://dx.doi.org/10.1046/j.1523-1739.2002.00306.x.

Endo K. 2009. Why had Korean tigers disappeared? Page (Lee EO, translator). Paju.

Estes JA et al. 2011. Trophic downgrading of planet Earth. Science (New York, N.Y.) **333**:301–306.

Farrow JA. 1987. The use of vignette analysis of dangerous driving situations involving alcohol to differentiate adolescent DWI offenders and high school drivers. The American journal of drug and alcohol abuse **13**:157.

Fontaine JJ. 2011. Improving our legacy: Incorporation of adaptive management into state wildlife action plans. Journal of Environmental Management **92**:1403–1408.

Fontúrbel FE, Simonetti JA. 2011. Translocations and human-carnivore conflicts: problem solving or problem creating? Wildlife Biology **17**:217–224.

Forder V. 2006. Reintroducing Large Carnivores to Britain.

FOS. 2009. Conceptualizing and Planning Conservation Projects and Programs: A Training Manual. Foundation of Success, Bethesda, Maryland, USA.

Frechtling J. 2002. The 2002 User Friendly Handbook for Project Evaluation. National Science Foundation.

Gebbie L, Glendinning A, Braun-Lefroy R, Victor M. 2008. Diagnostic study on Northern Uplands sustainable development. Sub-Working Group on Northern Uplands Development.

GoL. 2007. Forestry Law. Lao People's Democratic Republic National Assembly.

GoL. 2008. Regulation on Protected Area and Wildlife Management in the Nam Et-Phou Louey National Protected Area.

Goodman LA. 1961. Snowball Sampling. The Annals of Mathematical Statistics **32**:148–170.

Goodrich JM. 2010. Human-tiger conflict: A review and call for comprehensive plans. Integrative Zoology **5**:300–312.

Goodrich JM et al. 2012. Serosurvey of free-ranging Amur tigers in the Russian Far East. Journal of wildlife diseases **48**:186–9. Available from http://www.ncbi.nlm.nih.gov/pubmed/22247389.

Goodrich JM, Miquelle DG, Smirnov EN, Kerley LL, Quigley HB, Hornocker MG. 2010. Spatial structure of Amur (Siberian) tigers (Panthera tigris altaica) on Sikhote-Alin Biosphere Zapovednik, Russia. Journal of Mammalogy **91**:737–748.

Goodrich JM, Seryodkin I, Miquelle DG, Bereznuk SL. 2011. Conflicts between Amur (Siberian) tigers and humans in the Russian Far East. Biological Conservation **144**:584–592. Elsevier Ltd. Available from http://dx.doi.org/10.1016/j.biocon.2010.10.016.

Grantham HS, Bode M, McDonald-Madden E, Game ET, Knight AT, Possingham HP. 2010. Effective conservation planning requires learning and adaptation. Frontiers in Ecology and the Environment **8**:431–437.

Groves CR, Game ET. 2016. Conservation Planning: Informed Decisions for a Healthier Planet. Greenwood Village, CO: Roberts & Company.

Han S et al. 2013. Survey and Resource Management of Wildlife. 11-1480592-285–1. National Institute of Bioloigcal Resources, Rep. of Korea.

Harihar A, Pandav B, Goyal SP. 2009. Responses of tiger (Panthera tigris) and their prey to removal of anthropogenic influences in Rajaji National Park, India. European Journal of

Wildlife Research **55**:97–105. Available from http://link.springer.com/10.1007/s10344-008-0219-2.

Hayward MW et al. 2007. Practical considerations for the reintroduction of large, terrestrial, mammalian predators based on reintroductions to South Africa's eastern Cape province. The Open Conservation Biology Journal **1**:1–11.

Hebblewhite M, Miquelle DG, Murzin AA, Aramilev V V., Pikunov DG. 2011. Predicting potential habitat and population size for reintroduction of the Far Eastern leopards in the Russian Far East. Biological Conservation **144**:2403–2413. Elsevier Ltd. Available from http://dx.doi.org/10.1016/j.biocon.2011.03.020.

Hemson G, Maclennan S, Mills G, Johnson P, Macdonald D. 2009. Community, lions, livestock and money: A spatial and social analysis of attitudes to wildlife and the conservation value of tourism in a human-carnivore conflict in Botswana. Biological Conservation **142**:2718–2725. Elsevier Ltd. Available from http://dx.doi.org/10.1016/j.biocon.2009.06.024.

Hillen MA, van Vliet LM, de Haes HCJM, Smets EMA. 2013. Developing and administering scripted video vignettes for experimental research of patient-provider communication. Patient Education and Counseling **91**:295–309. Elsevier Ireland Ltd. Available from http://dx.doi.org/10.1016/j.pec.2013.01.020.

Hox JJ, Kreft IGG, Hermkens PLJ. 1991. The Analysis of Factorial Surveys. Sociological Methods & Research **19**:493–510.

Hughes R, Huby M. 2002. The application of vignettes in social and nursing research. Journal of Advanced Nursing **37**:382–386.

Im ES, Jung IW, Bae DH. 2011. The temporal and spatial structures of recent and future trends in extreme indices over Korea from a regional climate projection. International Journal of Climatology **31**:72–86. Available from http://doi.wiley.com/10.1002/joc.2063.

Inskip C, Carter N, Riley S, Roberts T, MacMillan D. 2016. Toward Human-Carnivore Coexistence: Understanding Tolerance for Tigers in Bangladesh. PLOS ONE **11**:e0145913. Available from http://dx.plos.org/10.1371/journal.pone.0145913.

Inskip C, Ridout M, Fahad Z, Tully R, Barlow A, Barlow CG, Islam MA, Roberts T, MacMillan D. 2013. Human-Tiger Conflict in Context: Risks to Lives and Livelihoods in the Bangladesh Sundarbans. Human Ecology **41**:169–186.

Inskip C, Zimmermann A. 2009. Human-felid conflict: a review of patterns and priorities worldwide. Oryx **43**:18.

Ireson CJ, Ireson WR. 1991. Ethnicity and Development in Laos. Asian Survey **31**:920–937.

IUCN. 2014. The IUCN Red List of Threatened Species. Version 2014.3.

IUCN/SSC. 2013. IUCN Guidelines for Reintroductions and Other Conservation Translocations. Version 1.0. IUCN Species Survival Commission, Gland, Switzerland.

Jasso G. 2006. Factorial Survey Methods for Studying Beliefs and Judgments. Sociological Methods & Research **34**:334–423. Available from http://smr.sagepub.com/cgi/doi/10.1177/0049124105283121.

Jenks B, Vaughan PW, Butler PJ. 2010. The evolution of Rare Pride: Using evaluation to drive adaptive management in a biodiversity conservation organization. Evaluation and Program Planning **33**:186–190. Available from http://linkinghub.elsevier.com/retrieve/pii/S0149718909000755.

Jeon SW, Myeong SJ, Shin MY, Lee MJ, Zhu W. 2008. Study of On Building of Strategy of Ecological Network in East-North Asia.

Jochum KA, Kliskey AA, Hundertmark KJ, Alessa L. 2014. Integrating complexity in the management of human-wildlife encounters. Global Environmental Change **26**:73–86. Elsevier Ltd. Available from http://dx.doi.org/10.1016/j.gloenvcha.2014.03.011.

Johnson A, Goodrich J, Hansel T, Rasphone A, Saypanya S, Vongkhamheng C, Venevongphet, Strindberg S. 2016. To protect or neglect? Design, monitoring, and evaluation of a law enforcement strategy to recover small populations of wild tigers and their prey. Biological Conservation **202**:99–109. Elsevier Ltd. Available from http://linkinghub.elsevier.com/retrieve/pii/S0006320716303214.

Johnson A, Vongkhamheng C, Hedemark M, Saithongdam T. 2006. Effects of human-carnivore conflict on tiger (Panthera tigris) and prey populations in Lao PDR. Animal Conservation **9**:421–430.

Johnson A, Vongkhamheng C, Saithongdam T. 2009. The diversity, status and conservation of small carnivores in a montane tropical forest in northern Laos. Oryx **43**:626.

Johnson A, Vongkhamheng C, Saypanya S, Hansel T, Strinberg S, Strindberg S. 2012. Using systematic monitoring to evaluate and adapt management of a tiger reserve in Northern Lao PDR. 42. Bronx.

Johnson B, Christensen LB. 2004. Educational Research: Quantitative, Qualitative, and Mixed Approaches, 2nd edition. Allyn & Bacon, Inc.

Jule KR, Leaver LA, Lea SEGG. 2008. The effects of captive experience on reintroduction survival in carnivores: A review and analysis. Biological Conservation **141**:355–363. Available from http://linkinghub.elsevier.com/retrieve/pii/S0006320707004417.

Kamler JF, Johnson A, Vongkhamheng C, Bousa A. 2012. The diet, prey selection, and activity of dholes (Cuon alpinus) in northern Laos. Journal of Mammalogy **93**:627–633.

Kapos V et al. 2008. Calibrating conservation: new tools for measuring success. Conservation Letters **1**:10. Available from http://doi.wiley.com/10.1111/j.1755-263X.2008.00025.x.

Karanth KK, Nepal SK. 2012. Local residents perception of benefits and losses from protected areas in India and Nepal. Environmental Management **49**:372–386.

Kellert SR. 1985. Public perceptions of predators, particularly the wolf and coyote. Biological Conservation **31**:167–189. Available from http://linkinghub.elsevier.com/retrieve/pii/0006320785900473.

Kelly P, Stack D, Harley J. 2013. A review of the proposed reintroduction program for the far eastern leopard (Panthera pardus orientalis) and the role of conservation organizations, veterinarians, and zoos. Topics in Companion Animal Medicine **28**:163–166. Elsevier. Available from http://dx.doi.org/10.1053/j.tcam.2013.09.004.

Kerley LL, Borisenko MI. 2007. Using Scat Detection Dogs to Collect Amur leopard and tiger scats for comparative analysis. Wildlife Conservation Society.

Kerley LL, Goodrich JM, Miquelle DG, Smirnov EN, Quigley HB, Hornocker MG. 2002. Effects of roads and human disturbance on Amur tigers. Conservation Biology **16**:97–108.

Kim D. 2010, February. A boom in establishing safari in northern Kyunggi. Yonhapnews.

Kinnaird MF, O'brien TG. 2012. Effects of Private-Land Use, Livestock Management, and Human Tolerance on Diversity, Distribution, and Abundance of Large African Mammals. Conservation Biology **26**:1026–1039.

Kleiven J, Bjerke T, Kaltenborn BP. 2004. Factors influencing the social acceptability of large carnivore behaviours. Biodiversity and Conservation **13**:1647–1658. Available from http://link.springer.com/10.1023/B:BIOC.0000029328.81255.38.

Korea Forest Serive. 2015. Forest Fire Statistics.

Korean Statistical Information Service. 2015. Population density of Korea in 2015. Available from http://kosis.kr (accessed May 9, 2017).

Lee H, Kim D-J, Lim JE, Cho J-H, Chun M-S. 2013. Basic Study of Korean Tiger Culture and Restoration Possibility.

Lee KS, Choung Y, Kim S-C, Shin SS, Ro C-H, Park SD. 2004. Development of Vegetation Structure after Forest Fire in the East Coastal Region, Korea. Korean journal of Ecology and Environment **27**:99–106.

Lee M-Y et al. 2012. Subspecific Status of the Korean Tiger Inferred by Ancient DNA Analysis. Animal Systematics, Evolution and Diversity **28**:48–53. Available from http://koreascience.or.kr/journal/view.jsp?kj=DMBRBT&py=2012&vnc=v28n1&sp=48.

Lee S-Y, Lee H-P. 2006. Analysis of forest fire occurrence in Korea. Fire Science and Engineering **20**:54–63.

Lescureux N, Linnell JDC. 2010. Knowledge and perceptions of Macedonian hunters and herders: The influence of species specific ecology of bears, wolves, and lynx. Human Ecology **38**:389–399.

Lescureux N, Linnell JDC, Mustafa S, Melovski D, Stojanov A, Ivanov G, Avukatov V, von Arx M, Breitenmoser U. 2011. Fear of the unknown: local knowledge and perceptions of the Eurasian lynx Lynx lynx in western Macedonia. Oryx **45**:600–607.

Liberg O, Chapron G, Wabakken P, Pedersen HC, Hobbs NT, Sand H, Thompson Hobbs N, Sand H. 2011. Shoot, shovel and shut up: cryptic poaching slows restoration of a large carnivore in Europe. Proceedings of the Royal Society B: Biological Sciences **279**:910–915. Available from http://www.ncbi.nlm.nih.gov/pubmed/21849323%5Cnhttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC3259920.

Linkie M, Martyr DJ, Harihar A, Risdianto D, Nugraha RT, Maryati, Leader-Williams N, Wong WM. 2015. Safeguarding Sumatran tigers: Evaluating effectiveness of law enforcement patrols and local informant networks. Journal of Applied Ecology **52**:851–860.

Linnell J, Swenson JE, Andersen R. 2001. Predators and people: conservation of large carnivores is possible at high human densities if management policy is favourable. Animal Conservation **4**:345–349. Available from https://univpn.univie.ac.at/+CSCO+c0756767633A2F2F6E6363662E7666767861626A79727174722E70627A++/full_record.do?product=WOS&search_mode=GeneralSearch&qid=274&SID=X16gldAInpa94gf63E3&page=1&doc=1.

Ludwick R, Zeller RA. 2001. The factorial Survey: An experimental Method to replicate real world problems. Methodology **50**:129–133.

Luo Z, Jiang Z, Tang S. 2015. Impacts of climate change on distributions and diversity of ungulates on the Tibetan Plateau. Ecological Applications **25**:24–38. Available from http://doi.wiley.com/10.1890/13-1499.1.

Macdonald DW. 2009. Lessons Learnt and Plans Laid: Seven Awkward Questions for the Future of Reintroductions. Pages 411–448in tt W. Hayward and M. J. Somers, editors.Reintroduction of Top-Order Predators. Wiley-Blackwell.

Macdonald DW, Sillero-zubiri C. 2002. Large carnivores and conflict : Lion conservation in context. Lion conservation research. Workshop 2: modelling conflict:1–8.

Margoluis R, Stem C, Salafsky N, Brown M. 2009. Using conceptual models as a planning and evaluation tool in conservation. Evaluation and Program Planning **32**:138–147.

Margules CR, Pressey RL. 2000. Systematic conservation planning. Nature **405**:243–253.

McCarthy MA, Possingham HP. 2007. Active adaptive management for conservation. Conservation Biology **21**:956–963.

McClanahan TR, Maina J, DAVIES J, Maina J. 2005. Factors influencing resource users and managers' perceptions towards marine protected area management in Kenya. Environmental Conservation **32**:42–49. Available from http://www.journals.cambridge.org/abstract_S0376892904001791.

McShane TO et al. 2011. Hard choices: Making trade-offs between biodiversity conservation and human well-being. Biological Conservation **144**:966–972. Available from http://linkinghub.elsevier.com/retrieve/pii/S0006320710001849.

Miller CS, Petrunenko YK, Goodrich JM, Hebblewhite M, Seryodkin I V, Miquelle DG. 2011. Translocation a success, but poaching remains a problem for Amur tigers. Cat News **55**:22–25.

Ministry of Environment. 2005. Endangered Species in National Parks of Korea. Ministry of Environment.

Ministry of Environment. 2006. Endangered wild fauna and flora restoration plan (2006-2015). 11-1480000-799–1. Ministry of Environment, Rep. of Korea.

Miquelle DG et al. 2005. Searching for the Co-Existence Recipe: A Case Study Of Conflicts Between People And Tigers In The Russian Far East. Pages 305–322in R. Woodroffe, S. Thirgood, and A. Rabinowitz, editors.People and wildlife: Conflict or coexistence? Cambridge University Press, Cambridge.

Miquelle DG. 2015. The Amur tiger in Northeast Asia: Conservation and ecology of an endangered subspecies. Integrative Zoology **10**:311–314.

Miradi. 2016. http://www.miradi.org.

Mohsanin S, Barlow ACD, Greenwood CJ, Islam MA, Kabir MM, Rahman MM, Howlader A. 2013. Assessing the threat of human consumption of tiger prey in the Bangladesh Sundarbans. Animal Conservation **16**:69–76.

Morrison JC, Sechrest W, Dinerstein E, Wilcove DS, Lamoreux JF. 2007. Persistence of Large Mammal Faunas as Indicators of Global Human Impacts.

National Institute of Environmental Research. 2013. Ecosystem survey around the DMZ. 11-1480523-1735–1. Ministry of Environment, National Institute of Environmental Research, Rep. of Korea.

Parrish JD, Braun DP, Unnasch RS. 2003. Are We Conserving What We Say We Are? Measuring Ecological Integrity within Protected Areas. BioScience **53**:851.

Pettigrew M, Xie Y, Kang A, Rao M, Goodrich J, Liu T, Berger J. 2012. Human-carnivore conflict in China: A review of current approaches with recommendations for improved management. Integrative Zoology **7**:210–226.

Post E, Stenseth NC. 1999. Climatic Variability, Plant Phenology, and Northern Ungulates. Ecology **80**:1322. Available from http://www.jstor.org/stable/177078?origin=crossref.

Pressey RL, Cabeza M, Watts ME, Cowling RM, Wilson KA. 2007. Conservation planning in a changing world. Trends in Ecology and Evolution **22**:583–592.

Prugh LR, Stoner CJ, Epps CW, Bean WT, Ripple WJ, Laliberte AS, Brashares JS. 2009. The rise of the mesopredator. BioScience **59**:779–791.

Qi J, Shi Q, Wang G, Li Z, Sun Q, Hua Y, Jiang G. 2015. Spatial distribution drivers of Amur leopard density in northeast China. Biological Conservation **191**:258–265. Elsevier B.V. Available from http://dx.doi.org/10.1016/j.biocon.2015.06.034.

Quigley H, Herrero S. 2005. Characterization and prevention of attacks on humans. Pages 27–48in R. Woodroffe, S. Thirgood, and A. Rabinowitz, editors.People and Wildlife: Conflict or Coexistence? Cambridge University Press, Cambridge, UK.

R Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Rigg R, Find'o S, Wechselberger M, Gorman ML, Sillero-Zubiri C, Macdonald DW. 2011. Mitigating carnivore–livestock conflict in Europe: lessons from Slovakia. Oryx **45**:272–280.

Ripple WJ et al. 2014. Status and ecological effects of the world's largest carnivores. Science **343**:1241484.

Ripple WJ, Beschta RL. 2003. Wolf reintroduction, predation risk, and cottonwood recovery in Yellowstone National Park. Forest Ecology and Management **184**:299–313. Available from http://linkinghub.elsevier.com/retrieve/pii/S0378112703001543.

Ripple WJ, Beschta RL. 2012. Trophic cascades in Yellowstone: The first 15years after wolf reintroduction. Biological Conservation **145**:205–213. Elsevier Ltd. Available from http://dx.doi.org/10.1016/j.biocon.2011.11.005.

Ripple WJ, Larsen EJ, Renkin RA, Smith DW. 2001. Trophic cascades among wolves, elk and aspen on Yellowstone National Park's northern range. Biological Conservation **102**:227–234.

Ritchie EG, Elmhagen B, Glen AS, Letnic M, Ludwig G, McDonald RA. 2012. Ecosystem restoration with teeth: What role for predators? Trends in Ecology and Evolution **27**:265–271. Elsevier Ltd. Available from http://dx.doi.org/10.1016/j.tree.2012.01.001.

Robinson HS, Goodrich JM, Miquelle DG, Miller CS, Seryodkin I V. 2015. Mortality of Amur tigers: The more things change, the more they stay the same. Integrative Zoology **10**:344–353.

Rondinini C, Boitani L. 2007. Systematic conservation planning and the cost of tackling conservation conflicts with large carnivores in Italy. Conservation Biology **21**:1455–1462.

Rosenblatt E, Becker MS, Creel S, Droge E, Mweetwa T, Schuette PA, Watson F, Merkle J, Mwape H. 2014. Detecting declines of apex carnivores and evaluating their causes: An example with Zambian lions. Biological Conservation **180**:176–186. Elsevier Ltd. Available from http://dx.doi.org/10.1016/j.biocon.2014.10.006.

Røskaft E, Händel B, Bjerke T, Kaltenborn BP. 2007. Human attitudes towards large carnivores in Norway. Wildlife Biology **13**:172–185. Available from http://www.bioone.org/doi/abs/10.2981/0909-6396%282007%2913%5B172%3AHATLCI%5D2.0.CO%3B2.

Rossi PH. 1979. 14. Vignette Analysis: Uncovering the Normative Structur of Complex Judgements. Page 176in R. K. Merton, J. S. Coleman, and P. H. Rossi, editors.Qualitative and quantitative social research: Papers in honor of Paul F. Lazarsfeld. The Free Press, New York, NY.

Ruid DB, Paul WJ, Roell BJ, Wydeven AP, Willging RC, Jurewicz RL, Lonsway DH. 2009. Wolf-Human Conflicts and Management in Minnesota, Wisconsin, and Michigan. Page 359in A. P. Wydeven, T. R. Van Deelen, and E. J. Heske, editors.Recovery of Gray Wolves in the Great Lakes Region of the United States. Springer New York, New York, NY. Available from http://link.springer.com/10.1007/978-0-387-85952-1.

Rungtusanatham M, Wallin C, Eckerd S. 2011. The vignette in a scenario-based role-playing experiment. Journal of Supply Chain Management **47**:9–16.

Saif S, Rahman THM, MacMillan DC. 2016. Who is killing the tiger Panthera tigris and why? Oryx **9**:1–9. Available from http://www.journals.cambridge.org/abstract_S0030605316000491.

Salafsky N et al. 2008. A standard lexicon for biodiversity conservation: Unified classifications of threats and actions. Conservation Biology **22**:897–911.

Salafsky N, Margoluis R, Redford KH, Robinson JG. 2002. for Conservation Science Improving the Practice of Conservation : a Conceptual Framework and Research Agenda for Conservation Science. Conservation Biology **16**:1469–1479.

Salmanova E. 2008. Territorial use of Far Eastern leopards. Far Eastern State University.

Satoshi Y. 2004. Forest, ethnicity and settlement in the mountainous area of northern Laos. Southeast Asian Studies **42**:132–156.

Saypanya S, Hansel T, Johnson A, Bianchessi A, Sadowsky B. 2013. Effectiveness of a social marketing strategy, coupled with law enforcement, to conserve tigers and their prey in Nam Et Phou Louey National Protected Area, Lao People's Democratic Republic. Conservation Evidence **10**:57–66.

Schlemmer G. 2001. Integrated Biodiversity Conservation and Community Development in Nam Et - Phou Loei NBCAs, Lao PDR. IUCN Lao PDR Office, Vientiane, Lao PDR.

Schlemmer G. 2002. Community livelihoods analysis, Nam Et Phou Louey National Biodiversity Conservation Areas. Page World Conservation Union (IUCN) and Ministry of Agriculture and Forestry (MAF), Vientiane.

Schwartz MW, Deiner K, Forrester T, Grof-Tisza P, Muir MJ, Santos MJ, Souza LE, Wilkerson ML, Zylberberg M. 2012. Perspectives on the Open Standards for the Practice of Conservation. Biological Conservation **155**:169–177. Elsevier Ltd. Available from http://dx.doi.org/10.1016/j.biocon.2012.06.014.

Seeley J, Skabelund A. 2015. Tigers - Real and Imagined - In Korea's Physical and Cultural Landscape. Environmental History **20**:475–503.

Seimon T a, Miquelle DG, Chang TY, Newton AL, Korotkova I, Ivanchuk G, Lyubchenko E, Tupikov A, Slabe E, McAloose D. 2013. Canine Distemper Virus: an Emerging Disease in Wild Endangered Amur Tigers (Panthera tigris altaica). mBio **4**:e00410-13-e00410-13. Available from http://mbio.asm.org/cgi/doi/10.1128/mBio.00410-13.

Shin HJ, Park M, Kim SJ. 2016. Evaluation of future climate change impact on snow hydrology for a mountainous watershed of South Korea using SLURP model and NOAA AVHRR images. Paddy and Water Environment **14**:145–158. Available from http://link.springer.com/10.1007/s10333-015-0486-y.

Smith JB, Nielsen CK, Hellgren EC. 2014. Illinois resident attitudes toward recolonizing large carnivores. The Journal of Wildlife Management **78**:930–943. Available from http://doi.wiley.com/10.1002/jwmg.718.

Sniderman PM, Grob DB. 1996. Innovations in Experimental Design in Attitude Surveys. Annual review of Sociology **22**:377–399.

Soh YH, Carrasco LR, Miquelle DG, Jiang J, Yang J, Stokes EJ, Tang J, Kang A, Liu P, Rao M. 2014. Spatial correlates of livestock depredation by Amur tigers in Hunchun, China: Relevance of prey density and implications for protected area management. Biological Conservation **169**:117–127. Elsevier Ltd. Available from http://dx.doi.org/10.1016/j.biocon.2013.10.011.

Spitzen V V. et al. 2013. A Program for reintroduction of the Far Eastern Leopard into Southern Sixhote-Alin, Primorskii Krai, Russain Far East. Ministry of Natural Resources Russian Federation, Russian Federal Natural Resources Oversight Agency, Lazovski Zapovednik, Administration of Primorskii Krai, Institute of Biology and Soils of the Russian Academy of Science Far Eastern Branch, European Zoo.

Stem C, Margoluis R, Salafsky N, Brown M. 2005. Monitoring and Evaluation in

Conservation : a Review of Trends and Approaches. Conservation Biology **19**:295–309.

Stephenson PJ, Ntiamoa-Baidu Y. 2010. Conservation planning for a widespread, threatened species: WWF and the African elephant Loxodonta africana. Oryx **44**:194. Available from http://www.journals.cambridge.org/abstract_S0030605309990846.

Stoneking M et al. 2002. A common rule for the scaling of carnivore density. Science **295**:2273–2276. Available from http://www.ncbi.nlm.nih.gov/pubmed/11910114%5Cnwww.sciencemag.org.

Sung K-C, Lee E-W, Park C-E. 2010. Prevalence on protective serum antibodies of canine distemper virus and canine parvovrus in Ulsan area. Korean Journal of Veterinary Service **33**:213–221.

Suryawanshi KR, Bhatnagar YV, Redpath S, Mishra C. 2013. People, predators and perceptions: patterns of livestock depredation by snow leopards and wolves. Journal of Applied Ecology **50**:550–560. Available from http://doi.wiley.com/10.1111/1365-2664.12061.

Sutherland WJ, Pullin AS, Dolman PM, Knight TM. 2004. The need for evidence-based conservation. Trends in Ecology & Evolution **19**:305–308. Available from http://linkinghub.elsevier.com/retrieve/pii/S0169534704000734.

Taylor BJ. 2005. Factorial Surveys: Using Vignettes to Study Professional Judgement. British Journal of Social Work **36**:1187–1207. Available from http://bjsw.oxfordjournals.org/cgi/doi/10.1093/bjsw/bch345.

Thapa Karki S, Hubacek K. 2015. Developing a conceptual framework for the attitude–intention–behaviour links driving illegal resource extraction in Bardia National Park, Nepal. Ecological Economics **117**:129–139. Available from http://linkinghub.elsevier.com/retrieve/pii/S0921800915002852.

Thirgood S, Woodroffe R, Rabinowitz A. 2005. The impact of human-wildlife conflict on human lives and livelihoods. Pages 13–26in R. Woodroffe, S. Thirgood, and A. Rabinowitz, editors.People and Wildlife: Conflict or Coexistence? Cambridge University Press, Cambridge, UK.

Thorn M, Green M, Dalerum F, Bateman PW, Scott DM. 2012. What drives human–carnivore conflict in the North West Province of South Africa? Biological Conservation **150**:23–32. Elsevier Ltd. Available from http://dx.doi.org/10.1016/j.biocon.2012.02.017.

Treves A, Karanth KU. 2003. Human-Carnivore Conflict and Perspectives on Carnivore Management Worldwide. Conservation Biology **17**:1491–1499.

Treves A, Naughton-Treves L. 2005. In press, in People and Wildlife, Conflict or Coexistence? (eds. Woodroffe, R., Thirgood, S., Rabinowitz, A.). Cambridge University Press, Cambridge, UK. Due out Jan. 2005 Evaluating lethal control in the management of human-wildlife conflict. Africa.

TREVES A, NAUGHTON-TREVES L, SHELLEY V. 2013. Longitudinal Analysis of Attitudes Toward Wolves. Conservation Biology **27**:315–323. Available from http://doi.wiley.com/10.1111/cobi.12009.

Treves A, Wallace RB, Naughton-Treves L, Morales A. 2006. Co-Managing Human–Wildlife

Conflicts: A Review. Human Dimensions of Wildlife **11**:383–396. Available from http://www.tandfonline.com/doi/abs/10.1080/10871200600984265.

Trolliet F, Huynen M-C, Vermeulen C, Hambuckers A. 2014. Use of Camera Traps for Wildlife Studies. A Review. Biotechnology, Agronomy, Society and Environment **18**:466–454. Available from http://www.pressesagro.be/base/text/v18n3/446.pdf.

van Vliet LM, Hillen MA, van der Wall E, Plum N, Bensing JM. 2013. How to create and administer scripted video-vignettes in an experimental study on disclosure of a palliative breast cancer diagnosis. Patient Education and Counseling **91**:56–64. Elsevier Ireland Ltd. Available from http://dx.doi.org/10.1016/j.pec.2012.10.017.

Viengthong District Agricultural Office. 2011. Socio-Economic statistics for villages in the Nam Et-Phou Louey National Protected Area. Lao PDR.

Walston J et al. 2010. Bringing the tiger back from the brink-the six percent solution. PLoS Biology **8**:6–9.

Wang SW, Macdonald DW. 2006. Livestock predation by carnivores in Jigme Singye Wangchuck National Park, Bhutan. Biological Conservation **129**:558–565. Available from http://linkinghub.elsevier.com/retrieve/pii/S0006320705005197.

Weber W, Rabinowitz A. 1996. A Global Perspective on Large Carnivore Conservation. Conservation Biology **10**:1046–1054.

Wieczorek Hudenko H. 2012. Exploring the Influence of Emotion on Human Decision Making in Human–Wildlife Conflict. Human Dimensions of Wildlife **17**:16–28. Available from http://www.tandfonline.com/doi/abs/10.1080/10871209.2012.623262.

Wikramanayake E et al. 2011. A landscape-based conservation strategy to double the wild tiger population. Conservation Letters **4**:219–227. Available from http://doi.wiley.com/10.1111/j.1755-263X.2010.00162.x.

Williams CK, Ericsson G, Heberlein TA. 2002. A quantitative summary of attitudes toward wolves and their reintroduction (1972-2000). Wildlife Society Bulletin **30**:575–584.

Woodroffe R. 2000. Predators and people : using human densities to interpret declines of large carnivores. Animal Conservation **3**:165–173.

World Bank. 2012. Lao PDR - Na-Nam Et-Phou Louey Tiger Landscape Conservation Project: involuntary resettlement process framework.

World Bank. 2015. Lao PDR. Available from http://www.worldbank.org (accessed May 9, 2017).

Worldatlas. 2015. World Map. Available from http://www.worldatlas.com (accessed May 9, 2017).

Wywialowski AP. 1994. Agricultural Producers' Perceptions of Wildlife-Caused Losses. Wildlife Society Bulletin **22**:370–382.

Zimmermann A, Baker N, Inskip C, Linnell JDC, Marchini S, Odden J, Rasmussen G, Treves A. 2010. Contemporary Views of Human–Carnivore Conflicts on Wild Rangelands. Pages 367–392in J. T. du Toit, R. Kock, and J. . Deutsch, editors.Wild Rangelands: Conserving

Wildlife While Maintaining Livestock in Semi-Arid Ecosystems. John Wiley & Sons, Ltd, Chichester, UK.

Zuur AF, Ieno EN, Elphick CS. 2010. A protocol for data exploration to avoid common statistical problems. Methods in Ecology and Evolution **1**:3–14. Available from http://doi.wiley.com/10.1111/j.2041-210X.2009.00001.x.

APPENDICES

Appendix A. A questionnaire survey

Date: Village: Interviewer: vignette:

Main respondent: [ ] Male [ ] Female
Participants? [ ] Male [ ] Female

Hello. My name is ________, and I am a student from the University of Laos. As a part of the research of Anya Lim, a graduate student from the University of Wisconsin – Madison, US, I would like to learn about your livestock husbandry practice, carnivore presence around the village and how you think of carnivores and their conservation.

This interview is voluntary, and you may decline to answer individual questions or to stop the interview at any time. That is fine. Although we hope that our research has a larger set of societal benefits, including for the people in the Nam Et-Phou Louey National Protected Area, participating will not bring any direct material benefits to you personally. Your participation or refusal to participate will not pose any risks to you.

In addition, your confidentiality will be maintained by not writing down your name on the notes containing your answers to our questions. Furthermore, your name will not be identified in any reports or publications produced as a result of this research. I might make audio recordings of this interview, but it will only be used by the researcher and stored in a secure location at all times. However, if you are not comfortable with audio recording, you can request not to do so at any time.

So, would you like to continue with the interview?

Demographic questions

1. How old are you?
   [ ]

2. How approximately long have you lived in this village?
   [ ] Born [ ] years [ ]

3. How many people in your family? [ ]

Socio-economic questions

4. What activities does your family do for a living (check all relevant)?
   [ ] Working for wages
   [ ] Trader/Businessmen
   [ ] Cultivating rice paddy
   [ ] Cultivating upland field
   [ ] Gardening
   [ ] Gathering forest products
   [ ] Hunting
   [ ] Fishing
   [ ] Retired
   [ ] Raising livestock
   [ ] Other _______________

5. Then, what are your family's major income sources (check all relevant)?

[ ] Working for wages
[ ] Trader/Businessmen
[ ] Cultivating rice paddy
[ ] Cultivating upland field
[ ] Gardening
[ ] Gathering forest products
[ ] Hunting
[ ] Fishing
[ ] Retired
[ ] Raising livestock
[ ] Other _______________

6. What other roles do you have in your village?

[ ] Le Ka Nouay Pak Haak Taan
[ ] Village Head
[ ] Village policeman
[ ] Village militia
[ ] Villager
[ ] Other______________

7. Does your family has;

[ ] Radio
[ ] Mill (   )
[ ] Bicycle
[ ] Motorbike
[ ] Concrete house
[ ] Fishing pond
[ ] Tractor
[ ] Modernized roof
[ ] Watch
[ ] Clock
[ ] Generator
[ ] TV
[ ] Refrigerator
[ ] Home phone
[ ] Cell phone
[ ] Car
[ ] Water heating system

8. What livestock does your family have and how many does your family have?

[   ] Chicken/Duck
[   ] Goat
[   ] Sheep
[   ] Pig
[   ] Dog
[   ] Cattle
[   ] Buffalo
[   ] Horse
[   ] Others _____

9. Where do you raise your cattle/buffalo/Horse?

	Location	Cattle #	Buffalo #	Horse #
	In the village			
	Sanam *Name(s):* ______________________ *Location(s):* ____________________ *Size(Ah):*_______________________ *Name(s):*_______________________ *Location(s):* _____________________ *Size(Ah):* _______________________			
	Elsewhere: ____________________			

10. Does your famaily raise cattle/buffalo/Horse for someone else, or ask other people to take care of your livestock?

[ ] Raise for others [ ] Ask others to take care of [ ] Neither

If yes,

How many are from others or to others? [ ]

Where are owners or breeders from? [ ]

How much do you paid or pay? [ ]

How many other families raise the livestock together in the sanam(s)?

Sanam________________[ ]

Sanam________________[ ]

11. How many livestock in the sanam(s) in total?

Sanam:_______Cattle/Buffalo[ ] Horse[ ] Pig[ ] sheep/goat[ ]

Sanam:_______Cattle/Buffalo[ ] Horse[ ] Pig[ ] sheep/goat[ ]

12. How do you raise your cattle/buffalos/horses?

Do you have a guard?

[ ] paid [ ] free

Do you have a fence, enclosure or forms of protection?

[ ] Yes [ ] No

if yes, how long?

[ ] All day [ ] Only at night

Do you freely release without supervision?

[ ] Yes [ ] No

13. Any seasonal change of grazing locations or grazing methods?

Interaction with Carnivores

14. Do you know these animals? (Show 7 animal photos and check if they identify the animal)

[ ] Tiger [ ] Leopard [ ] Clouded Leopard

[ ] Golden Cat [ ] Dhole [ ] Sun bear

[ ] Asiatic Black Bear

15. Have you ever seen these animals?

If yes,

which animal, where, when and how often have you seen each animal? (If many use the note)

For example:

Tiger

Year[2010] Month[5] Place [Forest on a way to Sanam] Frequency: Once

16. Which wildlife do you fear most and why?

[ ] Tiger [ ] Leopard [ ] Clouded Leopard
[ ] Golden Cat [ ] Dhole [ ] Sun bear
[ ] Asiatic Black Bear [ ] Other________________

Reason: ____

17. Have **your family** had any problem with wildlife, such as livestock or crop loss?
For example: Dhole, deer, Wild pig, rodents, civet, tiger, leopard, golden cat, Sun bear, Asiatic Black bear, clouded leopard

[ ] Yes [ ] No

If yes, tell me more the animal and damage (kind and degree)
when damages arose?

18. Have **your village** had any problems with wildlife, such as livestock or crop loss?
For example: Dhole, deer, rodents, civet, tiger, leopard, golden cat, Sun bear, Asiatic Black bear, clouded leopard

[ ] Yes [ ] No

If yes, tell me more the animal and damage (kind and degree)
when damages arose?

19. How did you know the problems came from that species (multiple choices)?

Animal name: [ ] Direct seeing [ ] Found tracks [ ] Guessing [ ]
Other Reasons:__________
Animal name: [ ] Direct seeing [ ] Found tracks [ ] Guessing [ ]
Other Reasons:__________
Animal name: [ ] Direct seeing [ ] Found tracks [ ] Guessing [ ]
Other Reasons:__________
Animal name: [ ] Direct seeing [ ] Found tracks [ ] Guessing [ ]
Other Reasons:__________

20. Which wildlife caused **your household** the most property loss, such as crop and livestock loss?

21. Which wildlife caused **your village** the most property loss, such as crop and livestock loss?
22. Do you think number of that animal/ those animals should be reduced to avoid possible damage?

[ ] Yes [ ] No

23. Would you or someone in your household participate in a training workshop to learn ways to protect livestock?

[ ] Yes [ ] No

24. Who do you think should help villagers protect their livestock around the NEPL?
    [ ] Owners (themselves)   [ ] Government
    [ ] Agricultural office   [ ]NPA
    [ ] Outside/Foreign organization

25. If changing the current livestock husbandry can prevent livestock loss by carnivore attack, would you change the practice? [ ] Yes   [ ] No
    if yes, why? ________________________________
    If no, why not? ________________________________

Attitudes of tigers and dholes

26. Has the tiger population changed in past five years?
    [ ] Decreased   [ ] Increased   [ ] No change

27. How about Dholes?
    [ ] Decreased   [ ] Increased   [ ] No change

28. Do you think number of tigers should increase?
    [ ] Yes   [ ] No
    If yes, Why? ________________________________

29. Do you think number of dholes should increase?
    [ ] Yes   [ ] No
    If yes, Why? ________________________________

30. Do you like living along tigers?
    [ ] Yes   [ ] No

31. How about Dholes?
    [ ] Yes   [ ] No

32. If tigers did not threaten you or your livestock, would you support tiger conservation?
    [ ] Yes   [ ] No

33. Would you be willing to report livestock kills by tigers voluntarily (without payment) to the village head?
    [ ] Yes   [ ] No

    If not, would you be willing to report livestock kills by tigers if there is compensation (payment)?
    [ ] Yes   [ ] No

34. Can you see the benefit of tigers?

    [ ] Yes [ ] No

    If Yes: What kinds of benefits? ______________________________

35. Do you think number of tigers should be reduced to avoid possible damage?

    [ ] Yes [ ] No

    If no, why?

Appendix B. A randomized block confounded factorial design of 32 vignettes

Vignette Set	Vignette number	Distance to villages (V)	Distance to agricultural lands (A)	Distance to ungulates (U)	Quality of grass (G)	Distance to carnivores (C)
1	1	near	near	near	poor	distant
1	16	near	distant	distant	good	near
1	20	distant	distant	distant	poor	distant
1	29	distant	near	near	good	near
2	5	near	near	near	good	distant
2	12	near	distant	distant	poor	near
2	24	distant	distant	distant	good	distant
2	25	distant	near	near	poor	near
3	2	near	distant	near	poor	distant
3	15	near	near	distant	good	near
3	19	distant	near	distant	poor	distant
3	30	distant	distant	near	good	near
4	6	near	distant	near	good	distant
4	11	near	near	distant	poor	near
4	23	distant	near	distant	good	distant
4	26	distant	distant	near	poor	near
5	7	near	near	distant	good	distant
5	10	near	distant	near	poor	near
5	22	distant	distant	near	good	distant
5	27	distant	near	distant	poor	near
6	3	near	near	distant	poor	distant
6	14	near	distant	near	good	near
6	18	distant	distant	near	poor	distant
6	31	distant	near	distant	good	near
7	8	near	distant	distant	good	distant
7	9	near	near	near	poor	near
7	21	distant	near	near	good	distant
7	28	distant	distant	distant	poor	near
8	4	near	distant	distant	poor	distant
8	13	near	near	near	good	near
8	17	distant	near	near	poor	distant
8	32	distant	distant	distant	good	near

Appendix C. Parameter estimates for the preference of grazing areas in the random-slope model.

	Coef.[a]	SE	*t* value
Intercept	6.92	0.84	8.22 *
Set2	0.60	0.34	1.77
Set3	-0.32	0.34	-0.94
Set4	0.39	0.34	1.17
Set5	0.60	0.33	1.79
Set6	0.86	0.33	2.57*
Set7	0.84	0.34	2.45*
Set8	0.54	0.33	1.63
HouayChod	-1.96	0.96	-2.03*
HouayHear	-1.27	1.09	-1.17
HouayHindeng	-1.70	0.93	-1.82
HouayKaning	-2.59	0.93	-2.77*
HouayKayang	-1.49	0.96	-1.55
HouayKee	-0.81	0.93	-0.87
HouayMorkang	-0.89	0.93	-0.95
HouayPhounghea	-1.71	0.93	-1.83
HouaySoc	-1.65	0.93	-1.76
HouaySom	-1.38	1.44	-0.96
HouayTeun	-3.18	0.93	-3.40*
Keolom	-1.57	1.08	-1.46
Leepee	-2.33	0.93	-2.49*
LongNguapaKhao	-1.46	1.03	-1.42
Nongdeng	-2.47	0.93	-2.65*
NV[b] LongNguapa	-0.64	1.46	-0.44
NV Natuan	0.28	1.18	0.23
NV Thathiem	1.07	1.44	0.74
Phabong	-2.66	0.93	-2.85*
Phakao	-2.13	0.93	-2.28*
Phamone	-2.04	0.93	-2.18*
Phasiengsy	-1.42	0.93	-1.52
Phatoup	-3.09	1.44	-2.15*
Phoukhea	-2.67	0.93	-2.89*
Phouloueynoy	-2.15	1.03	-2.10*
Phoupha	-1.84	0.93	-1.98
Pouked-Poumoun	-1.22	0.93	-1.31
Thamxang	-1.96	0.93	-2.12*
Thamxang LongNguapa	-1.46	1.02	-1.43

Yodhet	-0.88	1.46	-0.61
Yodnampai	-1.77	0.93	-1.90
Yodnamsong	-2.05	1.08	-1.90
Yodnamxat	-1.73	0.93	-1.85
Yodnamxat NV	-1.97	0.97	-2.03*
A[b]	0.42	0.16	2.55 *
V[b]	-1.37	0.16	-8.48 *
P[b]	-0.24	0.16	-1.46
C[b]	2.30	0.21	11. 07*
G[b]	2.62	0.21	12.62 *
A x V	0.13	0.42	0.32
V x P	-0.22	0.42	-0.54
A x C	0.02	0.32	0.07
V x C	0.48	0.33	1.47
P x C	-0.07	0.32	-0.23
A x G	-0.15	0.32	-0.45
V x G	0.23	0.33	0.69
P x G	0.19	0.32	0.60
A x V x P	-0.64	0.65	-0.99
A x P x C	0.42	0.83	0.50
A x P x G	0.99	0.83	1.19
A x C x G	0.57	0.66	0.86
V x C x G	1.57	0.65	2.43 *
P x C x G	0.58	0.66	0.88
A x V x P x C	-0.84	1.32	-0.64
A x V x P x G	3.12	1.32	2.37 *
A x V x C x G	-1.05	1.66	-0.63
V x P x C x G	-0.24	1.66	-0.14
A x V x P x C x G	4.20	2.58	1.63
SD of Random intercept	0.07		
SD of Random Slope for C	1.86		
SD of Random Slope for P	0.47		
SD of Level-one	2.30		

[a] Abbreviation: Coef., Coefficients of the model

[b] Abbreviation: *A*, Distance between agricultural land and grazing area; *V*, Distance between village and grazing area; *P*, Distance between prey and grazing area; *C*, Distance between carnivores and grazing area; *G*, Quality of grass in grazing area

* Significant *t* value of two-tailed *t*-test with 0.05 significance level (*t* value > 2).

Appendix D. Criteria for threat rankings*

Scope

4 = Very High: The threat is likely to be pervasive in its scope, affecting the target across all or most (71- 100%) of its occurrence/population.
3 = High: The threat is likely to be widespread in its scope, affecting the target across much (31-70%) of its occurrence/population.
2 = Medium: The threat is likely to be restricted in its scope, affecting the target across some (11-30%) of its occurrence/population.
1 = Low: The threat is likely to be very narrow in its scope, affecting the target across a small proportion (1-10%) of its occurrence/population.

Severity

4 = Very High: Within the scope, the threat is likely to destroy or eliminate the target, or reduce its population by 71-100% within ten years or three generations.
3 = High: Within the scope, the threat is likely to seriously degrade/reduce the target or reduce its population by 31-70% within ten years or three generations.
2 = Medium: Within the scope, the threat is likely to moderately degrade/reduce the target or reduce its population by 11-30% within ten years or three generations.
1 = Low: Within the scope, the threat is likely to only slightly degrade/reduce the target or reduce its population by 1-10% within ten years or three generations.

Irreversibility

4 = Very High: The effects of the threat cannot be reversed and it is very unlikely the target can be restored, and/or it would take more than 100 years to achieve this (e.g., wetlands converted to a shopping center).
3 = High: The effects of the threat can technically be reversed and the target restored, but it is not practically affordable and/or it would take 21-100 years to achieve this (e.g., wetland converted to agriculture).
2 = Medium: The effects of the threat can be reversed and the target restored with a reasonable commitment of resources and/or within 6-20 years (e.g., ditching and draining of wetland).
1 = Low: The effects of the threat are easily reversible and the target can be easily restored at a relatively low cost and/or within 0-5 years (e.g., off-road vehicles trespassing in wetland).

** The criteria come from (FOS 2009, p48).*

Appendix E. Criteria for strategy prioritization*

Potential Impact

Very High – The strategy is very likely to completely mitigate a threat or restore a target.
High – The strategy is likely to help mitigate a threat or restore a target.
Medium – The strategy could possibly help mitigate a threat or restore a target.
Low – The strategy will probably not contribute to meaningful threat mitigation or target restoration.

Feasibility

Very High – The strategy is ethically, technically, AND financially feasible.
High – The strategy is ethically and technically feasible, but may require some additional financial resources.
Medium – The strategy is ethically feasible, but either technically OR financially difficult without substantial additional resources.
Low – The strategy is not ethically, technically, OR financially feasible

** The criteria come from (FOS 2009, pp76-77).*