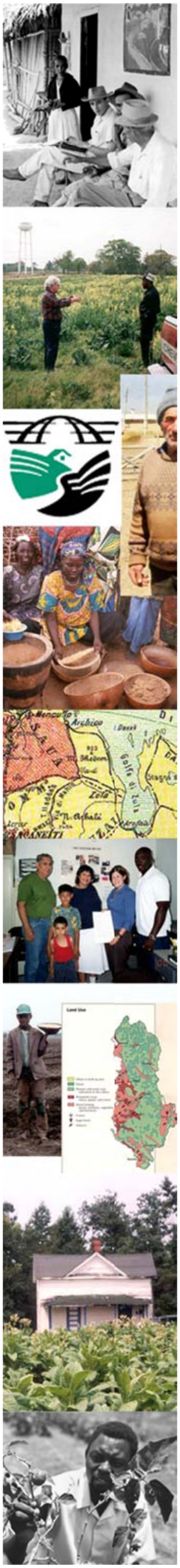

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Land Tenure Center

COMMUNITY ENGAGEMENT AND TRAINING PARABIOLOGISTS FOR THE PROTECTION OF GLOBALLY THREATENED SPECIES IN AND AROUND SOUTHERN SANGAY NATIONAL PARK, ECUADOR

MIDTERM REPORT

Adrian Treves: University of Wisconsin-Madison

Catherine Schloegel: Fundación Cordillera Tropical

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Provided by the **Land Tenure Center.** Comments encouraged:

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Carnivore Coexistence Lab

Cordillera Tropical Fundación

Community engagement and training parabiologists for the protection of globally threatened species in and around southern Sangay National Park, Ecuador

MIDTERM REPORT
August 18, 2010

By Adrian Treves, PhD
Catherine Schloegel, M.S.
for the
U.S. Fish and Wildlife Service International Programs

Wildlife Without Borders

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1. Grantee information

Organization name

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Assistance Award Number

96200 - 9 - G219

Start and end date of Award performance period

8/25/2009 – 3/30/2011

Start and end date of the reporting period

8/25/2009 – 8/18/2010

2. A description of the current project status:

Introduction

Ongoing human-wildlife conflicts threaten the integrity of wild animal populations and their native habitats found within southern Sangay National Park (SNP), Ecuador. Far-ranging animals, like the Andean bear (*Tremarctos ornatus*) and big cats, frequently foray on private lands, both inside and adjacent to the park, where they encounter people and their property. People often retaliate against the offending animals or clear habitat preemptively. Long-term solutions to these conflicts require community engagement, training, and collaborative management.

From its inception in 2002, the Don Oso Conservation Program has focused on field research, local capacity building and environmental education to identify site-specific solutions to human/wildlife conflicts and provide local landowners with the tools and knowledge to live alongside these far-ranging populations of wild, and often threatening, animals in southern SNP. The initiative represents an on-going collaboration between the University of Wisconsin–Madison, Fundación Cordillera Tropical, officials of SNP and local landholders.

The Carnivore Coexistence Lab (CCL) at the University of Wisconsin-Madison and Fundación Cordillera Tropical (FCT) seek to build the capacity of park officials, community-based parabiologists, and landowners for conservation of wildlife and habitats in southern Sangay National Park (SNP) by involving them in joint training and conservation planning to (a) use non-lethal methods to reduce conflicts with wildlife, and (b) monitor wildlife in and around titled lands in southern SNP. This training will take place in the context of a larger biodiversity monitoring project that will help verify landholder compliance with a national payment for the protection of environmental services (PPES) initiative.

With modest funding, CCL has greatly contributed toward understanding wildlife use of private lands in the region using state-of-the-art monitoring over the past two years. The culmination is the successful completion of two Masters theses and several scientific reports or peer-reviewed articles on human-carnivore conflicts in the Ecuadorian Andes.[1] This research complements FCT´s prior work on cattle/bear conflicts in the Colepato community which identified and evaluated the ubiquitous problem[2]. At the same time, FCT has leveraged local support to hire ten community park guards to patrol and protect southern SNP.

In late 2009, with greatly increased support from the United States Fish and Wildlife Service International Programs (USFWS), the Don Oso Program has been able to expand its staff and greatly increase the project´s area of influence. With this new capacity, FCT and CCL have been able to focus intensively on training landowners, park guards, and FCT staff to respond nimbly to human/wildlife conflicts and to undertake state-of-the-art wildlife monitoring.

The key elements of these changes include:

1. The hiring of a full-time field biologist, Lucas Achig, M.Sc., in March 2010 to co-design and implement a wildlife-monitoring program in southern SNP. Lucas brings four years of environmental education experience and two years of research experience on the Andean bear to this position. Dr. Adrian Treves of CCL trained Mr. Achig based on his experience with carnivore recovery in agro-ecosystem mosaics of private and public lands and research on wildlife threats to humans around park edges in six countries. These global insights on solutions applied elsewhere and knowledge of systematic methods for measuring the impact of our joint interventions provide pivotal baseline information to guide subsequent interventions in southern SNP. Combining the depth of CCL's international experience and FCT's local expertise, the resulting project staff brings a mix of local insights and global perspectives to the conservation challenges in southern SNP.

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[1] See references cited at end of document for a list of published articles.

[2] This project was funded by a USFWS grant # 98210-7-G309 for the project ¨Don Oso Project: Andean Bear Research, Awareness, Protection, and Compensation Plan¨ granted jointly to Round River Conservation Studies and Fundación Cordillera Tropical in 2007.

2. An expansion of our outreach and influence area from the original 1800 ha project area to the neighboring communities in the Dudas and Llavircay watersheds, a potential project area covering approximately 10,000 ha.

3. The development of farm-level pilot projects which apply CCL expertise in mitigation techniques – barriers, increased patrol, noise deterrents – to deter wildlife attacks on domestic animals within individual farms in southern SNP.

4. Training by CCL and subsequent close mentoring of FCT staff and park guards in the application of motion activated cameras to monitor wildlife in the forests of southern SNP.

Monitoring conservation outcomes in the context of an inchoate payment for the protection of environmental services program

FCT's habitat conservation efforts aimed at páramo and montane forests have focused equally on (i) improving control of public park lands via increased patrol and (ii) using economic incentives to ensure conservation on private lands. Like many protected areas in the tropics, the majority of SNP´s ostensibly public lands are also the property of farmers and indigenous communities with rights predating the park´s establishment. This intersection of private and public lands and interests provides the ideal laboratory for a payment for the protection of environmental services (PPES) program.
FCT has worked toward the establishment of a local PPES initiative that would link downstream water users to upstream providers since late 2006. By August 2009, a newly-formed government PPES initiative, Socio Bosque, approached FCT with a proposal to work together. Joining a national conservation initiative conferred both benefits and losses. While FCT has lost the ability to develop an initiative that responds explicitly to local needs, at the same time it has achieved a long-term stability with the Ecuadorian Ministry of Environment providing funding for the duration of 20-year conservation contracts.

Since September 2009, FCT has pre-enrolled 5260 ha of páramo and cloud forest in the Socio Bosque[3] program representing 168 beneficiaries on 50 parcels of privately titled land. The ultimate goal is to enroll 80% of privately-owned native páramo grasslands and cloud forest with its attendant wildlife, especially endangered species such as the Andean or spectacled bear (*Tremarctos ornatus*).

As of May 2010 (the end of the most recent enrollment period), Socio Bosque has accepted just four area landowners to participate in the conservation incentive program. Large-scale participation in the Socio Bosque conservation program has been inhibited by a myriad of unmet on-the-ground necessities. For example, initially Socio Bosque focused solely on forest conservation, excluding other ecosystems. However, the Ministry of Environment quickly expanded the program to include páramos in June 2009

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[3] For more information about Socio Bosque, visit their website at www.ambiente.gob.ec/paginas_espanol/sitio/sociobosque_es.html

and landowners within protected areas in March 2010. Nevertheless, the outstanding challenge will be for Socio Bosque to resolve the incompatibility between regional and national land titling agencies. Program designers have yet to accept the majority of landowners in the SNP region because they lack a georeferenced map of the property and reference to the total titled area (in hectares). These obstacles have impeded large-scale enrollment.

Monitoring flagship species is a critical component of successful assessment of local or regional habitat conservation efforts, like Socio Bosque. Our project team's flagship species is the Andean (spectacled) bear because of its globally vulnerable conservation status, its iconic role in Andean culture, and its damages to crops and livestock, all of which make it controversial and important to communities, park officials and conservationists alike.

CCL is actively testing methods for non-invasive monitoring of the bears and other wildlife. Our partnership creates an exceptional opportunity to train community park guards to understand and deploy advanced monitoring equipment, such as remotely triggered camera traps, and field devices for the passive collection of hair for DNA. At the same time, CCL is supporting social scientific research on landowners' attitudes to wildlife and preferences for wildlife management interventions. FCT is devoting time and resources to training the community park guards in all these techniques with the goal of ensuring that local community members become future leaders in park management and biodiversity monitoring.

Incentives, such as those within a PPES program, to protect wildlife and habitats are intended to assist local landowners in conserving critical habitat for threatened and endangered animals. Yet without additional training to ensure conservation of the associated fauna, in the face of crop or livestock damage by Andean bears and other wildlife, landowners often have no alternatives to lethal retaliation. CCL has been leading scientific inquiry into the factors that promote non-lethal management of vulnerable wildlife in many regions, with research on incentives, non-lethal deterrent devices, and changing attitudes that precipitate reprisals against wildlife.

This project proposed to mitigate wildlife/human conflicts and monitor wildlife – especially Andean bears – using intensive, non-invasive methods on participating properties in the Socio Bosque PPES program. However, Socio Bosque´s slow implementation has forced CCL and FCT to modify the proposed work. Those with experience in contested land claims and participatory processes involving incentive payments will not be surprised at these bumps in the road. But they have affected our objectives, activities, and plans as we describe below.

a. For each objective stated in the project proposal, describe the activities undertaken to achieve that objective. Describe any activities that differ from the original work plan and explain reasons for change.

Table 1 presents the original objectives (numbered), activities and outputs proposed in black text with strike-through and blue text added if a change was made.

Table 1. Original proposed objectives, activities, and outputs.

Objectives	Activities	Outputs	Change? Current status
1. Evaluate wildlife conservation outcomes on properties of ~~participants in PPES and WF programs~~ project participants	~~9 community parabiologists surveys conducted every 4 months~~ 5 pairs of community parabiologists conduct biodiversity surveys monthly	Records of wildlife presence and trends in relative abundance ~~on PPES and WF participating properties; 9 experienced community members~~ in 4 sub-watersheds; 10 community parabiologists employed and trained in wildlife monitoring techniques	No (in progress)
2. ~~Evaluate compliance with PPES and WF programs' demands for habitat/wildlife protection~~ Monitor human activities that impact biodiversity negatively	~~9 community parabiologists surveys conducted every 4 months~~ 5 pairs of community parabiologists conduct threat surveys monthly	Records of human threats and trends over time ~~on PPES and WF participating properties; 9 experienced community members~~ in 4 sub-watersheds; 10 community parabiologists employed and trained in systematic surveys for human threats to biodiversity	No (in progress)
3. Assess tolerance for wildlife and attitudes to conservation interventions	CCL and FCT conduct social scientific surveys (focus groups, interviews, questionnaires) with participating landowners	Information to guide future outreach, conservation policy, and improve designs (SNP, PPES,WF, project)	No (in progress)
4. Recruit landowners ~~to apply for Wildlife Friendly certification~~ for PPES program	~~Two half-day meetings with the Colepato Cooperative's 32 decision-making families~~ Individual and group meetings with decision-making families	~~Complete application for certification and a monitoring plan for wildlife~~ ~~Completed conservation agreements~~	Yes (Completed)
5. Calibrate parabiologists' ~~surveys with more systematic, scientific, and precise measures~~ indirect sign surveys with camera-trapping surveys	~~CCL field survey (3-4 months) of wildlife presence, distribution, and relative abundance + negative human impacts on habitats and wildlife~~ FCT parabiologists conduct monthly surveys on pre-determined transects to record wildlife signs and collect photos from camera-traps	~~Longitudinal data on individually identified Andean bears in 18 sq. km study area and spatial model of wildlife presence predicted by habitat suitability and wildlife presence~~ Longitudinal data on individually identified Andean bears across 70.4 square km project area	Yes (in progress)
6. Planning ~~/ Training~~ workshop	~~2 two-day conflict-mitigation workshops with 20-30 landowners and 4-5 parabiologists in each~~ Conflict-mitigation workshops with landowners and parabiologists	~~all participants in the PPES program will attend one conservation-planning workshop and produce a plan for non-lethal prevention of wildlife damage on their property~~ All participants that experienced losses to	Yes (in progress)

		Andean bears involved in a workshop and one individual session tailored to each participant's needs	
7. Training ~~workshop~~	~~1 one-day workshop on wildlife monitoring~~ Workshops, public lectures, and short courses	~~9 parabiologists trained to conduct field surveys for wildlife~~ All stakeholders involved in training and environmental education on wildlife damage management, human-wildlife conflicts, carnivore ecology, conservation, and monitoring	Yes (in progress
8. Model habitat suitability for wildlife and extrapolate to project area	CCL analyze habitat use in relation to landscape features ~~for common species, extrapolate to the entire project area~~	A map of predicted wildlife presence and density for use in conservation planning and fine-tuning the PPES program	No (in progress
9. Build teamwork among community parabiologists, ~~collect their data, share experiences~~	~~One annual one-day meeting~~ Weekly half-day meetings	~~Map of wildlife presence, georeferenced data on wildlife sign~~ Teamwork, training, data collection, and communication enhanced	Yes (in progress
10. Test and refine wildlife habitat suitability models	~~CCL team members will analyze parabiologists' data, verify any unusual records, and refine habitat suitability models~~ CCL will analyze parabiologists' data to refine and verify habitat suitability model	A predictive, spatial habitat suitability model for Andean bears with correlations to other wildlife presence data.	No (pending)
11. Involve participating landowners in conservation planning and offer technical support	Individual meetings with participating landowners to invite them to Planning/training workshop or if they refuse we offer technical support in the form of Spanish-language manuals on non-lethal mitigation of wildlife damage	Landowners facing threats from Andean bears supported with non-lethal mitigation measures or other technical support	No (in progress)
12. Reporting to stakeholders	Meetings, oral presentations, gray literature, peer-reviewed publications	Reports to project participants, donors, evaluators, scientific and conservation communities	No (in progress)

Detailed descriptions of changes made to Objectives, Activities and Outputs:

Objectives 1 and 2: CCL originally proposed to monitor biodiversity intensively in an 18 square km area for several months starting in May 2010, while 10 parabiologists would monitor biodiversity indirectly every four months starting in February 2010 across a larger area. As we entered in the project planning phase, we modified FCT and CCL roles to train in-country personnel more effectively and sustainably. CCL will train FCT parabiologists to monitor biodiversity intensively using remotely triggered camera traps in four sub-watersheds: Dudas, Mazar, Llavircay and Juval. This modification confers several advantages. The10 parabiologists can monitor a much larger area than that originally proposed, eventually contributing toward a more generalizable model of habitat suitability. Secondly, modification of our roles will increase the total time dedicated to wildlife monitoring on private lands. Indirectly, this modification will increase the amount of hands-on field training that the parabiologists receive. Finally, we should note that due to delays related to the start of PPES payments, our training activities will commence in early September 2010.

Objective 3: FCT staff, not CCL staff as originally proposed, will interview individual project participants and measure tolerance to wildlife and attitudes toward FCT and Sangay National Park at the beginning and end of the project period. Local vernacular and language barriers made it apparent that FCT staff (Lucas Achig) would be best suited to conducting these informal interviews and attitudinal surveys. During phase one, we identified potential participants, e.g. those with existing human/wildlife conflicts on their properties (June 2010). In a second phase, CCL trained Lucas Achig to apply a quantitative survey to affected landowners (August 2010).

Objective 4: FCT has completed the phase of landowner pre-enrollment and recruitment in Socio Bosque. Nevertheless, in the case of new enrollees, the proposed monitoring plan creates a uniform design that can easily be adapted if and when new landowners enter the program. Recruiting landowners for the WF incentive program is impractical as value-based production projects are well-behind schedule and likely to begin production in late 2011 or early 2012.

Objective 5: As noted for Objectives 1 and 2, following 12 months of capacity-building (August 2009 through July 2010), it is apparent that community parabiologists mentored by FCT and CCL staff are capable of installing, arming and down-loading data from infrared-activated remote cameras. CCL will provide on-site training to FCT and the community park guards who will then monitor the traps over five months. This data will (a) establish a longitudinal dataset on individually identifiable Andean bears (following methods from CCL staff (Zug 2009; Jones 2010); (b) correlate indirect sign abundances to rates of photo-capture of wildlife from camera traps; (c) document Andean bear use of the páramo in relation to the number of different bears photo-captured at camera traps in the forest; and (d) detect relative frequency and severity of threats to biodiversity such as forest clearing, burning, hunting. As inputs toward the analysis, CCL will provide a photo database of individual bears (Appendix 1) and lend much of the required equipment. Furthermore, results from CCL staff Zug and Jones reveal that Andean bear presence can predict the presence of 15 other medium-sized or larger vertebrates. These initial findings suggest that in the future, we may be able to use bear presence as an index of species richness. In addition, CCL will use the parabiologists' monitoring data to extrapolate habitat suitability estimates beyond the transect areas (see Objectives 8 and 10 above).

Objectives 6 and 7: Although we have not substantially changed these activities, we have reorganized the activities to better respond to landholder needs. We have also narrowed our scope to focus on landowners who have experienced damage by Andean bears because this species is culturally iconic, nationally and internationally protected, and the only endangered species that causes major problems for livestock and crop producers in the project region.

Objective 9: Rather than an annual meeting of parabiologists to share experiences and collate data, FCT has found that weekly (Friday) meetings of all parabiologists enhance collaboration by allowing for training, and greatly increased communication. These meetings will undoubtedly contribute toward greater data quality control and better training outcomes for the long term.

Objective 11. Due to the difficulties of implementing a national PPES program at the local level (noted in the Introduction), the project promotes advocacy and technical support needed by landowners to gain recognition of their conservation efforts.

Summary of change in objectives, activities, and outputs. CCL and FCT have addressed external challenges by enhancing our focus on training and empowering local people, particularly the community park guards. We have also focused on Andean bear ecology and conservation in both monitoring and mitigation activities. The former modification expands the area and time period over which we will collect scientific, rigorous data on wildlife persistence and survival, while also improving the sustainability of training received by community parabiologists. The latter modification makes more efficient use of our staff time, and resources by allowing us to focus on interventions that are specific to Andean bear attacks on livestock, a major concern for area landowners. Furthermore the park guards are gaining enhanced training by involvement in both monitoring and mitigation tasks, which helps them to build relationships and trust with affected landowners. Overall CCL and FCT have enhanced our collaborative efficiency, specialized our roles, and added capacity and skills necessary to attain our goals more quickly and sustainably.

Recipients are required to report in writing to the FWS Project Officer any deviations from the approved project scope of work.

Using tracked changes below, we indicate revisions to the scope of work.
Purpose and Scope of Work from the Assistance Award
This project titled "Community engagement of training parabiologists for the protection of globally threatened species in and around southern Sangay National Park, Ecuador" will support the training of ~~nine~~ ten members of the local community as parabiologists. In addition, a minimum of three park officials, nine community members and fifty local landowners will participate in a new payment program for the protection of ecosystem services (PPES) aimed at conserving high elevation páramo and cloud forests in and around Sangay National Park. Overall project goals include: (1) training of ~~nine~~ ten community parabiologists ~~(related activities: a one-day workshop on wildlife monitoring, an annual meeting to share data and experiences)~~to fulfill all duties of park guards including wildlife monitoring using state-of-the-art techniques (related activities: weekly team meetings, field training in wildlife monitoring and systematic field surveys), (2) recruitment of landowners in a payment for the protection of ecosystem services

program (related activities: individual meetings with landowners, technical support and invited participation in various workshops - see below), (3) the evaluation of wildlife conservation outcomes and compliance on properties of participating landowners (related activities: wildlife surveys by parabiologists every ~~four~~ month and generation of habitat suitability models), (4) recruitment of landowners ~~to apply for Wildlife Friendly Certification (related activities: two half-day meetings with the Colcpato Cooperative's 32 decision-making families~~for PPES and conservation contracts (related activities: technical support for landowners and advocacy for them with central government and payers), (5) reduction of human-wildlife conflict (related activities: two conflict mitigation workshops for a minimum of 20 landowners and parabiologists, field surveys to assess wildlife presence, abundance, and negative impacts due to humans), and (6) assessment of habitat suitability via GIS and satellite imagery (related activities: analyze habitat use of Andean bears within the PPES area using information from parabiologists, extrapolate to entire project area in the southern zone of Sangay National Park).

b. *If objective(s) were not accomplished, explain the problems encountered, such as how they were addressed and the impact on the project results.*

See the Introduction for a description of obstacles and subsequent delays encountered. Appendix 2 presents a revised timeline taking into account results achieved and delays mentioned previously.

Due to matters outside of FCT`s control, the foundation has not been able to successfully register the projected number of participants in the Socio Bosque program. Ongoing negotiations with other affected NGOs, an environmental law firm in Quito and the Ministry of Environment seek to reach a mutually acceptable solution. In the interim, most landowners will not be able to participate in the program despite their interest and pre-enrollment, due to the aforementioned problems between regional land titles and national expectations. A poorly organized decentralization of land titling to provincial leaders led each of the 24 provinces to title land in a distinct manner. Ultimately, some provinces' titles are not recognized by functionaries in the regional capital.

Also CCL staff shortages for fieldwork slowed our progress in training and fieldwork on wildlife monitoring. However this change has had salutary effects by leading us to rely more heavily on the capable community parabiologists. Moreover CCL has reinvigorated its training and technical support roles including additional fund-raising that will contribute to the long-term sustainability of FCT's vital work.

c. Describe the results achieved and the products generated. Explain any deviation(s) between the expected products and the actual products.

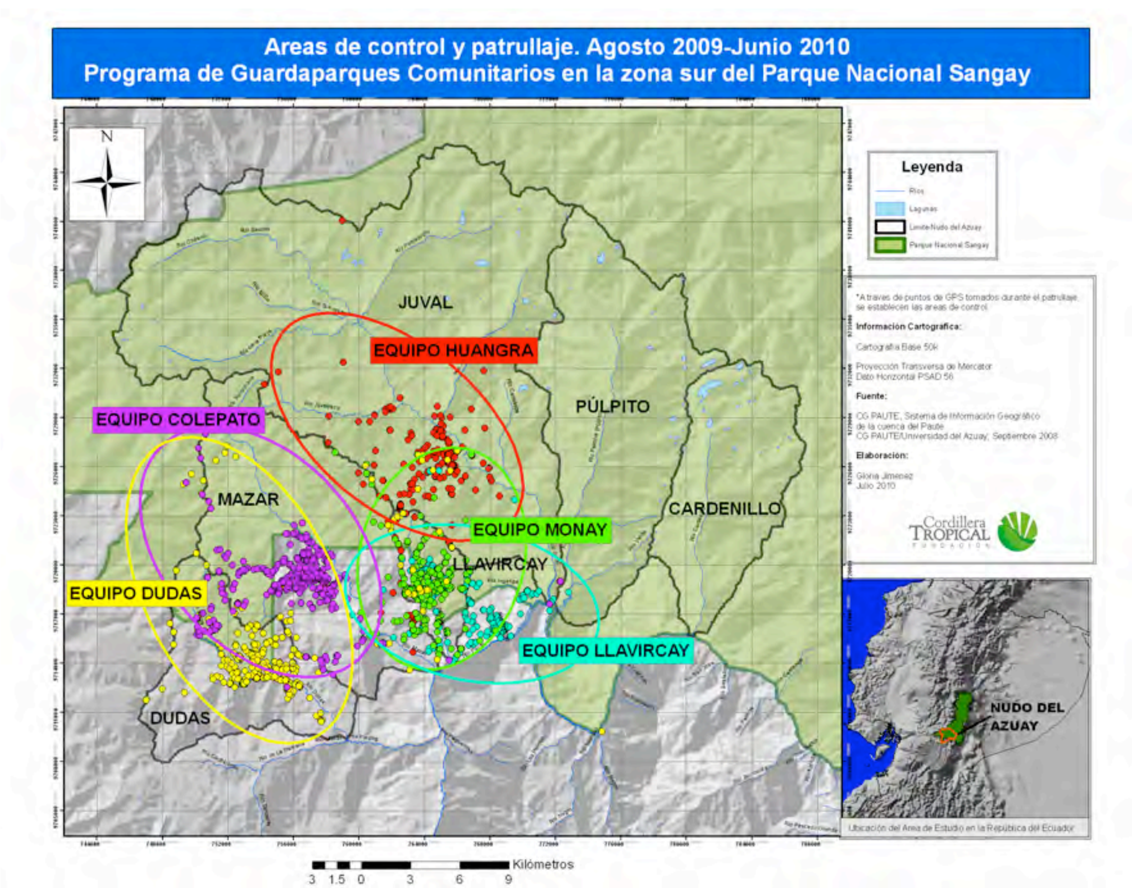
Results by Objective

1. Evaluate wildlife conservation outcomes on properties of project participants; and 2. Evaluate compliance with PPES and WF programs' demands for

habitat/wildlife protection.

FCT and CCL are training the 10 community park guards to achieve Objectives 1 and 2. The park guards include representatives from seven mestizo and indigenous communities within or near the park; additionally, three of the members are bilingual Quichua-Spanish speakers. Although most park guards have little formal education (most have completed school through 6th grade), they have far exceeded all expectations serving as interlocutors between the park and their communities, providing on-site education about the park to residents, school children, and visitors, and demonstrating a keen interest in research and monitoring projects.

Over the last 11 months the 10 parabiologists have had weekly training sessions with FCT that have focused on biodiversity monitoring techniques, use of scientific equipment (GPS, digital camera, camp stoves and tents), professional and organizational tools (leadership, team work, computers), and management of a small business (formation of a board of directors, accounting systems and document organization and storage). They patrol in teams of two throughout four sub-watersheds of Dudas, Mazar, Llavircay and Juval using field notebooks to maintain high-quality records of wildlife sign (Figure 1).



3. Assess tolerance for wildlife and attitudes to conservation interventions.
CCL and FCT designed a survey to measure landowners' tolerance and attitudes

toward wildlife, SNP, Andean bears and Ministry of Environment support for landowners that will be applied at the beginning and end of this project. The Institutional Review Board for Human Subjects Protection at the University of Wisconsin approved the survey. The aim is to use this survey to measure changes in participant's attitudes as a result of our interventions. This information will provide critical feedback for future interventions looking to establish the types of assistance that landholders find most useful in their daily property management. FCT implemented the initial surveys in late August 2010. The number of participating households is smaller than hoped for, but we aim to expand the program using word-of-mouth advertising. FCT has frequently found that landowners are reticent to participate in new and unknown activities, usually waiting for the successful outcome from a neighbor or relative's participation. The nature of our work with our neighbors seeks to respect this intransigence and provide quick and replicable results.

Initially we had proposed to develop a socio-economic survey to understand how landowners make land-use decisions and the costs (both economic and familiar) that result from transforming forest to pasture, for example. By late 2009, FCT completed an intensive household survey in 50 households in three sub-watersheds (Appendix 3). The refined survey questions looking specifically at tolerance for wildlife in the project area are presented in Spanish and in English (Appendix 4).

Initial results show that landholders view wildlife and particularly the Andean Bear as a cost with few countervailing benefits. These results are not surprising for participants in our project given that all suffered an economic loss (as measured in number of cattle lost) due to a past bear attack. Many expressed a frustration that they had received no assistance in managing bear/cattle conflicts nor any compensation for their losses.

The attacked cattle are those who are left loose in the upper-most pastures farthest from the landholders dwelling. In contrast, cows that are tied with a lead rope to a specific area of improved pasture seem not to be attacked thus far. Generally, however, those cows on a lead rope are located much closer to dwellings than their far-ranging counterparts in the upper pastures. Those interviewed related that a simple change in management from free-range grazing to controlled grazing on lead ropes is not possible due to the economic constraints of creating improved pasture with exotic grasses: rye, bluegrass, and kikuyu and the challenge of the terrain. Improved pastures are created on level plains, while free-range pasture is often located in the steepest terrain. Given the large areas that these pastures cover, many of which lack connectivity and are interspersed with large patches of forest, interviewees unanimously suggested that increased patrol of distant pastures on horseback with dogs would be the best method to deter future bear attacks. Respondents viewed other methods including alarms, visual deterrents or barriers as impractical given the immensity of the terrain.

Next steps will include working with each landholder to increase patrol of all affected pasture areas.

4. Recruit landowners for PPES program.

FCT pre-enrolled 5260 ha representing 168 beneficiaries on 50 parcels to participate in the Socio Bosque conservation incentive program run by the Ecuadorian Ministry of Environment. As noted above, all but four of these participating properties continue to await approval for program inclusion. It appears increasingly unlikely that these remaining properties will be incorporated into the Socio Bosque program for the October 2010 registration deadline, as there is little political interest in working with provincial authorities to recognize existing legal land titles.

The short-term result is that the Socio Bosque program continues to value overall number of hectares enrolled, without necessarily creating contiguous conservation blocks linking national parks with their buffer zones. Increasingly, the role of local actors, such as FCT, is to apply these novel conservation tools in a locally coherent context. FCT will continue to support the applications of all area landholders to the program as their properties form contiguous conservation areas, blocks up to 5,000 ha, that provide important habitat for wide-ranging wild animals like the Andean bear.

The Wildlife Friendly Enterprise Network is a global community formed in 2007 to develop and market products that conserve threatened wildlife while contributing to the economic vitality of rural communities. Each registered product must demonstrate that it (i) directly contributes to *in situ* conservation of key species listed on the IUCN red list, (ii) has a positive impact on the local economy, and that (iii) the product's conservation mission has a clear enforcement mechanism. At a global level, eight producers have achieved this rigorous certification. Particularly notable is the property, All Things Alpaca Ecuador, located in southern SNP that achieved certification in 2009 and continues to be certified as wildlife-friendly (http://www.wildlifefriendly.org/all-things-alpaca). At this time, no other property owners have developed finished local products that could potentially apply for WF certification.

We had initially hoped that a large indigenous cooperative might have applied for WF certification and sell a value-added cheese in local markets. This project, however, has faced innumerable and unforeseen delays. It is hoped that plant construction will begin in late 2010 and cheese production may begin in late 2011.

5. Calibrate parabiologists' indirect sign surveys with camera-trapping surveys.
We have begun to design a monitoring program that would pair indirect sign transects with camera-trapping to monitor wildlife systematically in páramo grasslands and adjacent cloud forests. Past monitoring has focused almost exclusively on one habitat or another, e.g. exclusively cloud forest or páramo. The costs of establishing a monitoring protocol across these diverse terrains has been prohibitive up until this point. However, the support of USFWS will allow us to develop the first large-scale monitoring program in both ecosystems. Given that many animals, including the Andean bear, spend part of their time in the páramo ecosystem, the conservation of bear habitat must consider the unique habitat matrix, including seasonal food sources in páramo and forest, which form an integral part of the bear's habitat. Based on two field seasons using remote camera traps, CCL has found that cameras successfully monitor numerous large vertebrates and especially carnivores in the dense cloud forest

understory. Moreover, CCL has developed a two-camera trap station design that resulted in 87% success rate of individual identification of bears (Jones 2010; Appendix 1).

CCL and FCT will assist each team of parabiologists with the installation of two cameras per station (and two stations per zone) following recommendations made by Zug (2009) and Jones (2010) for placement, height, and selection of micro-sites. Priority in site selection will be placed on finding the two best camera trap stations based on wildlife trail definition and shrub layer density (Appendices 1 and 5). The distance between the two stations will be between 200 and 500 m. Between these two stations, each team will define a D-shaped transect traversing forested and páramo habitats. The parabiologists will walk the entire "D" each month starting September 2010 and record GPS locations of any indirect sign (scat, tracks, bedding areas, hair, consumed plants, or other signs) of wildlife. The aim is to identify the species that made the sign and correlate indirect signs found in páramo to wildlife photo-captured in the forest. CCL will complete the training of the parabiologists and FCT staff by mid-September 2010 (See #7 for an explanation of the training program).

6. Planning workshops.

Since 2007, CCL and FCT have been engaging landowners to manage human-wildlife conflicts non-lethally (Treves et al. 2009d). In May 2010, CCL trained two FCT employees, one SNP staff member, two parabiologists, and 15 community members in methods for mitigating human-wildlife conflicts and camera-trapping with a focus on carnivores and particularly Andean bears. Our goals are two-fold: (i) protect the bears from lethal retaliation by landowners attempting to protect their property, and (ii) protect the landowners' property and improve their tolerance for bears.

In May and June of 2010, community parabiologists conducted informal household interviews to identify landowners affected by bear attacks during the past twelve months. We did not actively recruit landowners from Juval sub-watershed (Figure 1) to join our mitigation project because of the difficulties of accessing the community (6 hours on horseback from the nearest road) and their desire not to work with any NGOs currently.[4] The community parabiologists identified four affected landholders who had lost four cattle to bear attacks and had one injured cow who survived in the Mazar and Llavircay watersheds in the last 12 months. This rate of attack is greater than FCT had observed in the Colepato community where initial pilot project was developed in 2008.

Moreover, the site of the attacks varied from previous registered attacks in the Colepato community. An initial project in the community of Colepato identified several characteristics of bear attacks on dairy cattle: (i) cattle located four or more hours on foot from nearest dwelling, (ii) visits to cattle less than one time per week, and (iii) maintenance of many smaller heifers in distant pastures (Achig and Santillan 2009). However, the most recent registered attacks occurred in pastures located between 5

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[4] The Quichua communities in the Juval watershed are self-sufficient with relatively low level of interaction with outsiders, be they neighboring communities, local governments or NGOs. This attitude is slowly changing as they become more accustomed to the rhythms of the outside world.

and 90 minutes walking distance from the nearest dwelling, significantly closer to inhabited dwellings than previously reported. Additionally, management varies drastically between these two areas and most of those recently affected by attacks relate that they visit their cattle at least one time per day to provide them with water. Finally, all the attacks in the Colepato community occurred in distant páramo grasslands, while all the most recent attacks occurred in lower pastures adjacent to recently deforested cloud forest.

In June 2010, FCT led a conflict mitigation workshop for these five affected landowners from Mazar and Llavircay, sub-watersheds. Participants indicated a limited knowledge of mitigation techniques: fencing, increased patrol, noise or visual deterrents (Appendix 6). Several suggested that enhanced supervision of herds and pastures could be successful, but indicated a need for greater technical support to implement these and other mitigation efforts. FCT facilitators asked participants if it would be viable to abandon some of these distant pastures, but none of the landowners could economically afford to cease using established pastures. The cost of establishing a pasture (from a previously forested area) can exceed \$648 per ha according to a study by FCT (Hernandez 2009). Given the large economic investment in pasture creation and our twin goals of protecting bears and people, we continue to search for mitigation methods that do not require pasture abandonment.

Five landowners participated in the initial workshop; however, two declined to develop individual farm mitigation plans in a subsequent meeting, because they felt they had already mitigated the problem successfully. One landowner abandoned the distant pasture and moved his cattle into a pasture closer to home. The other had faced no subsequent attacks and believed the problem to be resolved. FCT expects that the project will slowly gain momentum and will continue to offer technical support to these two landowners with the aim of securing their participation at a later point.

See Appendix 6 for the results of the surveys and a review of next steps.

7. Training.
To date, the majority of our work has focused on training parabiologists and FCT staff to mitigate human-wildlife conflicts and to develop a monitoring model. Beginning in March 2010, CCL staff trained FCT staff in the mitigation of human-wildlife conflicts and carnivore monitoring during a 72-hour hands-on, intensive course offered in Cuenca, Ecuador. In May 2010, CCL and FCT designed and led a two-week short course entitled "Balancing human needs and carnivore conservation" for 15 undergraduates from the University of Azuay in Cuenca, Ecuador (co-financed by the Fulbright Senior Specialist Program). This short course included 50 hours of contact time with students, FCT staff, community park guards and SNP staff. The overnight field excursion allowed participants to learn camera-trapping techniques *in situ* and enhance understanding of bear attacks on livestock via interviews with local landowners. Participants of these two courses are well versed in mitigation and monitoring techniques for large mammals, with a particular focus on the Andean bear. In August 2010, FCT will begin training affected landowners and their families how to design, install, and maintain deterrents

and preventive measures to prevent bear attacks on dairy cattle.

Since late 2009, FCT staff have been training 10 parabiologists in a variety of administrative, scientific, and field skills during weekly meetings. Their results between August 2009 and the end of June 2010 include the following:

- 13,520 hours of patrol in the Dudas, Mazar, Llavircay and Juval sub-watersheds (see Figure 1).
- 3,520 hours of training and capacity building via formal workshops about hydrological monitoring, herpetofauna identification and monitoring, and large mammal monitoring; and informal discussions and skill-based training about the use of scientific equipment (GPS, digital camera, field notebooks, tents, and backpacking stoves, professional skills (teamwork, leadership, field work, and computer skills), and management of a microenterprise (organization, delegation, obligations, etc.).
- 80 hours of environmental education in local schools
- 64 hours of patrol for illegal fishing in the Dudas sub-watershed.

See Appendix 7 for a list of names and photos of the ten parabiologists.

8. Model habitat suitability for wildlife and extrapolate to project area. Based on two years of intensive camera trapping in an 18 sq. km area (Zug 2009; Jones 2010), results suggest that locations with many bear photo-captures are associated with many photo-captures of other wildlife species and usually occur along well-defined wildlife trails with dense vegetation. Based on these initial findings, community parabiologists will identify existing game trails (July-August 2010) and install the motion-activated cameras in September 2010 (See full methods in #5).

The monitoring will occur during the dry season over a period of five months. This plan will greatly increase the total number of trap nights over previous work and expand our knowledge of habitat use by animals from the wet season to the dry season. By March 2011, we expect to have (i) estimates of relative abundance of bears and other wildlife within each participating sub-watershed, (ii) a minimum count of individually identified Andean bears with possible estimates of individual home range extent, and (iii) a means to estimate bear use of páramo habitats by relating indirect sign surveys to photo-captures of individually recognizable bears.

From these sets of data we will construct a model of habitat suitability for bears within cloud forest and páramo habitats of the entire project area. The modeling effort is underway as CCL has developed methods for logistic regression and information-theoretic model selection procedures to discriminate camera trap sites without bear photos from those with bear photos on the basis of differences in habitat. In addition the recapture of known bears (individually identifiable from facial markings) at different locations and in the same locations over time will permit a more robust estimate of home range size and population density than previously available for our region.

9. Build teamwork among community parabiologists.

FCT has and will continue to train the ten community parabiologists in wildlife monitoring, patrol and protection, environmental education, and hydrological monitoring. Each park guard team works in a different, remote field location with little interaction between the different crews. As such, weekly meetings between park guards and FCT staff facilitate communication, provide on-going training, respond quickly to equipment problems, and discuss problems and seek potential solutions collaboratively.

10. Test and refine wildlife habitat suitability models.
In March 2011, CCL will verify and validate the habitat suitability model generated from the parabiologists' field data. Habitat suitability models tend to fail when extrapolated beyond the environmental conditions from which they were generated, or tend to fail when they are over-fitted (too many weak variables included as predictors). A legitimate test of any model demands that it predict future, unmeasured sites beyond the original study area with better-than-chance precision and accuracy. Therefore CCL and FCT will conduct their own independent validation by selecting sites predicted to be higher or lower suitability and attempting to verify those predictions using the same methods as the parabiologists used.

11. Provide technical support to participating landowners.
FCT is engaged continuously in an effort to gain central government recognition and payments for the conservation efforts of the 168 beneficiaries in the PPES program. This advocacy and support is expressed in on-going negotiations with the Ministry of Environment's Socio Bosque program and its potential constituents. Also FCT and CCL continue to collaborate with interested landowners to mitigate human-wildlife conflicts.

12. Reporting to stakeholders.
At each training opportunity (Objective 7 above), we review our goals and collaborative activities so audiences are made aware of all the elements of our work in the region. Specifically FCT participates monthly in meetings of a consortium called FONAPA (Paute River water fund whose members include ETAPA E.C., CELEC-Hidropaute E.C., EMAPAL, ElecAustro, University of Cuenca, The Nature Conservancy and FCT) and is sharing information on monitoring efforts with other participants toward the final aim of forming a Paute River biodiversity monitoring plan and protocol.

Providing Spanish-language information to our partners continues to be a top priority for FCT and CCL. FCT publishes information about our efforts in a small, colorful bulletin that is distributed four times per year in the region's communities. CCL publishes its Spanish-language manuals on the LTC website and in person during training (see http://www.nelson.wisc.edu/ltc/publications.html#briefs). CCL reports to U.S. and international media outlets on our work investigating human-wildlife conflicts and coexistence (www.nelson.wisc.edu/people/treves/Press.html), presents findings to scientific audiences at conferences, and prepares manuscripts for publication in pee-reviewed scientific journals (www.nelson.wisc.edu/people/treves/Publications.html). Of particular relevance to the current project are two Masters theses, seven public presentations, and two peer-reviewed papers CCL has produced (Zug & Treves 2008; Treves 2009; Treves & Jones 2009; Treves et al. 2009a; Treves et al. 2009b; Treves et al. 2009c; Treves et al. 2009d; Zug 2009; Jones 2010; Treves et al. 2010a; Treves et al. 2010b; Treves & Martin in press) See Appendix 8 for copies. The conference presentations are listed below:

Carnivores 2009 Special Symposium	Uses of individual identification for conservation initiatives in and around Sangay National Park, Ecuador	T. Jones, R. Zug, A. Treves	Denver, CO, November 2009
Carnivores 2009 Special Symposium	Andean Bear (Tremarctos ornatus) Presence on Private Lands in the Ecuadorian Andes	R. Zug, A. Treves	Denver, CO, November 2009
1st Annual Meeting, Assoc. Environmental Studies and Sciences, Special Symposium	Uses of individual identification for conservation initiatives in and around Sangay National Park, Ecuador	T. Jones, R. Zug, A. Treves	Madison, WI, October 2009
1st Annual Meeting, Assoc. Environmental Studies and Sciences, Special Symposium	Andean Bear (Tremarctos ornatus) Presence on Private Lands in the Ecuadorian Andes	R. Zug, A. Treves	Madison, WI, October 2009
Universidad de Azuay, Cuenca, Ecuador	Balancing human needs with carnivore conservation	A. Treves	Cuenca Ecuador, May 10, 2010

d. Provide a brief assessment of the project's impact on the conservation and management of plants, fish, habitats, or ecosystems. If possible, provide a list of the numbers and names of migratory, endangered or threatened species benefiting from the project, as well as major ecosystems and any reserves or protected areas benefiting from the project.

The Andean bear is endangered in Ecuador and listed as "vulnerable" by the IUCN. Our project helps to protect individual bears surviving on private lands encompassed by SNP. Global attention to the fate of endangered species helps our team raise international awareness of Andean bear conservation needs. Support from the USFWS through this grant helped to leverage additional support for work in 2010–2011 through the Disney Wildlife Conservation Fund and USAID through the Leader with Associates Cooperative Agreement No.EPP-A-00-06-00014-00 for implementation of the Translink project. No federal funds were matched with other federal funds.

Our project trains and raises awareness of the need for biodiversity conservation of the montane forests and páramos of the tropical Andes of Ecuador among varied stakeholders and audiences. As a direct result of our work with USFWS funds, we have received no reports of retaliatory killing of wildlife since August 2009 due in part to an increased level of patrol, but more generally to a growing confidence on the part of landholders to seek help from park guards or FCT to confront these conflicts.

The four enrolled properties in the Socio Bosque conservation incentive program protect valuable montane forest habitat for a period of twenty years. We hope to expand the total number of hectares conserved and contiguous area of conservation to 10,000 ha in the future.

As a by-product of our monitoring in 2008 and 2009, CCL has also photo-captured two species thought to be absent from high Andean montane forests, the margay, *Leopardus wiedii* and the oncilla, *Leopardus tigrinus* (Zug 2009). This is the first registered sighting of an oncilla in Sangay National Park, a widely distributed species that is nevertheless rare in occurrence and a major habitat extension for the margay which usually occurs between 900 and 1,450 masl (Tirira 2007).

e. *Briefly describe any cooperation or collaboration among local organizations that was directly associated with this project.*

CCL and FCT have been collaborating since late 2006 and tend to complement each other with the following division of labor: CCL provides wildlife monitoring expertise with respect to carnivores and large vertebrates, training and technical support in human dimensions of wildlife, and fund-raising support. FCT coordinates with participating stakeholders, provides training and logistical support in the field, planning and permitting, and critical capacity for project management, administration, and on the ground project implementation.

FCT is coordinating training and dissemination of results with colleagues at nearby Cajas National Park in the Azuay Province of Ecuador, renowned Ecuadorian bear expert, Armando Castellaños, at Fundación Espiritu del Bosque in Ecuador, and the Ecuadorian Ministry of Environment. CCL has also been reporting on project goals and methods to the Wildlife Conservation Society–Ecuador (Dr. Andy Noss) and Conservation International–Ecuador (Dr. Luis Suarez).

f. *If equipment was purchased under this Award, provide the cost and the acquisition date of the equipment and a brief description of how the equipment was used during the period of performance of the Award and how it will be used in the future. Equipment purchase under this Award will become Recipient's property if it was used only for the purposes of the Award and can continue to be used for a similar purpose throughout its useful life. See Section IV for additional information on equipment management and disposition.*

No item exceeding $5,000 was purchased with this grant.

FEDERAL FINANCIAL REPORT

(Follow form instructions)

1. Federal Agency and Organizational Element to Which Report is Submitted Interior, US Department of Interior	2. Federal Grant or Other Identifying Number Assigned by Federal Agency (To report multiple grants, use FFR Attachment) 96200-9-G219	Page 1 of 1 pages

3. Recipient Organization (Name and complete address including Zip code)
Board of Regents of University of Wisconsin System, 21 North Park Street, Suite 6401, Madison WI 53715

4a. DUNS Number	4b. EIN	5. Recipient Account Number or Identifying Number (To report multiple grants, use FFR Attachment)	6. Report Type	7. Basis of Accounting
161202122	396006492	MSN126944	☐ Quarterly ☐ Semi-Annual ☐ Annual ☐ Final	☐ Cash ☒ Accrual

8. Project/Grant Period From: (Month, Day, Year)	To: (Month, Day, Year)	9. Reporting Period End Date (Month, Day, Year)
August 25, 2009	March 30, 2011	July 31, 2010

10. Transactions	Cumulative
(Use lines a-c for single or multiple grant reporting)	
Federal Cash (To report multiple grants, also use FFR Attachment):	
a. Cash Receipts	$9,116.10
b. Cash Disbursements	$30,401.65
c. Cash on Hand (line a minus b)	($21,285.55)
(Use lines d-o for single grant reporting)	
Federal Expenditures and Unobligated Balance:	
d. Total Federal funds authorized	$32,477.00
e. Federal share of expenditures	$30,401.65
f. Federal share of unliquidated obligations	$0.00
g. Total Federal share (sum of lines e and f)	$30,401.65
h. Unobligated balance of Federal funds (line d minus g)	$2,075.35
Recipient Share:	
i. Total recipient share required	$146,826.00
j. Recipient share of expenditures	$98,421.74
k. Remaining recipient share to be provided (line i minus j)	$48,404.26
Program Income:	
l. Total Federal program income earned	$0.00
m. Program income expended in accordance with the deduction alternative	$0.00
n. Program income expended in accordance with the addition alternative	$0.00
o. Unexpended program income (line l minus line m or line n)	$0.00

11. Indirect Expense	a. Type	b. Rate	c. Period From	Period To	d. Base	e. Amount Charged	f. Federal Share
	Predetermined	0.26	8/25/09	3/30/11	$24,128.30	$6,273.36	$6,273.35
					$0.00	$0.00	$0.00
				g. Totals:	$24,128.30	$6,273.36	$6,273.35

12. *Remarks: Attach any explanations deemed necessary or information required by Federal sponsoring agency in compliance with governing legislation:*

13. Certification: By signing this report, I certify that it is true, complete, and accurate to the best of my knowledge. I am aware that any false, fictitious, or fraudulent information may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 18, Section 1001)

a. Typed or Printed Name and Title of Authorized Certifying Official **Sarah M. Gatz** **Senior Sponsored Projects Financial Officer**	c. Telephone (Area code, number and extension) 608/262-9794 d. Email address sgatz@RSP.WISC.EDU
b. Signature of Authorized Certifying Official Sarah M Gatz	e. Date Report Submitted (Month, Day, Year) August 17, 2010
	14. Agency use only:

Standard Form 425
OMB Approval Number: 0348-0061
Expiration Date: 10/31/2011

REQUEST FOR ADVANCE OR REIMBURSEMENT

RSPBS06 (see instructions)

Approved by Office of Management and Budget, No. 80-R0183		Page 1	of 1 pages
1. TYPE OF PAYMENT REQUESTED	a. "X" one, or both boxes: ADVANCE; REIMBURSEMENT X b. "X" the applicable box: FINAL; PARTIAL X		2. BASIS OF REQUEST: CASH; ACCRUAL X

3. FEDERAL SPONSORING AGENCY AND ORGANIZATIONAL ELEMENT TO WHICH THIS REPORT IS SUBMITTED INTERIOR, US DEPARTMENT OF INTERIOR	4. FEDERAL GRANT OR OTHER IDENTIFYING NUMBER ASSIGNED BY FEDERAL AGENCY 96200-9-G219	5. PARTIAL PAYMENT REQUEST NUMBER FOR THIS REQUEST MSN0128993 05

6. EMPLOYER IDENTIFICATION NUMBER 396006492	7. RECIPIENT'S ACCOUNT NUMBER OR IDENTIFYING NUMBER MSN126944	8. PERIOD COVERED BY THIS REQUEST FROM (month, day, year) 07/01/2010	TO (month, day, year) 07/31/2010

9. RECIPIENT ORGANIZATION

Board of Regents of University of Wisconsin System
21 North Park Street, Suite 6401
Madison, WI 53715

10. PAYEE (Where check is to be sent if different than item 9)

UW-Madison GAR Account
Office For Research & Sponsored Programs
Drawer #538
Milwaukee, WI 53278-0538

11. COMPUTATION OF AMOUNT OF REIMBURSEMENT/ADVANCES REQUESTED

PROGRAMS/FUNCTIONS/ACTIVITIES		(a)	(b)	(c)	TOTAL
a. Total program outlays to date	(As of Date) 07/31/2010	$ 128,823.39	$	$	$ 128,823.39
b. Less: Cumulative program income		0.00			0.00
c. Net program outlays (Line a minus line b)		128,823.39			128,823.39
d. Estimated net cash outlays for advance period		0.00			0.00
e. Total (Sum of lines c & d)		128,823.39			128,823.39
f. Non-Federal share of amount on line e		98,421.74			98,421.74
g. Federal share of amount on line e		30,401.65			30,401.65
h. Federal payments previously requested		29,678.94			29,678.94
i. Federal share now requested (Line g minus line h)		722.71			722.71
j. Advances required by month, when requested by Federal grantor agency for use in making prescheduled advances	1st month				
	2nd month				
	3rd month				

12. ALTERNATIVE COMPUTATION FOR ADVANCES ONLY

a. Estimated Federal cash outlays that will be made during period covered by the advance	
b. Less: Estimated balance of Federal cash on hand as of beginning of advance period	
c. Amount requested (Line a minus line b)	

13. CERTIFICATION

I certify that to the best of my knowledge and belief the data above are correct and that all outlays were made in accordance with the grant conditions or other agreements and that payment is due and has not been previously requested.	SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL Sarah M Gat[signature]	DATE REQUEST SUBMITTED 08/09/2010
	TYPED OR PRINTED NAME AND TITLE ADMINISTRATIVE OFFICER	Phone (Area Code, No., Ext.) 608/262-3822

Appendix 1
Two Masters theses attached with this report. T. Jones (2010) "Detection probability and individual identification of the Andean bear (Tremarctos ornatus) using camera trapping methods" Masters Thesis in Conservation Biology and Sustainable Development, Nelson Institute for Environmental Studies, University of Wisconsin–Madison. B. Zug (2009) "Individual identification and habitat use of Andean bears on private lands in the Ecuadorian Andes" Masters Thesis in Conservation Biology and Sustainable Development, Nelson Institute for Environmental Studies, University of Wisconsin–Madison. For digital copies, email atreves@wisc.edu

Appendix 2
Table. Revised timeline as of July 2010

ACTIVITY	Pre-POP	Project POP (March 2010 – March 2011)												
Highlighted items are completed	May-Nov 2009	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
FCT recruits landowners for PPES	X	X	X	X										
CCL monitors biodiversity intensively in the study area	X													
Parabiologists monitor biodiversity in their localities								X	X	X	X	X	X	X
FCT and CCL work with individual project participants				X			X	X					X	
CCL and FCT conduct training	X			X	X		X	X						
Weekly meetings with parabiologists		X	X	X	X	X	X	X	X	X	X	X	X	X
Report to stakeholders	X	X	X	X	X	X	X	X					X	X

Appendix 3. Summary of socio-economic survey of landowners in the Nudo del Azuay (Spanish) attached. Or email director@cordilleratropical.org for a digital copy in Spanish.

SOCIOECONOMIC INFORMATION OF THE COMMUNITY OF MONAY, SUB-WATERSHED LLAVIRCAY.
Prepared by: Lucas Achig B.
April 2010
English version
General socioeconomic information
All interviewed people have property title over the lands. The majority lives more than twenty years in this area. The number of dependents per household is approximately 5 persons. From all persons in each family, an average of three, to work in agricultural tasks.
The main sources of livelihood are agricultural crops, livestock production and some uses from the forests of the area. The local market more closest is Zhoray, localized from 1 hour and half by horse or 30 minutes by car.

Land Use

The most important use of land is given to maintaining the forest. Other important uses are the grass production and the presence of high grass. In lesser extent are: pine plantations, production of mixed crops and home gardens (Figure 1).

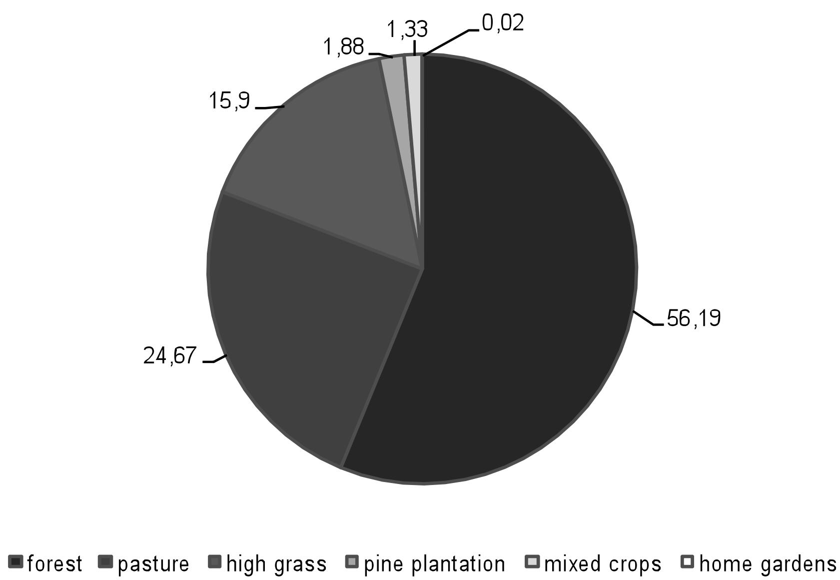


Figure 1. Percentage of land use in the interviewed families of the Monay community, Sub-watershed Llavircay. Data taken from Hernandez study, 2009.

Crops

Corn, beans and potatoes are the main crops present in the locality. Other crops less common are fava beans and peas. Although two producers sowed large areas of peas (Figure 2).

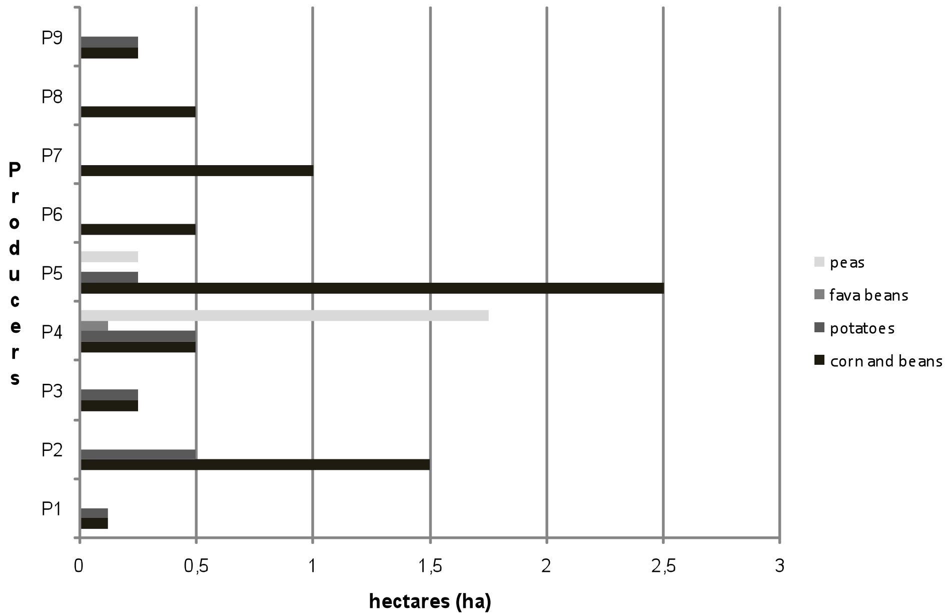


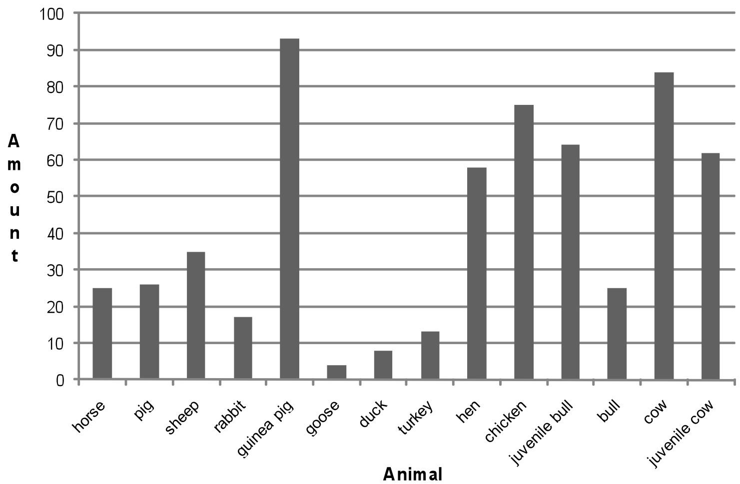
Figure 2. Crops in interviewed families from Monay community, Sub-watershed Llavircay. Data taken from Hernandez study, 2009.

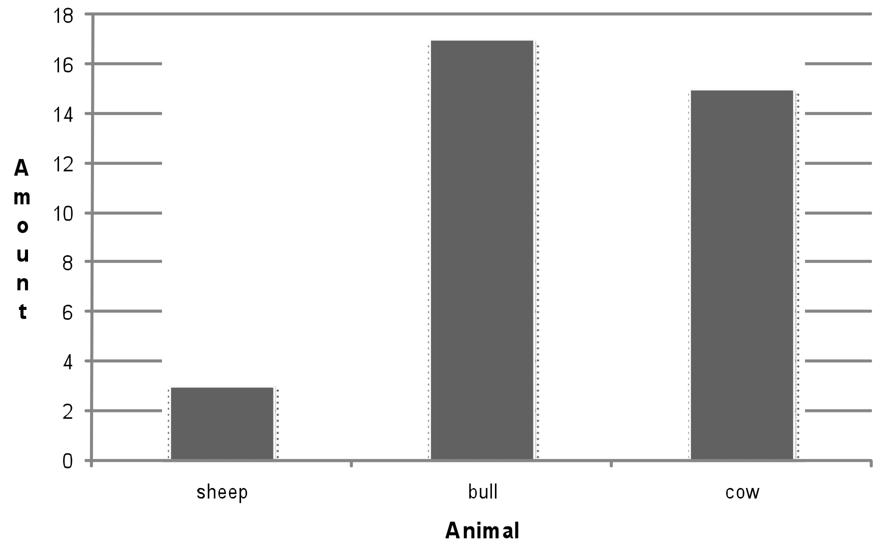
All farmers sowed beans and corn together. A farmer sowed peas with potatoes and another sowed fava beans with corn.
From harvest obtained: beans, fava beans and corn are used almost entirely for self-consumption. Even though, also the potatoes and peas are consumed by producers; those can be sold off, mainly in market of Shoray. Four families hold home gardens for self-consumption.

Animal husbandry

The main animals are raising on Monay are cattle (cows, juvenile cows and bull, and bulls), as well as chickens, and guinea pigs (Figure 3). The most widely used grass for livestock production is the Kikuyu. Also people used a lesser extent mixed grasses (ray-grass, kikuyu, clover and bluegrass). Most farmers do not use fertilizers and chemicals in their pastures.

Figure 3. (Left) Animals bred by interviewed families of the commnunity of Monay, Sub-watershed Llavircay. Data taken from Hernandez study, 2009. Figure 4. (Right) Animals sold by interviewed families of the community of Monay, Sub-watershed Llavircay. Data taken from Hernandez study, 2009.





The animals being sold by the interviewed families are cows, bulls and sheep. Therefore, these animals are an important element in monetary flow of the families in this area (Figure 4).

Derivatives of livestock production

The main derived from livestock production are milk, fresh cheese, and eggs. However, the milk is used mainly for the production of fresh cheeses and it is the only that sold out of their homes each week. The remaining eggs and milk is used for self consumption.

Use of forest resources

Among the interviewed families, the main uses from forest are trees or branches cut for obtaining fence posts and firewood for domestic use. Another use is the extraction of timber. In the answers not reported extraction of forest resources for sale at local markets or other communities.

Appendix 4
Figure. Attitudinal survey for landowners facing threats from Andean bears (Spanish and English versions)

ENCUESTA SOBRE PERCEPCIONES DE LOS AFECTADOS POR EL CONFLICTO OSO ANDINO/ GANADO VACUNO. PROYECTO DON OSO. AÑO 2010

Nombre del Entrevistado .... **Fecha:** ....

Entrevistador (es): ....

1. La fauna silvestre en su propiedad aumenta el valor de su propiedad
Muy de acuerdo ☐ De acuerdo ☐ No responde ☐
En desacuerdo ☐ Muy en desacuerdo ☐

2. El oso andino trae beneficios para ustedes
Muy de acuerdo ☐ De acuerdo ☐ No responde ☐
En desacuerdo ☐ Muy en desacuerdo ☐

3. El oso andino ocasiona gastos para ustedes
Muy de acuerdo ☐ De acuerdo ☐ No responde ☐
En desacuerdo ☐ Muy en desacuerdo ☐

4. Otros animales silvestres traen beneficios para ustedes
Muy de acuerdo ☐ De acuerdo ☐ No responde ☐
En desacuerdo ☐ Muy en desacuerdo ☐

5. Otros animales silvestres ocasionan gastos para ustedes
Muy de acuerdo ☐ De acuerdo ☐ No responde ☐
En desacuerdo ☐ Muy en desacuerdo ☐

6. Prevenir el daño que le ocasionan los osos es imposible
Muy de acuerdo ☐ De acuerdo ☐ No responde ☐
En desacuerdo ☐ Muy en desacuerdo ☐

7. ¿podría usted ser más tolerante a los osos si estos están fuera de su propiedad?
Muy de acuerdo ☐ De acuerdo ☐ No responde ☐
En desacuerdo ☐ Muy en desacuerdo ☐

8. ¿Cree que el gobierno debería poner a los osos lejos de su propiedad?
Muy de acuerdo ☐ De acuerdo ☐ No responde ☐
En desacuerdo ☐ Muy en desacuerdo ☐

9. ¿Cree que con algo de ayuda de afuera, podría mantener lejos de su propiedad a los osos?
Muy de acuerdo ☐ De acuerdo ☐ No responde ☐
En desacuerdo ☐ Muy en desacuerdo ☐

Jaime Roldós 4-80 y Huayna Cápac, edificio El Consorcio, oficina 412, Telf.: 593 7 2809382
P.O. Box 01-01-1986 / correo-e: info@cordilleratropical.com / Cuenca, Ecuador

Questions translated into English:

Ask participants in human-bear conflict mitigation if they agree or disagree with the following structured questions:

1. Wildlife on my property raises the value of my property
   • Strongly agree • agree • neutral • disagree • Strongly disagree
2. Andean bears bring benefits to property owners
   • Strongly agree • agree • neutral • disagree • Strongly disagree
3. Andean bears bring costs to property owners
   • Strongly agree • agree • neutral • disagree • Strongly disagree
4. Other wildlife bring benefits to property owners
   • Strongly agree • agree • neutral • disagree • Strongly disagree
5. Other wildlife bring costs to property owners
   • Strongly agree • agree • neutral • disagree • Strongly disagree
6. Preventing Andean bears from damaging property is impossible
   • Strongly agree • agree • neutral • disagree • Strongly disagree
7. I would be more tolerant of Andean bears if they stayed away from my property
   • Strongly agree • agree • neutral • disagree • Strongly disagree
8. I believe the government should keep bears away from my property
   • Strongly agree • agree • neutral • disagree • Strongly disagree
9. With some outside help I can keep bears away from my property
   • Strongly agree • agree • neutral • disagree • Strongly disagree

Appendix 5.
Reports on individual identification of bears for community members and collaborators (2009).

2009 Report on Wildlife Friendly monitoring and verification project, Ecuador
by Adrian Treves, PhD
September 17, 2009

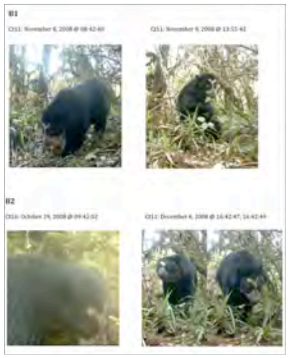


Figure 1. Individually identified Andean bears (*Tremarctos ornatus*) photo-captured on the private property of All Things Alpaca Ecuador, a Certified Wildlife Friendly producer of alpaca fiber, and on Colepato community land, a participant in the Payment for Protection of Ecosystem Services program of Selec Hidropaute and Fundacion Cordillera Tropical.

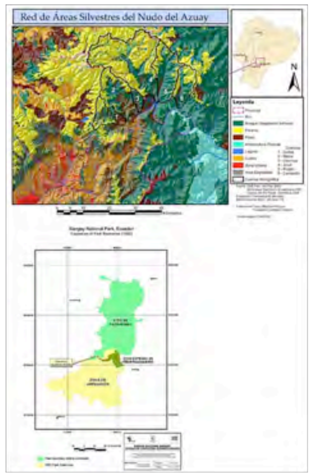


Figure 2. The project site (Nudo del Azuay NdA) in south-central Ecuador (upper left and right). NdA is situated in the southern sector of Sangay National Park (lower), which was extended over private, titled lands in 1992.

Overview: Rewards for food and fiber production that protects biodiversity demand that one connect environmentally sensitive consumers to producers who collect and manufacture without harm to habitats and wildlife.

Goals of our project:

1. Verify conservation of threatened wildlife on lands claiming to produce wildlife-friendly food and fiber.
2. Investigate methods for monitoring that can become producer-based, cost-effective, and credible to scientists and consumers.
3. Analyze strategic trade-offs between consumer confidence in Certified Wildlife Friendly and producer incentives to join and maintain the eco-label.

Background: We investigated the IUCN red-listed (2008) Andean bear (Figure 1) in south-central Ecuador (Figure 2) on two private properties totaling >30 km^2. The property owners are both participants in 1–2 programs paying for the protection of ecosystem services (PPES). We began work in the summer

1

Presentation of Project Results to the Colepato Community Cooperative
Prepared by R. Zug, V. Shelley, T. Jones and A. Treves of the Carnivore Coexistence Lab, Nelson Institute for Environmental Studies, University of Wisconsin-Madison

On May 31, 2009, we returned to the Colepato community to present the results from the 2008 Andean bear camera trap study. The goals of this meeting were to (1) share the results in a way that was meaningful to the community and beneficial to current and future conservation projects, (2) compare the results of species diversity with their knowledge of the wildlife on their property, and (3) to ask permission to continue Andean bear research on their land. We complied an album of camera trap photos from their property as a thank-you gift to the community and as a visual record of the project to be stored in the community meeting hall. For the individual community members, we brought printed copies of bear and puma photos for each family to take home.

Our study was one of several on Colepato land in 2008. Before the meeting began, we were told that the community was frustrated because they had not been informed of the outcomes of these projects. There was also concern that they might feel negatively towards additional projects on their land because they did not perceive any benefits. As a result, we hoped to use this meeting to show the community that their participation in conservation-based research is productive. Making the results available to them for their own conservation initiatives would ensure that they felt relationships with researchers to be mutually beneficial.

We invited the entire community to the presentation and projected the camera trap photos on the wall of the meeting hall. Overall, the community seemed very excited about the photos and our results. The photos sparked conversations between community members and many questions. Members discussed the locations of photo-captured wildlife and identified most species using local names (e.g. puma = gran bestia). We reported that through the use of the unique facial patterns we were able to identify at least three bears on their land (at the time a fourth bear was not yet identified). In response, one community member claimed that there were many more than three bears on their property. We

Photos: (top) Local alpaca rancher and owner of All Things Alpaca Ecuador, a Certified Wildlife Friendly business, Stuart White, looks at an album of camera trap photos;(middle) R. Zug presents the album of camera trap photos to the Colepato community president, Jose Manuel Ojeda;(bottom) Colepato community members select printed camera traps photos to take home.

Photo Credit: V. Shelley/Carnivore Coexistence Lab

Appendix 6. FCT activity reports

Fundación Cordillera Tropical's 'Don Oso' Program aims to reduce retaliatory killing of the endangered Andean bear to zero in southern Sangay National Park, Ecuador

(*Cuenca, Ecuador*) – Fundación Cordillera Tropical (FCT) announces a new program to mitigate conflicts between private property owners and the Andean bear (*Tremarctos ornatus*) in southern Sangay National Park. In Ecuador, the Andean bear is endangered due to habitat loss and hunting, often as a result of human/bear conflicts. Retaliatory killing of bears following attacks on cattle is considered one of the primary threats to long-term conservation of the species.

Retaliatory killing following attacks on cattle poses a major threat to the endangered Andean bear

FCT's Don Oso Program began six years ago as an environmental education initiative in schools in southern Sangay National Park. Since then, the program has expanded to focus on two additional aspects of Andean bear conservation: scientific research on habitat use and survivorship, and conflict mitigation to increase landholder tolerance toward this emblematic species. This work directly addresses the action strategies put forth in the Ministry of Environment's "National Strategy for Bear Conservation," published earlier this year.

In June 2010, in conjunction with the community associative small business "Park Guards for Nature Conservation", FCT identified four property owners in the Mazar and Llavircay sub-watersheds who had experienced problems with the Andean bear, and analyzed the conflicts specific to each. These property owners report losses over the last two years of four cows, one bull, and one yearling bull as well as injury to one cow. Such bear attacks are not unusual for the region; other residents relate that just two years ago they worked in unison to scare off a "problem" bear.

Cattle kept in isolated areas and rarely visited are at greater risk of bear attack

Generally, bear attacks occur in areas that are distant from population centers and close to the forest edge. A 2008 pilot project in the community of San Carlos de Colepato, located in the Mazar sub-watershed, found that bear/cattle conflicts occurred exclusively in isolated areas of páramo where cattle grazed without surveillance. As one community member related, "We kept them [our cattle] loose. Sometimes we did not have time – maybe three weeks or one month would pass before we went up… That's how the bear attacked [our cattle] and ate them".

Initial results from the current project suggest a different pattern than in Colepato, however. In the communities of Mazar and Llavircay, human/bear conflict zones are close to occupied dwellings and roads, which suggests that conditions preceding a bear attack vary greatly between communities and may require different mitigation strategies.

In the coming months, FCT, landowners and community park guards will evaluate the efficacy of potential mitigation methods, including physical barriers to protect cattle (wooden fences or wire mesh), loud noises or visual deterrents, or an increase in cattle surveillance. The participation of park guards and landowners as para-biologists in this program sets an important precedent in training these local community members to respond effectively to future bear attacks.

The Don Oso Program aims to reduce retaliatory killings of the Andean bear to zero in this region, and to identify successful methods of deterring bears from approaching human settlements. The program is a collaboration between FCT and the Carnivore Coexistence Lab (CCL) at the University of Wisconsin at Madison. CCL won financial support from the United States Fish and Wildlife Service, the Disney Worldwide Conservation Fund, and the U.S. Agency for International Development through the TransLinks Cooperative Agreement with The Wildlife Conservation Society and The Land Tenure Center.

INFORME DEL TALLER

"MÉTODOS PARA REDUCIR LA PÉRDIDA DE GANADO POR ATAQUE DEL OSO ANDINO"

Fecha: 28 de junio del 2010

Facilitador: Lucas Achig Balarezo

Participantes:

Afectados de las comunidades
- Segundo Calle y Esposa
- César Abad
- José Antonio Tenelema

Técnicos de la Fundación Cordillera Tropical
- Karina Chamorro
- Gloria Jiménez
- Patricio Padrón

Guardaparques Comunitarios
- Santiago Marquina
- Remigio Mejía
- Marco Pesántez
- Fabián Tamay
- Simón Abad
- Danilo Ávila
- Homero Abad
- Armando Garzón

Objetivos:

- Compartir los objetivos del proyecto Don Oso.
- Introducir el tema de conflictos y conservación del oso andino.
- Presentar a los afectados y guardaparques el menú de opciones para mitigar el conflicto ganado / osos.
- Acordar los futuros pasos para continuar el programa de mitigación de conflictos.

Desarrollo de Actividades:

El día viernes 25 de junio de 2010, se realizó el taller "Métodos para reducir la pérdida de ganado por ataque del oso andino" en la oficina de la Fundación Cordillera Tropical en Zhoray.

El taller fue abordado en dos tiempos debido a la urgencia de los pobladores afectados (cuenca del Llavircay) por regresar a sus casas antes del medio día para realizar sus tareas cotidianas. A esto se sumó el hecho de no poder contar con la presencia de los guardaparques (para esa hora) pues ellos se encontraban en reunión y realizando sus actividades normales del viernes. Entonces para esta primera instancia del taller, se tuvo la presencia de los afectados Segundo Calle con su esposa y César Abad (ver anexo Archivo fotográfico) con quienes se realizó la presentación de forma sintetizada. La ausencia de Don César Crespo, de acuerdo a los afectados se debió a que él manifestó que su ganado fue únicamente herido y que por lo tanto no era necesaria su presencia.

AT--Too bad Don Crespo did not attend. Do you think this means he does not wish to participate in mitigation either?

En vista del poco tiempo para cubrir las actividades totales del taller, se realizó una presentación lo más didáctica y con muchas imágenes para que entiendan los objetivos del programa y la lista de posibilidades para reducir la pérdida de ganado. En todo momento se manifestó el deseo del programa de mantener una convivencia armónica entre los seres humanos y el oso, recalcando la importancia del oso en los ecosistemas de altura y al mismo tiempo la problemática que representa el perder animales de sustento a causa del oso. Bajo este enfoque se desarrolló todo el taller. Los afectados manifestaron su deseo de recibir un pago por la muerte de su ganado, ante lo cual se les explica que por el momento no es posible y se les reafirma el objetivo en común de reducir las pérdidas a través de ciertas estrategias preventivas.

Una de las actividades del taller para trabajar en grupo fue desarrollada a manera de plenaria con ellos. Se conversó acerca del manejo del ganado, y se constató que los ataques ocurren en pastizales junto a la montaña, en zonas que se encuentran a más de una hora de camino desde su domicilio, donde la vigilancia varía entre 2 a 3 días. Sin embargo estos aspectos serán evaluados a mayor detalle durante la visita que se realizará casa por casa.

Precisamente al informarles sobre los próximos pasos que se tienen previstos, los participantes mencionan que ellos se comunicarán con los guardaparques en caso de un nuevo ataque, minimizando en alguna medida la idea de implementar las estrategias de mitigación revisadas. Esto pone en evidencia que ellos aun no mentalizan la necesidad de prevenir los ataques para dejar de ser afectados. Acciones que deberán ser reforzadas durante las jornadas de visita.

AT--Your intention to reinforce the idea of prevention is very important and perceptive. Well done.

El taller culminó y se quedó en el compromiso de avisarles cuando se realizará la visita a sus respectivos domicilios. La hora sugerida para las visitas es pasada las 14H00, que es cuando regresan de sus labores cotidianas.

Una segunda exposición del taller se efectuó al medio día junto al afectado de la cuenca del Mazar (Don José Antonio Tenelema), los guardaparques y equipo técnico de la Fundación. En este caso se realizó el taller tal como fue planificado, aunque se alteró el orden de la presentación debido a que los guardaparques anteriormente ya fueron introducidos al tema de “importancia de la conservación del oso andino” (Ver Cuadro 1).

Cuadro 1. Actividades, tiempo y herramientas utilizadas durante el taller “Métodos para reducir la pérdida de ganado por ataque del oso andino”. Zhoray, Junio 2010.

ACTIVIDAD	**Tiempo estimado**	**Herramienta**
1. Presentación del equipo técnico y participantes	10 min.	Dinámica. Presentación en parejas.
2. Explicación de los objetivos del programa Don Oso	15 min.	Papelotes. Llevar escrito.
3. Desarrollo del taller		Infocus

- Relaciones seres humanos / osos (Juan del Oso, Oso como Humano) - Introducción del conflicto (causas, riesgos relacionados al oso andino) - Métodos para reducir el problema - Síntesis del propósito del programa - Conservación del oso. Un hecho importante	1h05 min	Videos Trabajo en grupo para el tema manejo del ganado (aumento de riesgos de pérdida de ganado) Dramatización de uno de los métodos de métodos de mitigación de conflicto.
4. Compromisos	10 min.	Plenaria y siguientes pasos a dar
5. Firma de hojas de asistencia	5 min.	Hoja de asistencia llenada.
6. Refrigerio	15 min.	

El taller se realizó con normalidad, el afectado y los guardaparques participaron activamente en cada una de las actividades propuestas. Entre las reflexiones de la parte inicial, se expresó que el oso es considerado más vulnerable que el ser humano debido al avance de las poblaciones humanas hacia las montañas, por lo que se considera que es esta especie quien más pierde en una situación de conflicto.

A través del trabajo en grupo se concluyó que el oso ataca cerca a los bosques, en zonas alejadas donde pasta libremente el ganado. Como alternativa para reducir el conflicto, los guardaparques y el afectado proponen dos acciones:

a) Cercar el ganado que está pastando junto al bosque para aislarlo de los animales problema. Does this mean to "isolate the problem cattle" or "isolate the cattle from problem bears" (Google translator did not help here.)

b) Colocar cercas eléctricas que condicionen el comportamiento de los osos y al mismo tiempo funcionen como alarma para alertar al propietario quien pueda con tiempo acudir a vigilar al ganado.

Por otro lado, el afectado de la zona de Mazar ha dejado de pastar en la zona donde ocurrió el ataque. Entonces su inclusión en el programa se realizará en caso que decida regresar a esta zona considerada de riesgo. ← AT--This is important because ot could eb a form of non-monetary compensation if he can begin to use that pasture again. Es importante recalcar que tanto los afectados como los guardaparques afirman que no todos los osos ocasionan el problema, sino solamente aquellas que comen carne, denominados wagreros. ←AT--This is very interesting. Esto ya fue advertido en un estudio anterior sobre el conflicto en la comuna de Colepato, donde un poblador manifestó lo siguiente: *"hay dos clases de osos, no son todos los mismos. Uno hay que come ganado y otro no, otro come solo hojas. El que come el huicundo es cara blanca, el que come al ganado es cara amarilla. El wagrero es amarillo ese es grandote también, más grande es pues que el otro"* (Achig 2009). ← AT--*Becky will be very interested in that detail but I am skeptical that white and yellow faces can be distinguished during a brief glimpse, under different light conditions, at a distance, etc.*

Esta parte del taller termina con los compromisos de los guardaparques de acompañar durante todo este proceso (taller inicial, visita a las casas, colocación de dispositivos y monitoreo del éxito).

Conclusiones generales y recomendaciones futuras

Este taller inicial fue el punto de partida para el proceso de mitigación de conflictos en la zona. Los resultados han sido satisfactorios en la medida del cumplimiento de los objetivos: reconocimiento del valor de la especie en la zona, y del potencial peligro de pastar en áreas de alto riesgo (cerca a la montaña y lejos de las casas). Del mismo modo, se reconoce la existencia de medidas factibles para reducir el conflicto que no requieren de mayor inversión pero si de un compromiso compartido de cada una de las partes.

En la evaluación preliminar se considera importante la inclusión de dispositivos sonoros, pues la gente afirma que el oso podría asustarse con ellos. También se expresan acciones como aumentar la vigilancia para que el oso se ahuyente de las áreas de pastoreo, aunque la gente en su temor natural manifiesta que no sabrían como proceder en caso de encontrarse cara a cara con un oso. There is abundant advice from North American black bears on how to behave when you come face to face with a bear. Is this useful or have you already eadvised the owners to do the following: making oneself seem big, waving the hands, making noise, shouting are usefufl?

Por otro lado, la noción de prevención del conflicto debe ser reforzada en las futuras acciones con los afectados y guardaparques, pues al parecer ellos aun no asimilan la necesidad de prevenir antes que resultar afectados por ataques del oso. ← as mentioned above this is very important. How can we reinforce that idea – with analogy to disease prevention? With analogy to preventing crop loss to minor pests? With short theatrical performances (e.g., juxtapose the owner who only reacts to an owner who prevents bear attacks)? También se considera primordial el continuar afirmando la importancia del oso en los ecosistemas donde habitan para de este modo, crear puentes de enlace entre la conservación de la especie y la supervivencia de las comunidades locales.

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ANEXOS: Archivo Fotográfico del Taller

Foto 2. Inicio del taller con afectado y

Foto 1. Presentación del taller con los afectados

guardaparques.

Foto 3. Actividad en grupos

Foto 4. Participación de los asistentes.

Foto 5. Explicación de la actividad para mitigación de conflictos.

Foto 6. Preparación de la actividad Grupo 1.

Foto 7. Preparación de la actividad Grupo 2.

Foto 8. Dramatización mitigación de conflictos.

Foto 9. Explicación de la estrategia para mitigación de conflictos.

Foto 10. Compromisos y próximos pasos

Appendix 7. Figure. Ten community parabiologists trained and supervised by FCT.

Guardaparques Comunitarios del Nudo del Azuay

Equipo Colepato

Benedicto Leonardo Romero Maurizaca

Jorge Fabian Tamay Tenelema

Equipo Dudas

Remigio Wilfrido Mejía Orellana

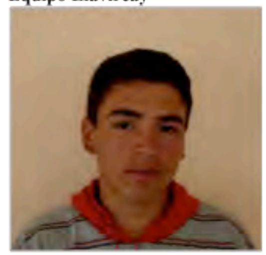
Ángel Santiago Marquina Marquina

Equipo Huangra

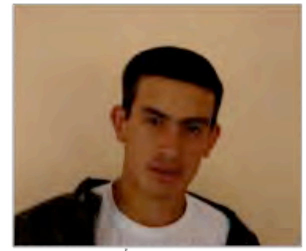
Martín Zanahuaray Uzhca

Pascual Zhibri Camas

Equipo Llavircay



Simon Gregorio Abad Méndez



Henry Danilo Ávila Pacheco

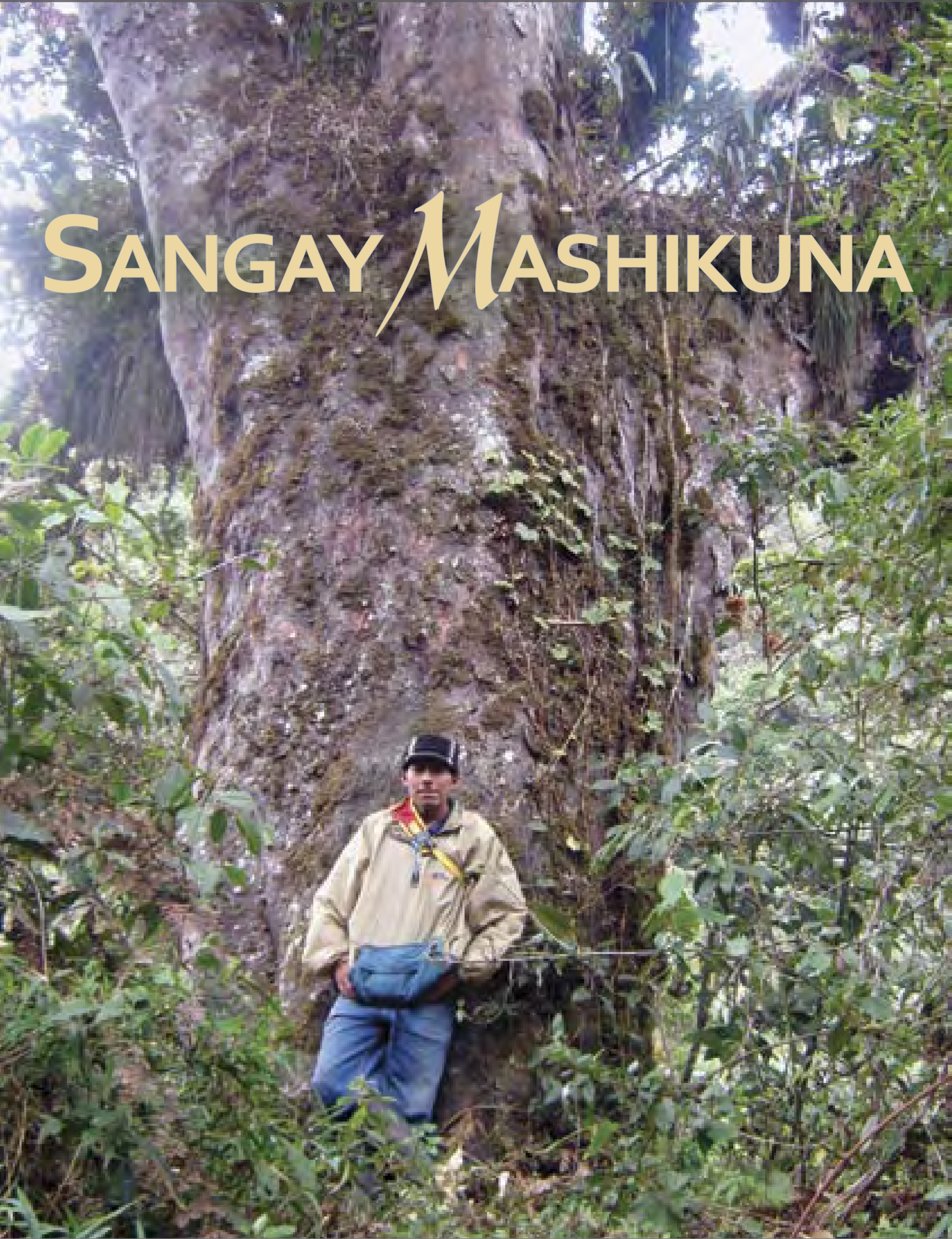
Equipo Monay

Carlos Homero Abad Peñafiel

José Armando Garzón Saeteros

Boletín informativo 3 • Guardaparques • Mayo/Junio/Julio 2010

SANGAY MASHIKUNA



Una publicación de la Fundación Cordillera Tropical

En esta edición:

HABLAREMOS DE GUARDAPARQUES

En la portada: Remigio Orellana frente a un mollón (foto: Santiago Marquina).

Simon Abad y Armando Garzón durante un patrullaje en Cochancay.

ACERCA DE LA FUNDACIÓN CORDILLERA TROPICAL

Somos una fundación ecuatoriana sin fines de lucro dedicada a la conservación de bosques y páramos de la zona sur del Parque Nacional Sangay y sus alrededores.

Trabajamos con comunidades locales en educación ambiental, capacitación para crear líderes en la conservación, e investigación científica.

NOTICIAS DEL MES

¡Vuelve a aparecer una ranita única en nuestros bosques!

La ranita venenosa de altura.

¿Sabías qué en esta zona viven ranitas muy especiales? Una de ellas es la ranita conocida como "ranita venenosa de altura". El año pasado, el investigador Alejandro Arteaga, encontró una mientras recorría los bosques de la zona.

Estas ranitas son especiales porque no existen en otros lugares, es decir son **endémicas** y además se encuentran en poca cantidad. Esta rana se creía desaparecida pues no fue vista desde 1995, probablemente está afectada como otras ranas por un hongo que las mata y por la desaparición de los bosques.

¿Has visto alguna de estas ranitas? Ayúdanos a protegerlas para que su canto siga alegrando nuestros bosques.

Con respeto al programa de Socio Bosque

Todas las carpetas con sus respectivas inscripciones se encuentran en las oficinas del Ministerio del Ambiente en Quito. Esperamos únicamente que sean aprobadas para retomar los siguientes pasos.

Por más información, contáctenos:

En Zhoray los días viernes
Agr. Patricio Padrón
07 2809382 / 09 8833785

En Achupallas
Ing. Hugo Huebla
08 6207880

bosque@cordilleratropical.org

O llame a Quito: www.ambiente.gov.ec, 1800 AMBIENTE (262436)

¿Qué hace un guardaparque?

Un guardaparque es una persona del campo encargada de concocer y cuidar los recursos naturales y culturales.

Él **visita y monitorea** los bosques y pajonales,
apoya a sus vecinos a cuidar el ambiente,
y **ayuda** a solucionar algunos problemas ambientales.

¡Un guardaparque tiene que estar bien preparado! Por eso, los guardaparques comunitarios se han capacitado en talleres de:

Primeros Auxilios

Recursos Naturales y Manejo de Equipos

Investigación Científica

Control de Incendios Forestales

... ¡y mucho más!

PARQUES COMUNITARIOS?

Apoyo al cuidado del Parque Nacional Sangay

PATRICIO PADRÓN

Se formó el equipo de guardaparques comunitarios para que ayuden a cuidar los recursos naturales de sus comunidades, a la vez que se capaciten en temas de conservación de la biodiversidad.

¿Qué piensan los guardaparques sobre su trabajo?

Homero Abad

Motivamos a la gente de **no quemar y no talar** nuestros bosques.

Nuestro trabajo es divertido, educativo, y provechoso. El **compañerismo** es muy importante.

Remigio Orellana

Tratamos de **dar iniciativa a los niños** para conservar.

Armando Garzón

Conozca a los guardaparques comunitarios

EQUIPO COLEPATO

Marco Pesantez

Fabian Tamay

EQUIPO DUDAS

Remigio Orellana

Santiago Marquina

EQUIPO HUANGRA

Pascual Zhibri

Martín Zanahuaray

Somos un equipo de diez guardaparques. Trabajamos en la conservación de la naturaleza y para apoyar al bienestar de las comunidades locales en el Parque Nacional Sangay.

EQUIPO MONAY

Homero Abad

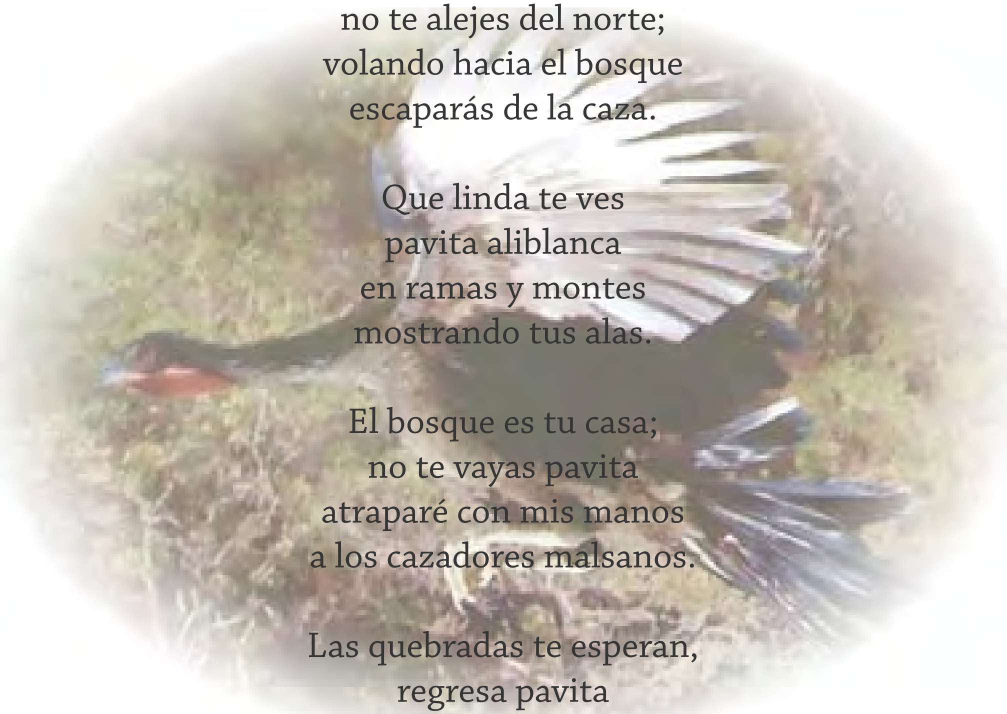
Armando Garzón

EQUIPO LLAVIRCAY

Simon Abad y Henry Ávila

¡Unos guardaparques también escriben poesía! ¿Has visto una pava aliblanca? ¿Qué otras aves has visto en el bosque o páramo?

PAVITA ALIBLANCA



Pavita de ala blanca
no te alejes del norte;
volando hacia el bosque
escaparás de la caza.

Que linda te ves
pavita aliblanca
en ramas y montes
mostrando tus alas.

El bosque es tu casa;
no te vayas pavita
atraparé con mis manos
a los cazadores malsanos.

Las quebradas te esperan,
regresa pavita
al bosque regresa
noble amiguita.

Por Walter Flores Aguilar, Guardaparque

Homero Abad, Henry Ávila, y Armando Garzón en un patrullaje; un ave vista durante un recorrido del pajonal de Huangra; y Pascual Zhibri cruzando el Río Huangra.

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Appendix 8.

The most pertinent, peer-reviewed, scientific publications from CCL attached. For digital copies, please email atreves@wisc.edu or visit http://www.nelson.wisc.edu/people/treves/Publications.html for free downloads.

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Detection Probability and Individual Identification of the Andean Bear (*Tremarctos ornatus*) Using Camera Trapping Methods

By

Taylor Jones

A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science

(Conservation Biology and Sustainable Development)

at the

University of Wisconsin-Madison

2010

Abstract

One of the most intractable problems in modern biodiversity conservation is protecting large, destructive species while at the same time meeting the needs of the people who share space with them. The conservation of large carnivores in developing countries is challenging, as these animals may compete directly with humans for food and space within a matrix of heterogeneous land uses (Distefano 2005; Treves et al. 2006). Typically, economically or socially marginalized groups disproportionately bear the costs of wildlife presence. The Andean bear (*Tremarctos ornatus*), though an iconic species in the Andes of South America, is threatened by habitat loss and fragmentation, retaliation after crop raiding or predation on livestock, and hunting, particularly for the use of bear parts in traditional medicine. Human tolerance for bear presence on private lands will be crucial to the survival of the species, as ~18% of potential bear habitat is within protected areas (Castellanos et al. 2010).

Monitoring bears using individual identification could enable researchers to assess the persistence of individual animals on private lands. Refining our knowledge of the detectability of the Andean bear in different environments would help conservationists determine the best sites for monitoring this elusive species on private lands. Individual identification could be used to support economic incentives for conservation and verify their success at preserving individual animals of focal species.

In Chapter 1 I analyze microsite, landscape-level, methodological, and biodiversity variables to predict bear presence and detectability at a camera trap station. I compare variables at different spatial scales, discuss the implications for bear detectability, and offer suggestions for possible applications of the results.

In Chapter 2 I examine the advantages and disadvantages of using individual identification as a monitoring and verification method for economic incentives for conservation. I focus specifically on two types of indirect, market-based conservation interventions: eco-labeling and Payment for Ecosystem Services. Both require reliable wildlife monitoring methods to determine if the intervention is improving the condition of biodiversity (Ferraro & Pattanayak 2006; Schloegel 2010; Treves & Jones 2009). Camera trapping has significant potential as a monitoring method for these types of initiatives because, along with ecological information, it provides photographs of charismatic individual animals that can be used for outreach to both producers and consumers.

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I gratefully dedicate this thesis in honor of those who came before me: Great-Grandmother Maria Luisa Plaza de Escandon Ferguson, Grandmother Angelica Ferguson Rhodes Bojarski, and Grandfather Richard Jones.

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CHAPTER 1:
Detection Probability and Habitat Modeling of the Andean Bear: an Investigation Using Camera-Trapping Methods

Abstract

The conservation of large carnivores in developing countries is challenging, because these animals may compete directly with humans for food and space within a matrix of heterogeneous land uses. The Andean bear (*Tremarctos ornatus*), though an iconic species in the Andes of South America, is threatened by habitat loss and fragmentation, retaliation after crop raiding or predation on livestock, and hunting. Human tolerance for bear presence on private lands will be crucial to the survival of the species, because ~18% of potential bear habitat is within protected areas. Monitoring individually identifiable bears over time may allow estimation of density and individual persistence on private lands. More detailed knowledge of factors affecting the detection probability of this elusive animal would help conservationists determine the best sites for monitoring and potentially aid in the design and validation of population density and life history estimators. In 2009, I conducted a 3-month camera trap study of Andean bears on two private properties in the Nudo del Azuay watershed in Sangay National Park, Ecuador. I placed 18 trap stations into 17 cells of a 24 km^2 sampling grid for a total of 899 station days. I photographed bears during 11 visits at 7 stations (39%). I collected microsite, landscape-level, and human use data for all sites. I used univariate tests to evaluate individual predictors for independent bear visits per station day. I used Akaike's Information Criteria to evaluate models predicting independent bear visits per station day.

Wildlife trail definition (well/moderately defined vs. poorly defined/no trail) and non-bear wildlife abundance (number of independent sightings of other species per station day) were the strongest predictors of bear presence, but a model which includes distance to nearest human habitation could not be eliminated. Goodness-of-fit tests indicate that the models may be overdispersed. However, the models support the results of the univariate tests. Cameras or other methods of detecting Andean bears in cloud forest habitats will be more successful when deployed along well-defined wildlife trails. Shrub density also appeared to have some predictive power, but its role requires further study. The positive relationship between non-bear wildlife abundance (which covaried with biodiversity) and bear presence lent some support to the idea that bears could be used as an effective "surrogate" or "indicator" species for Andean biodiversity, though more information is needed about the ecological role of the bear in both forest and páramo.

Introduction

One of the most challenging problems in modern biodiversity conservation is protecting large, destructive species while at the same time meeting the needs of the people who share space with them. Large carnivores are particularly difficult to conserve because they compete both directly and indirectly with humans for space and resources (Treves et al. 2006). Carnivores have direct effects on herbivore and scavenger abundance and indirect effects on vegetation and food webs through trophic cascades (Ripple & Beschta 2004, 2006; Smith et al. 2003), which makes their conservation both important and complex.

The conservation of carnivores in developing countries, where protected areas and wildlife habitat are embedded in a matrix of heterogeneous land uses, rapid land-use change, and insecure land tenure, is particularly challenging (Chazdon et al. 2009; Ferraro 2002; Himley 2009; Peyton et al. 1998). Ninety percent of tropical forest lies outside the borders of protected areas (Chazdon et al. 2009). Large carnivores in the tropics are unlikely to persist in these multiple-use zones unless hunting is effectively regulated (Naughton-Treves et al. 2003) and habitat degradation is controlled.

The Andean bear (*Tremarctos ornatus*), also known as the spectacled bear, is an iconic species in the Andes. The Andean bear is the only ursid in South America, and was chosen as a focal species for conservation of biodiversity in the Northern Andes Ecoregional Corridor (Rodríguez et al. 2003). Throughout its range, the species is threatened by habitat loss and fragmentation, retaliation after crop raiding or predation on livestock, and hunting, particularly for the use of bear parts in traditional medicine (Kattan et al. 2004; Peralvo et al. 2005; Peyton 1999; Peyton et al. 1998; Quintero &

Fernandez 2005; Rodríguez et al. 2003). It has been listed as an Appendix I species by the Convention of International Trade in Endangered Species of Flora and Fauna (CITES) since 1977, prohibiting international trade in Andean bear parts and live specimens. The International Union for the Conservation of Nature (IUCN) first red-listed the species as "vulnerable" in 1982. IUCN continues to list them as such after a 2008 assessment by the IUCN SSC Bear Specialist Group (Goldstein et al. 2008). The species is listed as "endangered" in Ecuador (Cuesta & Suarez 2001).

Andean bears are large, cryptic carnivores, whose mountainous habitat and extensive range make study of their life history difficult. They live in a variety of habitats throughout the tropical Andes including páramo (high-altitude grassland), cloud (montane) forest, dry coniferous forests, and foothills in an altitudinal range of 250 to 4750 m asl (Castellanos 2010). They are present in six countries: Venezuela, Colombia, Ecuador, Perú, Bolivia, and northeast Argentina (Castellanos 2010). They feed mainly on the hearts of bromeliads, primarily of the genera *Puya* and *Greigia*, which are available all year. In July and August, abundant seasonal fruits make up a large part of their diet, particularly *Hyeronima macrocarpa* (Troya et al. 2004). They include a diverse array of fruit in their diet, including that of the fig (*Ficus* spp.), avocado (*Nectandra* spp.), myrtle (*Myrcianthes* spp.), and cinnamon tree (*Ocotea* spp.), among others (Castellanos 2010). Bears may play an important role as a seed disperser for large-seeded plants (Castellanos 2010; Torres 2006; Young 1990). Andean bears are also known to feed on berries, bulbs, worms, insects, bamboo hearts, palm frond petioles, tree wood, maize crops, and carrion, and to hunt rodents, birds, rabbits, brocket deer, and possibly tapirs. Some individuals, particularly males, may prey on domestic livestock

(Castellanos 2010; Goldstein et al. 2006; Peyton 1980). Radio telemetry and camera trap studies on small numbers of bears suggest that they are diurnal and wide-ranging (Castellanos 2010; Paisley & Garshelis 2006; Zug 2009).

Despite impressive collaboration between nations that contain Andean bear habitat and research efforts by biologists, there are still major gaps in our scientific knowledge of this species, such as population dynamics, habitat uses, and courtship or reproductive behavior in the wild (Rodríguez et al. 2003). As human populations continue to expand and encroach on carnivore habitat, biological characteristics of the bear common to many large carnivore species – limited geographic range, long gestation period, low population density, and high trophic level – are likely to become more and more important as determinants of extinction risk (Cardillo et al. 2004). Therefore, it will become ever more crucial to understand the biology of this species. Because baseline ecological information about the Andean bear is key to improving existing conservation strategies, planners prioritize research on species ecology, the impacts of habitat fragmentation, and human-caused mortality, which often follows from defense of crops and livestock (Rodríguez et al. 2003).

Bears whose ranges extend outside of protected areas into agricultural lands have been known to raid maize, banana, or sugarcane crops or to kill cattle (Castellanos 2010; Flores et al. 2005; Goldstein et al. 2006). Landowners who raise crops or livestock or wish to convert native habitat to more economically productive uses may find it difficult to justify conserving this imperiled bear or its habitat. But given increased conservation concern, private landowners may be willing to attempt non-lethal deterrents against wildlife, if they are provided with cost-effective options, technical support on implementation, and better information on bear numbers and habits. Of 57 Ecuadorian landowners who convened to discuss bear conservation in 2007, three stood up on their own initiative to persuade their neighbors of the need to protect wildlife and the feasibility of doing so (Treves et al. 2009; White & Treves 2007). Seven of these 57 landowning families went on to commit to voluntary wildlife conservation plans on their lands. More recently, Fundación Cordillera Tropical pre-enrolled 5260 ha for 168 beneficiaries on 50 parcels for participation in the Socio Bosque conservation incentive program run by the Ecuadorian Ministry of Environment (A. Treves, 2010, pers. comm.). In Colombia, Quintero & Fernandez (2005) noted a desire on the part of some property owners to protect the bear despite crop-raiding. They also suggest that in areas where little is known about the bear, education has the potential to foster positive views of the animal.

Throughout the bears' range, ~18% of potential habitat is within protected areas (Castellanos et al. 2010), but this estimate is uncertain as it relies on broad extrapolation from presence/absence field studies conducted in the 1980s (Peyton et al. 1998), and the status of bear populations and land cover may have changed significantly since then. Though about 17% of the national territory of Ecuador is protected by its National System of Protected Areas (Sistema Nacional de Áreas Protegidas, or SNAP), 38% of the original cloud forest and páramo cover in Ecuador has been transformed into agriculture or urban lands (Cuesta et al. 2003). On average, 12% of the land within an Ecuadorian protected area is settled, and within protected areas resource-extraction activities such as hunting, grazing, logging, and mining continue (Naughton-Treves et al. 2006). These constraints on the bears' potential habitat underscore the fact that conservation of the

Andean bear cannot be guaranteed by protected areas alone, but must be aided by the promotion of sustainable development and coexistence with wildlife both inside and outside of park boundaries (Naughton-Treves et al. 2006). Indeed, the preservation of biodiversity in protected areas is linked to surrounding land uses (Chazdon et al. 2009). Private land management for bear habitat and conservation will be a key component of this species' survival into the future.

My study uses camera traps to identify individual Andean bears on two private properties in the Ecuadorian Andes. In order to refine these methods and increase the probability of detecting bears at camera trap stations, I performed a statistical analysis of trap station characteristics potentially associated with habitat use or detectability .

Methods

Study Site

The study site is located in the eastern mountain range of Ecuador, on the southern edge of Sangay National Park (SNP)(Figure 1.1). The park, covering 5,117 km^2, is one of the largest protected areas that supports Andean bears, and is thought to contain one of the largest populations of bears in Ecuador (Suarez 1998).

In 1992, the park boundaries were almost doubled and extended over pre-existing titled lands. The study took place near the west of the new boundary, within the park. Elevations at the study site ranged from 2900 to 3680 m asl (Zug 2009). The terrain is rugged, with slopes up to 70%. The area is a patchwork of native montane forest, shrub and secondary forest, páramo, pasture, pine plantations, and cropland (FCT 2008).

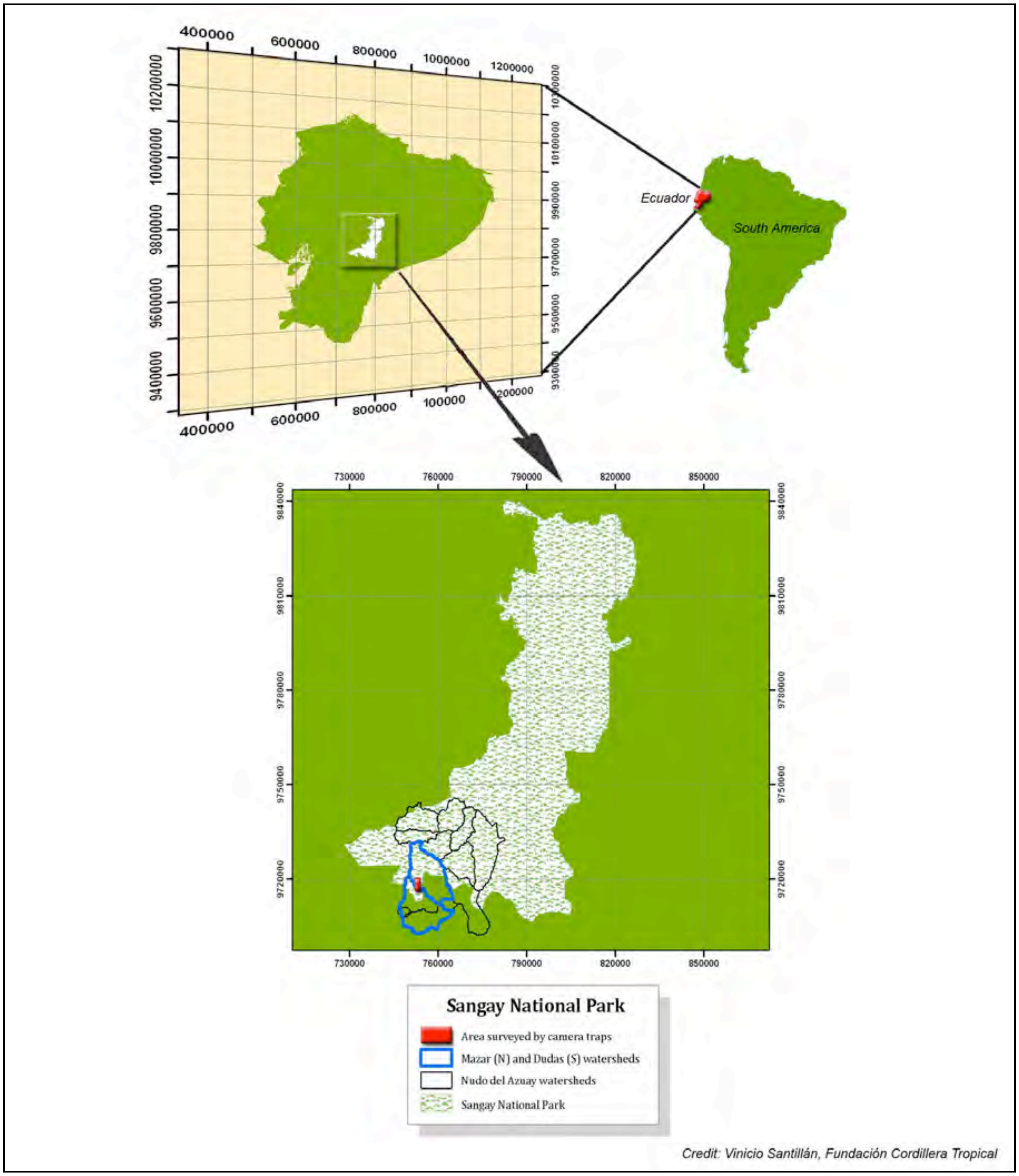

Figure 1.1 The study area in relation to Sangay National Park

Politically, the Nudo del Azuay is located in Pindilig Parish, Azogues Canton, Province of Cañar. In 2006, the population of Pindilig Parish was 2262 inhabitants, with human population densities moderate to low as compared to other areas in the Ecuadorian sierras (central mountain range)(FCT 2008). The main source of income is milk production followed by cultivation of crops such as potatoes and peas. A number of forest products are harvested in the area, including duda cane (bamboo), timber, charcoal, and yashipa (a native fern used in floral arrangements). There are also small numbers of non-native pine plantations (FCT 2008).

At higher elevations within the watershed, the average temperature is 11ºC, with 1600 mm of precipitation per year. Mid-valley average temperatures are 18ºC and precipitation is lower, with 1200 mm per year. There are two distinct seasons: the dry season (Oct/Nov – Jan/Feb) and the wet season. The wettest months on average are June, July, and August (FCT 2008).

This study was conducted across two adjacent private properties traversed by the SNP park boundary. The first is a family-owned alpaca ranch that produces alpaca fiber and clothing under the name All Things Alpaca (ww.wildlifefriendly.org/all-things-alpaca). All Things Alpaca is a Certified Wildlife Friendly property, meaning that the managers follow wildlife friendly practices to conserve threatened and endangered species on the property (see Chapter 2). The alpaca ranch covers approximately 1400 ha, and operations are split into three locations. The two lower sites, where the young, productive alpacas are raised, are referred to as La Libertad for ease of reference. A full-time ranch manager and his family live on-site. At the upper site, Rumi Loma, there are two buildings – one houses the caretaker for the gelded male alpacas grazed at the upper site (the alpaca ranch at Rumi Loma), and the other is a research station which is inhabited periodically by researchers and school groups. The other property included in the study was the neighboring community cooperative of Colepato. Colepato is a communal property of approximately 5000 ha supporting 32 cooperative member families and 30 non-member families (~400 people) who live, farm, and raise livestock on the property (Zug 2009). Colepato had one structure within the study site, the alpaca house, which is inhabited sporadically by caretakers of the alpacas grazed in the nearby páramo. The majority of residents live in the town of Colepato, ~2.5 km from the nearest border of the study site.

Camera trap study

I adapted the camera trapping methods of Zug (2009), developed from a suite of camera-trapping techniques used to study cryptic carnivores around the world (Jackson et al. 2006; Karanth & Nichols 1998; Karanth et al. 2006; Kauffman et al. 2007; Marnewick et al. 2008; McCain & Childs 2008; Séquin et al. 2003), except my primary goal was recapture of known bears. Zug used one camera per trap station, and placed her stations within an 8 km^2 grid divided into 1 km^2 grid cells in a 2 x 4 pattern. Each grid cell was further subdivided into four 0.25 km^2 sub-cells, and trap stations were placed in two of the four sub-cells within each cell (Zug 2009). Data collection sheets for my study were adapted from Zug (2009), which in turn were based on studies by Cuesta et al. (2003) and Jackson et al. (2005). I added surveys of vegetative cover density adapted from the riparian area survey developed by Stacey et al. (2006)(Appendix 1.1).

I used two models of passive infrared (PIR) motion-detecting digital cameras: the Reconyx® PC85 (RECONYX, Inc., Holmen, WI) and the CamTrakker® Digital Ranger (CamTrakker, Watkinsville, GA). At each camera trap station (Ct), I placed two camera traps facing each other and looking up and down a wildlife trail. The pairs of cameras included either one Reconyx® and one CamTrakker® or two Reconyx®.

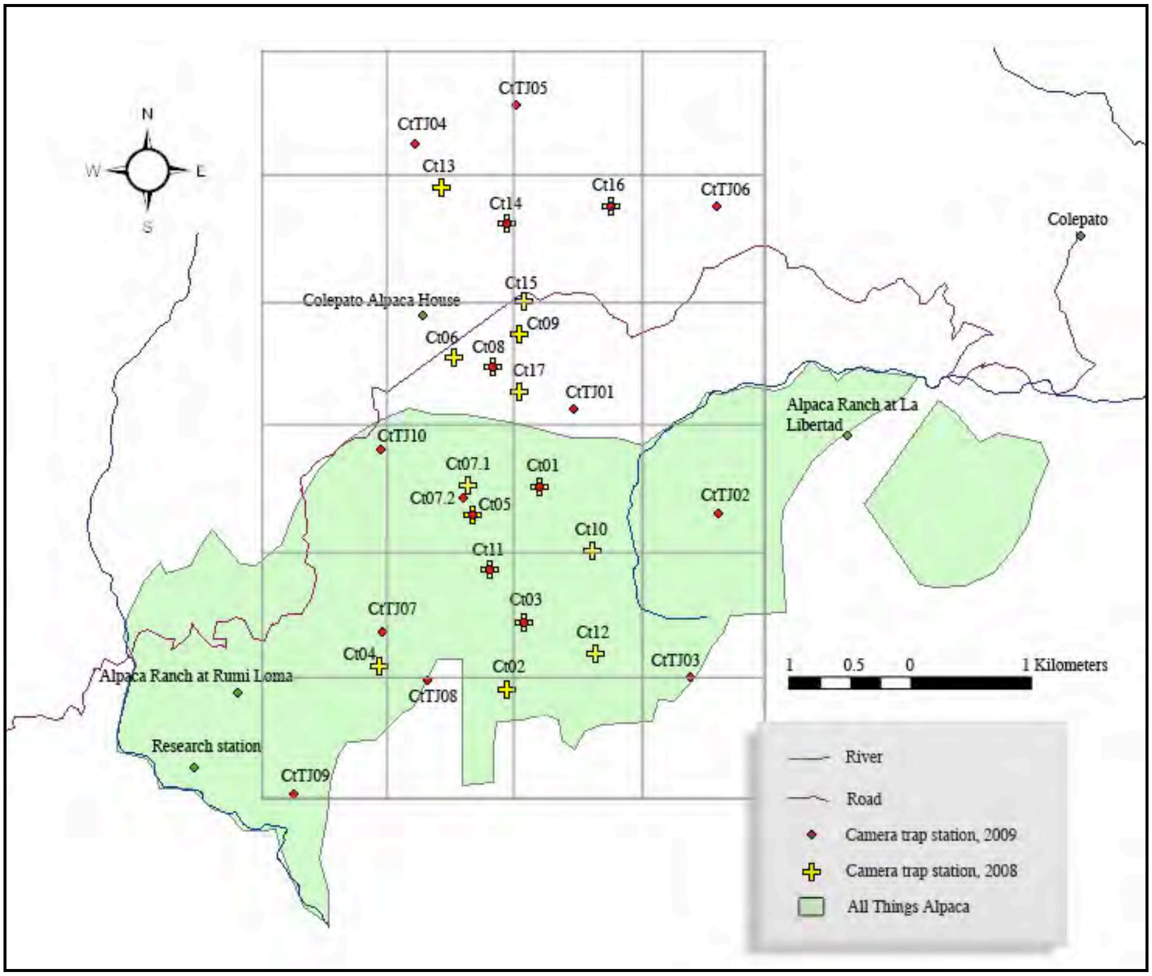

Figure 1.2 Locations of trap stations and landscape features. Trap stations to the north of the All Things Alpaca property line are on Colepato land (Credit: Taylor Jones, Alvin Rentsch).

From May 24 to Aug. 24, 2009, I placed 18 trap stations into a 24 km^2 sampling grid (Figure 1.2). The grid overlapped and enlarged the sampling grid used in 2008 by Zug (2009), and was divided into twenty-four 1 km^2 cells in a 4 by 6 pattern. I placed one camera trap station per cell, with the exception of Ct05, which was placed in the same cell as Ct07.2 for the short 23-day period it was deployed. I sampled 17 cells of the 24. Instead of dividing the cells into four 0.25 km^2 sub-cells as per Zug (2009), I treated each cell as one unit and selected one station location within each grid cell in order to cover a larger area.

I selected the station location within each grid cell according to three principles. In cells that had been surveyed in 2008, I placed the trap station in the location that had recorded the highest number of individual bear photos. If none of the former stations had recorded bears, I chose a new location within one of the 0.25 km^2 sub-cells that remained unsurveyed by Zug (2009). The only exception was Ct07.1, which I moved approximately 100 m upslope to a new location (Ct07.2) that I predicted would be a better location for sighting bears and also easier to access.

In the remaining cells, I systematically selected station locations based on evidence of bear sign and wildlife trails (Torres 2006; Zug 2009). With the assistance of a local guide from Colepato (Don Jose Ojeda, J.O.), we located the grid cell using GPS coordinates, entered the forest at the first wildlife trail we located, and searched the trail itself for bear sign, placing the trap station in the first site found with substantial evidence of bear use. In the two grid cells we surveyed that contained little or no forest, I chose trap locations based on (a) an old wildlife trail at CtTJ08 and possible food source (puya) and (b) location near a ridge-line and possible cover for the bears at CtTJ10. Bears are known to use ridgelines in order to travel from one forest patch to another (Goldstein & Marquez 2004), but unless seeking a highly desirable resource, they appear to avoid traveling more than 150 m from the forest edge based on sign surveys (Galasso 2002).

I collected UTM and elevation data at every station. During the initial set-up, J.O. and I would search for bear sign in a circular area with an approximately 10 m radius centered on the midpoint between the two camera traps (Torres 2006). We would then clear the area of bear sign to detect fresh bear sign when we returned. To gather microsite data, I conducted vegetation transects adapted from Stacey et al. (2006). The transects were 10 m in length, one in each cardinal direction, starting from the midpoint between the two camera traps. I measured percent vegetation cover in the shrub layer (1-4 m), the mid-canopy layer (4-10 m), and the upper canopy layer (>10 m) by traveling along the transect and noting presence or absence of each vegetation layer every 2 m. I then divided the total number of "present" results by the total number of measurements collected for the transects. I also measured canopy cover as percentage of a 1 ft. by 1 ft. square held overhead at the midpoint between the two camera traps. Last, we cleared the area in front of both camera traps of hanging vegetation that might trigger the cameras. To protect the cameras from moisture in the wet forest environment, I placed a desiccant packet inside each camera trap and also sealed the casings of the CamTrakkers® with silicon caulk. We replaced the seal and desiccant packs at every site visit (once every two weeks) along with memory cards and batteries as necessary.

To encourage the bears to cross camera viewpoints, I baited each station with Ultimate Bear Lure® (Wildlife Research Center, Inc., Ramsey, MN), which has been used successfully to attract Andean bears (Zug 2009). To protect the lure from the rain, I tied a sponge soaked with the lure inside a plastic cup, which I then hung upside-down at the station near the mid-point of the two camera traps. I hung the lure 2.2 – 3.2 m above the ground and away from any overhanging branches so that the bears could not reach it. We refreshed the lure at every site visit, and J.O. re-walked the circular 10 m radius area surrounding the trap station to check for fresh bear sign.

To maximize coverage of the study site, I moved four trap stations during the study into adjacent unsurveyed cells. If a trap station recorded a photograph of an identifiable bear, it was moved during the subsequent site visit, on the initial assumption that it was likely to have captured all the bears present in the grid cell based on estimates of Andean bear home range size (Castellanos 2003; Kattan et al. 2004; Peyton et al. 1998; Rios-Uzeda et al. 2007; Rodríguez et al. 2003). In all other cases (unidentifiable bears, bear sign but no photos, no bear sign or photos) the trap station was left in place. Using this method, I moved Ct03 to CtTJ09 on 7/22/09, Ct11 to CtTJ08 on 7/22/09, and Ct16 to CtTJ10 on 7/24/09. I also moved Ct05 to CtTJ02 on 6/18/09 after I realized it was sharing a grid cell with Ct07.2.

Spatial Analysis

I used ArcMap 9.3® (ESRI, Redlands, CA, 2008) to plot the locations of trap stations on a map (Figure 1.2). I used GIS layers of the roads (FCT 2008), rivers, and population centers (UDA-CGPAUTE 2009) to measure distances from the trap stations to those landscape features and to areas of human influence. I log-transformed all distances to minimize errors in distance estimation due to rugged topography; previous experience at the study site suggests including elevation in the distance measures increases them dramatically (Zug 2009). I did not analyze bear presence in relation to differing land cover classes because the available LANDSAT data did not correspond on a fine scale to what I observed in the field and lacked resolution of forest types as coarse as pine plantation versus cloud forest.

Statistical Analysis

My data set for statistical analysis of variation in bear detectability at stations included both my data set, collected in 2009, and the data set of Zug, collected in 2008. By combining these data sets, we intended to increase our sample size and detect recaptures of known individuals over time. For all analyses, I used the software package JMP® 8.0.2 (SAS Institute Inc., Cary, NC, 2009). I used a Chi-square test to determine the relationship between the presence of bear sign and photos of bears.

My response variable (BEARS) was the number of independent bear visits (more than 12 h apart – bears traveling together were counted as a single visit) divided by the number of active station days. I defined active station days as 24 h periods during which at least one of the cameras at a station was functional. If a bear moved the camera and changed the field of view, I still considered the camera functional as several cameras captured photos of bears even after their positions had been changed. I only considered the camera non-functional if it was facing directly at the ground, was broken by the bear, was drained of batteries, or was malfunctioning. In situations when the exact date that the camera ceased functioning could not be determined, I removed from the denominator the number of station days since the last trigger event or half the station days since the last station visit, whichever was smaller. I used median tests to determine if year, station type, or station location in forest vs. páramo was predictive of BEARS to detect possible confounding effects of methods and observers.

BEARS corrects for effort between different stations. BEARS was not normally distributed, so I used the box-cox transformation to bring it as close to a normal distribution as possible, using the default parameters set in JMP®:

$$\frac{\text{response} + 1^{-2} - 1}{-1.93094140046654}$$

Beginning with a large set of variables (Table 1.1), I eliminated several from analysis for procedural reasons. For example I eliminated “topographic features” because I felt this was adequately described by “slope.” I eliminated “human use of site” and “frequency of human presence” because the definitions of these variables varied between 2008 and 2009. We estimated “wildlife trail definition” by assigning the trail to a category of “well defined,” “moderately defined,” “poorly defined,” or “no trail.” These categories were collapsed into “well/moderately defined” (n=29) or “poorly defined/no trail” (n=6) because of the small number of stations with no trail (n=2), and the difficulty of separating a well- from a moderately-defined trail across two years and two observers . Well/moderately defined trails were generally easily distinguishable from the surrounding vegetation because of bare soil or flattened vegetation (Figure 1.3).

“Bamboo” indicates the presence of dense bamboo (*Poaceae* spp., *bambusoideae* sub-family) and “Nacran” indicates the presence of dense nacran, a broad-leafed, tall grass (*Poaceae* spp.), within the viewfinder of either camera. I ultimately discarded most of the distance measures from stations to topographic features for reasons that will be explained below. The distance measure retained, “distance to nearest habitation,” indicates the log-transformed distance to the nearest of the following: the Colepato alpaca house, the alpaca ranch at La Libertad, the alpaca ranch at Rumi Loma, or the research station. These sites were similar in occasionally hosting small numbers of humans and domestic animals.

Table 1.1 Variables collected for each trap station

Category of variable	Variable	Definition	Data Structure
Methodology	Station type	1 Reconyx®, 1 CamTrakker®, Mix, 2 Reconyx®	Categorical
	Year	2008, 2009	Categorical
Trail	Wildlife trail definition	well/moderately defined, poorly defined/no trail	Ordinal
Wildlife	Wildlife abundance	number of independent wildlife visits/active station nights, not including bears	Continuous
	Wildlife biodiversity	number of species detected/active station nights, not including bears	Continuous
Microsite	Slope at station	severe, moderate, flat	Ordinal
	Aspect at station	N, NE, E, SE, S, SW, W, NW	Categorical
	Percent canopy cover	percentage	Continuous
	Vegetation density	shrub, mid-canopy, upper canopy	Continuous
	Bamboo	present or absent at the trap station	Categorical
	Nacran	present or absent at the trap station	Categorical
Landscape	Altitude	meters above sea level	Continuous
	Cover type	forest, páramo	Categorical
	Distance to	closest active camera trap station, closest town, closest point on the Colepato-Quesaries road, closest river point, Colepato alpaca house, alpaca ranch (La Libertad), alpaca ranch (Rumi Loma), research station	Continuous
	Property owner	All Things Alpaca, Colepato	Categorical

Figure 1.3 Poorly defined/no trail (left) and Well/moderately defined trail (right)

I used Pearson's correlation to detect colinearity between continuous variables, median tests to detect relationships between continuous and categorical variables, and Chi-square tests to detect relationships between categorical variables. I used $r>0.7$ as the threshold to indicate colinearity for Pearson's correlation, and $p<0.01$ as the threshold to indicate colinearity for the median and Chi-square tests. When variables covaried significantly, the one with the higher p-value in the univariate tests was discarded.

I used univariate analysis to refine the set of variables selected to run a model using stepwise criteria. I chose to do this because of the lack of *a priori* knowledge about which habitat variables may predict bear detectability and the need to reduce the number of predictors stringently due to the small sample of stations (n=35). I eliminated most variables that did not meet the 0.10 level of significance in univariate tests, only including one which did not, "station type," to test for any effect of differing methods between years and between stations. I used Spearman's ρ to detect continuous predictors and a median test to detect categorical predictors of BEARS.

To compare alternative models, I used Akaike's Information Criteria for small samples (AIC_C). I first ran the AIC_C using a General Linear Model (GLM) with a normal distribution and an identity link function, using stepwise criteria (referred to hereafter as the "stepwise GLM"). I began with the saturated model (station type, distance to closest habitation, wildlife abundance, and trail definition), removed the weakest predictor and repeated the model stepwise, recalculating the negative log likelihood at each iteration until all predictors were removed, leaving the intercept model. I retained models with $\Delta AIC_C < 2$ where ΔAIC_C is the difference between that model and the best model (Mazerolle 2006).

In addition to the stepwise GLM, I created *a priori* models using the full set of variables that had survived tests for colinearity. I did this to compare models built from predictors at different scales (microsite versus landscape-level) and predictors of specific interest (vegetation density versus wildlife abundance, versus methodology) to the models generated by the stepwise criteria.

Several variables were measured only in 2009, namely shrub density, mid-canopy density, upper canopy density, and aspect at site. These variables could be imputed to 2008 from only the stations that were repeated (hence n=25). I ran separate models to test these variables on the smaller subset of trap sites for which they were measured, referred to hereafter as the shrub density subset.

Results

Camera trap study

In all, 18 trap stations were active for a total of 899 station days. Altitudes of the stations ranged from 3186 m asl to 3631 m asl. I photographed bears during 11 visits at 7 stations (39%). All these stations but one had photographed bears in 2008. Bear visits only occurred between 0800 and 1700. This supports earlier conclusions about diurnal rather than nocturnal activity in Andean bears, at least in areas where they are not persecuted (Paisley & Garshelis 2006, Zug 2009).

I identified seven individuals, two of whom had been detected the year before. In total, ten bears were detected in the study site, at least two of which were present for both trapping periods (2008 and 2009). A full description of the methods and results for individual identification of the bears can be found in Chapter 2.

Statistical Analysis

Because I was working with data sets from two studies, I tested whether differences observed in BEARS (the number of bears detected per active station day) were an artifact of differing methods. However, year was not a significant predictor of BEARS (p=0.25, X^2=1.35, n=35). Year was collinear with station type (p=0.0001, X^2=35.00, n=35), which is not surprising because only one camera was deployed per station in 2008. Therefore I tested if station type was significantly associated with BEARS. Throughout our combined studies (June 26 – Dec. 17, 2008, BZ, and May 24 – Sept 3, 2009, TJ), there were four types of trap station deployed: one Reconyx®, one CamTrakker®, stations with one of each (mix), and stations with two Reconyx®. I found no significant difference in BEARS for any station type (p=0.6, X^2=1.85, n=35). Because two stations were located in the páramo only in 2009, I tested to see if páramo vs. forest predicted BEARS; it did not (p=0.16, X^2=1.95, n=35). In addition, when I removed the páramo stations from the data set and re-ran the AIC_C using the stepwise criteria, beginning with the saturated model (station type, distance to closest habitation, wildlife abundance, and trail definition), the results were almost identical.

Finding bear sign at the station (feeding remains, claw marks, scat, moved camera traps) was highly associated with photographs of a bear having been taken during the preceding trapping period (p<0.0001, X^2=22.03, n=41 visits to stations after set-up).

When variables covaried, the one with the higher p-value in the univariate tests was discarded, with the exception of mid-canopy density. Mid-canopy density covaried with % cover, and % cover was discarded despite the lower p-value so I could examine the suite of vegetation density measures together. The variables that survived this process were: wildlife abundance, distance to nearest habitation, distance to alpaca ranch (La Libertad), distance to nearest town, distance to nearest active camera trap station, wildlife trail definition, shrub density, mid-canopy density, upper canopy density, nacran, bamboo, station type, aspect, and owner. "Distance to nearest habitation" indicates the log-transformed distance to the nearest of the following: the Colepato alpaca house, the alpaca ranch at La Libertad, the alpaca ranch at Rumi Loma, or the research station. I therefore discarded "distance to the alpaca ranch (La Libertad)" as it was included in the "distance to nearest habitation" variables.

To further refine the set of variables used for the stepwise GLM, I discarded variables with p>0.10 in the univariate tests (Table 1.2). This left wildlife abundance (p=0.08, ρ=0.3, n=35), wildlife trail definition (p=0.01, X^2=6.64, n=35), shrub density (p=0.03, ρ=0.44, n=25), and distance to nearest habitation (0.04, ρ=0.35, n=35).

Table 1.2 Results of the univariate tests for BEARS

Predictor	Test	p-value
Station type	Median	0.64
Year	Median	0.25
Wildlife trail definition[1]	**Median**	**0.01**
Wildlife abundance	**Spearman's ρ**	**0.08**
Wildlife biodiversity	Spearman's ρ	0.17
Slope at station	Median	0.17
Aspect at station	Median	0.17
Percent canopy cover	Spearman's ρ	0.79
Shrub density	**Spearman's ρ**	**0.03**
Mid-canopy density	Spearman's ρ	0.87
Upper canopy density	Spearman's ρ	0.98
Bamboo	Median	0.34
Nacran	Median	0.59
Cover type	Median	0.16
Property owner	Median	0.39
Closest active camera trap station	Spearman's ρ	0.74
Closest town	Spearman's ρ	0.57
Closest point on the Colepato-Quesaries road	Spearman's ρ	0.15
Closest river point	Spearman's ρ	0.55
Distance to nearest habitation	**Spearman's ρ**	**0.04**
Distance to Colepato alpaca house	Spearman's ρ	0.61
Distance to alpaca ranch (La Libertad)	Spearman's ρ	0.29
Distance to alpaca ranch (Rumi Loma)	Spearman's ρ	0.99
Distance to research station	Spearman's ρ	0.89

1. Boldface indicates variables with p < 0.10

To determine if shrub density had an effect, I re-ran the stepwise GLM using the shrub density subset, including shrub density in the saturated model but eliminating the stations for which no data on shrub density had been collected (n=25)(Table 1.5). Shrub density replaced wildlife abundance in this alternate best model, suggesting it may be an important characteristic to consider in camera trap site selection.

Wildlife abundance was the only predictor included in the best *a priori* model for the full sample size (Table 1.4). Using the shrub density subset, the *a priori* model using wildlife abundance only and the *a priori* model using vegetation density measures only were included in the suite of best models (Table 1.6).

Given the small sample size and some detectable pattern in the residuals (Figure 1.4), we consider the results of the multivariate GLM tests somewhat suspect. The univariate tests for the four predictors (wildlife trail definition, wildlife abundance, distance to nearest habitation, and shrub density) seem robust because we used non-parametric tests but a multivariate model of bear presence at stations may require further research to refine our estimates of detectability.

Figure 1.4 Plot of Studentized deviance residuals from the best model (n=35) predicting BEARS, using wildlife trail definition and wildlife abundance (Table 1.3)

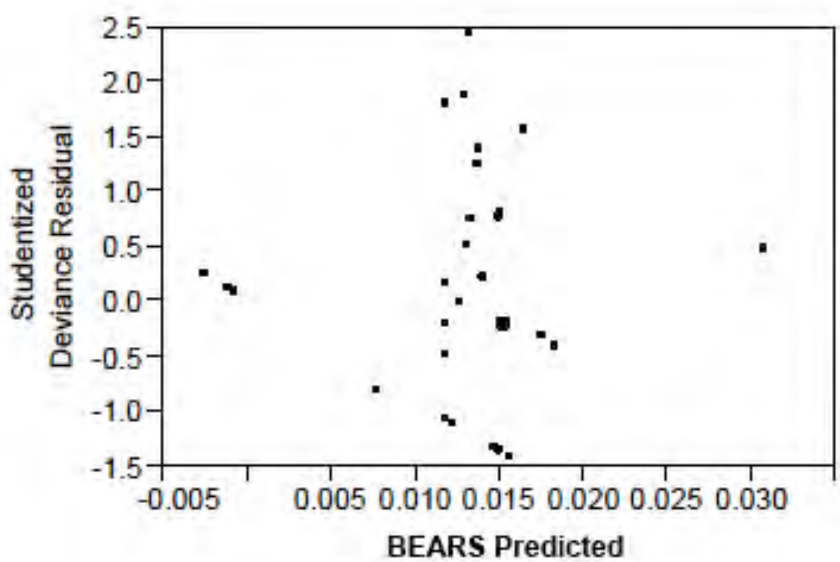

Table 1.3 Full sample size: General Linear Model using backwards stepwise regression to predict BEARS

Predictors	N	AIC_C	ΔAIC_c	AIC weight	Whole model test (X^2)	Whole model test (p-value)
Station type, distance to nearest habitation, wildlife abundance, trail definition	35	-196.03	9.91	0	-	-
Distance to nearest habitation, wildlife abundance, trail definition	**35**	**-204.95**	**0.99**	**27**	**11.86**	**0.008**
Wildlife abundance, trail definition[1]	**35**	**-205.94**	**0**	**44**	**10.11**	**0.006**
Trail definition	**35**	**-205.06**	**0.88**	**29**	**6.67**	**0.01**
None	35	-200.78	5.15	0	-	-

1. The best model in this set and in the set of *a priori* models with full sample size (Goodness of fit: X^2= 0.004, Deviance=1.00)

Table 1.4 Full sample size: General Linear Model using *a priori* models to predict BEARS

Predictors	N	AIC_C	ΔAIC_c	AIC weight	Whole model test (X^2)	Whole model test (p-value)
Microsite variables (reduced): nacran and bamboo	35	-196.33	4.85	0	-	-
Landscape-level variables: distance to nearest habitation, distance to nearest active trap station, distance to nearest town, property owner	35	-194.28	6.90	0	-	-
Wildlife abundance[1]	**35**	**-201.18**	**0**	**100**	**2.79**	**0.09**
Station type	35	-193.85	7.33	0	-	-
Microsite variables (reduced) + wildlife abundance	35	-196.31	4.84	0	-	-
Microsite variables (reduced) + station type	35	-188.4	12.78	0	-	-
Landscape-level variables + station type	35	-187.38	13.80	0	-	-
Landscape-level variables + wildlife abundance	35	-192.83	8.35	0	-	-

1. The best model in the set of *a priori* models with full sample size (Goodness of fit: X^2= 0.005, deviance=1.00)

Table 1.5 Shrub density subset: General Linear Model using backwards stepwise regression and including shrub density as a predictor

Predictors	**N**	**AIC_C**	**ΔAIC_c**	**AIC weight**	**Whole model test (X^2)**	**Whole model test (p-value)**
Distance to nearest habitation, station type, wildlife abundance, shrub density, trail definition	25	-133.24	16.62	0	-	-
Station type, wildlife abundance, shrub density, trail definition	25	-137.88	11.98	0	-	-
Wildlife abundance, shrub density, trail definition	25	-147.76	2.09	0	-	-
Shrub density, trail definition[1]	**25**	**-149.86**	**0**	**1**	**15.64**	**0.0004**
Trail definition	25	-146.29	3.56	0	-	-
None	25	-139.68	10.18	0	-	-

1. The best model in this set and in the set of *a priori* models using the shrub density subset (Goodness of fit: X^2= 0.002, deviance=1.00)

Table 1.6 Shrub density subset: General Linear Model using *a priori* models and including vegetation density measures and aspect as predictors

Predictors	**N**	**AIC$_C$**	**ΔAIC$_c$**	**AIC weight**	**Whole model test (X^2)**	**Whole model test (p-value)**
Microsite variables (all): shrub density, mid-canopy density, upper canopy density, nacran, bamboo, aspect	25	-109.01	29.83	0	-	-
Landscape-level variables: distance to nearest habitation, distance to nearest active trap station, distance to nearest town, property owner	25	-130.1	8.74	0	-	-
Wildlife abundance[1]	**25**	**-138.84**	**0**	**67**	**1.76**	**0.18**
Station type	25	-134.46	4.86	0	-	-
Microsite variables (all) + station type	25	-79.88	58.96	0	-	-
Microsite variables (all) + wildlife abundance	25	-100.38	38.46	0	-	-
Landscape-level variables + station type	25	-122.59	16.25	0	-	-
Landscape-level variables + wildlife abundance	25	-126.8	12.04	0	-	-
Vegetation density: shrub density, mid-canopy density, upper canopy density	**25**	**-137.45**	**1.39**	**33**	**6.39**	**0.09**
Vegetation density + wildlife abundance	25	-134.79	4.05	0	-	-
Vegetation density + station type	25	-128.98	9.87	0	-	-

1. The best model in the set of *a priori* models using the shrub density subset (Goodness of fit: X^2= 0.004, deviance=1.00)

Discussion

Upon examining the *a priori* models with the full sample size of 35 stations, I determined that models created from sets of landscape-level and microsite features did not predict BEARS well. Of the landscape-level features, only "distance to nearest habitation" was significant in the univariate tests. Of the microsite features, only "shrub density" was significant in the univariate tests (I did not include "trail definition" in the set of microsite variables as it was related to our site selection criteria). For the full sample size, none of the *a priori* models were more successful at predicting bear presence than the models derived from backwards stepwise regression.

The best model identified in backward stepwise regression (in Table 1.3) included two predictors: wildlife abundance and wildlife trail definition (well/moderately defined or poorly defined/no trail). However, a model that also includes distance to nearest habitation cannot be ruled out. Bears may avoid encounters with people and/or with their dogs, reducing the chances that bears will be detected closer to human habitations (Lacerda et al. 2009; Zug 2009).

In light of these results, and for several design-related reasons, making inferences about bear microsite associations or preferred habitat characteristics is not possible. Although grid placement was random with respect to bear presence, the placement of stations within each grid cell was correlated with prior bear presence. Some site locations in 2009 were chosen because of high numbers of bear photos collected at those stations in 2008 – those stations are not independent of each other from one year to the next. Therefore, microhabitat predictors (the 10 m circular area surrounding the camera trap station and visual detection of bamboo and nacran) had previously been associated with bear presence and did not usefully distinguish stations with and without bear photos in 2009. Given our search image for bear sign, it is not surprising that wildlife trails were highly correlated with bear presence in the model. We confirmed that bears could be photo-captured at sites where indirect bear sign was found and at sites where they were photo-captured in the past. Bear behavior and path use has an element of predictability that can be used to maximize recaptures. The larger-scale landscape predictors (distance measures) reflected the random grid placement better. Because of equipment limitations we were not able to survey all grid cells. Therefore grid cells containing large forest patches were selected more often than grid cells containing primarily páramo.

Second, the lure may have affected bear behavior. Ultimate Bear Lure® appears to be effective at drawing bears into the stations, as bears visited the stations nearly four times as often as the second most commonly sighted large mammal (little spotted cat, *Leopardus tigrinus*). In 2008, no bears were photo-captured while using a fish- and blood-based lure, and when stations were switched over to the commercial lure, the capture rate was five times higher than the next closest mammal species (puma, *Puma concolor*)(Zug 2009). It may be that the lure draws bears in from short distances. The higher incidence of bear detection may indicate bears are using these wildlife trails more frequently than other animals, or that the lure is more attractive to bears than to other animals. We do not know enough about lure dissipation or Andean bear home range size and behavior to deduce the effect of the lure on behavior and density in the study site.

Lastly, the results of the goodness-of-fit tests indicate that the multivariate models may be overdispersed. The probability distribution used in the model may not be a good representation of the shape of the response variable (Dunteman & Ho, 2006. The small sample size also weakens the predictive power of the models. Although we cannot say that bears prefer particular habitats or microsites, some univariate predictors (shrub density, wildlife abundance, and distance to nearest habitation) were significant in non-parametric tests and unrelated to our station selection criteria (Table 1.2). The multivariate models did show these were independently predictive of bear presence, rather than being different measures of the same site characteristics (Table 1.3). In other words, information contained in all the predictors significant in the univariate tests was useful for predicting BEARS in the multivariate models. The results of these tests shed light on the probability that a camera trap station will detect a bear assuming a bear's home range overlaps the station (MacFarland 2009).

This individual detection probability (p_i) can be affected by many factors. Characteristics of individual animals may change p_i, including home range size and movement behavior, which can be influenced by life history variables such as age, sex, or grouping patterns (Treves et al. 2010). Variation in p_i is likely as behaviors change from season to season and year to year. Detection can also be influenced by station characteristics such as location, attractiveness of bait, and station configuration (MacFarland 2009).

Detection probability is important for two reasons. First, when designing a study such as the one detailed in Chapter 2, which is focused on using a limited number of camera traps to maximize the number of individual identifications, it is important to refine trap placement for the highest chance of bear detection and identification. Knowing which site characteristics tend to increase detection probability may allow us to increase our rate of successful capture. Second, some camera trap studies are used to make estimates of population abundance. These studies assume equal detectability for all individuals, but this assumption has rarely been tested (Larrucea et al. 2007). Station-based indices such as frequency of photo-captures are commonly used to detect changes in population density of cryptic animals, despite the fact that limited understanding of the statistical properties of station based indices and other confounding factors may make such indices unreliable (MacFarland 2009). To improve the performance of these indices, individual identification as described in Chapter 2 could be used to create a cumulative index, which quantifies the number of individuals detected at a station and infers changes in population from changes in counts of unique visitations. Cumulative indices perform well in simulation, acting generally as linear functions of density (MacFarland 2009). However, without an understanding of detection probability, in particular different detection probabilities among individuals of the same species, it is not possible to determine the relationship between index response and population density.

Detection probability was greater for camera traps than for sign surveys at the stations. I analyzed only the 2009 data to control for the number of cameras used. There were two instances where photographs of a bear were recorded but we did not detect any bear sign. However there were no instances where we detected bear sign but did not have a photographic record of at least one bear.

Well-defined wildlife trails may increase the detectability of bears because of visibility, access to resources, or ease of travel through steep terrain (well/moderately defined trails were associated with more severe slopes at $p=0.0002$, $X^2=17.06$, $n=35$). This finding has implications for ongoing camera trapping work in the study area, as it confirms that our criteria for placing trap stations lead to high numbers of bear photo-captures. It may also be useful for studies that use DNA testing for individual identification, indicating that a single-catch hair snare or wire fence along a well-used trail may be more effective at capturing hair than attempting to lure the bears under a wire fence with bait or odor. It also has conservation implications in that the bears' consistent use of easy-to-locate trails may make them more vulnerable to capture or hunting.

When moving the camera traps, we were working under the assumption that ≤1 bear would be present in each 1 km^2 grid cell based on estimates of Andean bear home range size (Castellanos 2003; Kattan et al. 2004; Peyton et al. 1998; Rios-Uzeda et al. 2007; Rodríguez et al. 2003). Therefore, if a camera captured an identifiable bear, we moved the camera under the assumption that it was likely to have captured all the bears present in the grid cell, and that moving the camera to expand the study site would be more profitable for maximizing the number of individual bears identified than leaving the trap in place. However, we discovered two sets of bears traveling as pairs, and also captured different bears consecutively at the same station on multiple occasions. One station recorded six individuals over both study periods (see Chapter 2). These data weaken our assumption that bears were defending exclusive territories, and indicates that leaving traps in place may provide information on how individual bears share space with conspecifics.

The positive association ($p=0.08$, $\rho=0.3$, $n=35$) between bear presence and non-bear wildlife abundance is interesting for several reasons. First, it seems to support tentatively the idea that bear presence is a good indicator of biodiversity, at least for the suite of birds and mammals detectable by camera trap (see Chapter 2). Second, it indicates that in habitats where conditions support high densities and diversities of other species, one is more likely to find bears as well. This lends some support to the idea that bears could be used as an effective "surrogate" or "indicator" species for Andean large vertebrate biodiversity. The well-established trails made by the Andean bear, which is the largest animal in its ecosystem, may have an influence on its environment (Castellanos et al. 2010). Bear trails may facilitate the presence of other wildlife by allowing easier access or greater efficiency of travel through dense undergrowth. This may partially explain the correlation between bear photos and abundance of other wildlife. More information is needed about the ecological role of the bear in both forest and páramo and the relationship of bear habitat use to overall biodiversity.

The shrub density subset used a reduced sample size, and therefore was not comparable to the models using the full sample size. However, it suggested that shrub density and trial definition may interact to affect the detectability of the bears. Shrub density was significant in the univariate tests. Dense shrub cover around wildlife trails may raise the probability of a large mammal moving through a camera trap station because of the absence of other routes.

Since there were only two páramo stations included in this study, there are not enough data to draw conclusions about which areas of the páramo provide the best opportunities for detecting bears. Because of the difficulty of locating páramo areas that have characteristics associated with bear detectability (well-defined wildlife trails and dense shrub cover), I would recommend a different method for studying bear habitat use in the páramo.

I was not able to demonstrate predictive power for multivariate models based on either microsite variables or landscape-level variables. Theoretically, I would expect a microsite model to be more predictive than a landscape-level model at this scale, because the small dimensions of the study site (17 km^2) mean that landscape-level characteristics tend to be more similar to each other (for example, the elevation range at the study site is small compared to the bears' known elevation range). Because of this and because elevation was not predictive in any model run by Zug in 2008, I did not include elevation in any model. For larger-scale studies I would expect large-scale features such as distance to towns to become correspondingly more important, as in the habitat modeling carried out in the Oyacachi River basin, Ecuador (Clark 2004). Landscape-level variation will be more important to projects attempting to create connectivity between protected areas, model gene flow between subpopulations, or other large-scale initiatives.

At small scales similar to that of this project, cameras or other individual identification methods will be most successful if they are deployed along a well-defined wildlife trail in the midst of dense shrub cover. It should be kept in mind that the presence of conspecifics may influence detectability, through either competition, attraction, or group dynamics (Campomizzi et al. 2008, Treves et al. 2010). Territory boundaries may influence detectability; in a study of coyotes, sites on the edges of territories captured a broader range of animals (alpha, beta, and transient), and sites near the center of territories captured a more biased sample (mainly beta animals)(Larrucea et al. 2007). As we know that a large number of individual bears used a small area (Chapter 2), it will be important to learn more about how Andean bears share space with conspecifics.

Knowledge of the trap station characteristics most conducive to increasing the detectability of study animals will improve the success rate of individual identification methods. Some environmental initiatives, such eco-label certification or PES project enrollment, depend on individual identification of animals on small areas of private land (Chapter 2). Improving the detectability of focal species will be key to the success of such initiatives.

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Appendix 1.1 Data collection sheet for camera trap stations

Form #: ________________	**Grid Cell ID:** ________________
Name of Person(s): ________________	**Station ID:** ________________
Date (MM/DD/YY): ________________	**Elevation:** ________________
Set-up Time: ________________	**UTM:** ________________
Set-up Weather: ________________	________________
Camera Trap 1 ID: ________________	**Battery type, % full:** ________________
Camera Trap 2 ID: ________________	**Battery type, % full:** ________________
Height of CT __: ________________	**Distance between traps:** ________________
Angle of CT __: ________________	**Height of CT __:** ________________
Direction of CT __: ________________	**Angle of CT __:** ________________
	Direction of CT __: ________________

** If moved from previous site list form # of that location:* ____________

SITE CHARACTERISTICS:

Reason for site selection
__ Trail (___ intersection)
__ Food source (list:__________)
__ Bear sign (*detail below*)
__ Other

Distance from:
____ water source
____ road
____ human used trail
____ human settlement
____ forest
explain:

Trail Type:
__ well defined
__ moderately well defined
__ poor, hard to see
__ no trail

Human use of area:
__ rangeland (seasonal, non-seasonal)
__ farming (type:_________)
__ no human use
__ other: __________

Frequency of Human presence:
__ daily
__ once/week
__ multi/week
__ once/month
__ rarely
__ never

Comments:

Topo features:
__ cliff
__ ridgeline
__ valley floor
__ stream bed
__ hill-slope

Slope at site:
__ severe
__ moderate
__ flat

Aspect:

Veg Cover Type:
__ paramo
__ ecotone
__ forest
Percent canopy cover_____

Major Vegetation Type:
__ pine forest (planted)
__ primary forest
__ secondary forest
__ grass paramo
__ scrub paramo
__ cropland
__ fallow field
__ burned area
__ bamboo
__ puya field

Surrounding Vegetation Type:
__ pine forest (planted)
__ primary forest
__ secondary forest
__ grass paramo
__ scrub paramo
__ cropland
__ fallow field
__ burned area
__ bamboo
__ puya field

Lure Height: __________

Cover density:
Groundcover (0-1 m)
Shrub (1-4 m)
Mid-canopy (4-10 m)
Upper canopy (>10 m)

Bear sign in transect:
__claw marks (__ recorded)
__ feeding remains
Type: ________________
__ scat (detail below)
Sample #:
__ print
Size: ________________

Scat:
Sample #:
UTM: ________________
____
Elevation:
VST:

Comments:

Revisit 1				
Date:				
People:				
Days since last visit:				
Camera				
Number of pictures:				
% battery:				
Battery type:				
Changed:	Memory card	Dessicant	Batteries	Removed
Camera				
Number of pictures:				
% battery:				
Battery type:				
Changed:	Memory card	Dessicant	Batteries	Removed
Lure				
Odor:				
Color:				
Moisture:				
Cup:				
Refreshed:	yes	no	removed	
Bear sign:				

CHAPTER 2:
Individual Identification of Focal Animals as a Monitoring and Verification Method for Eco-Labels and Payment for Ecosystem Services Projects

Abstract

One of the most intractable problems in modern biodiversity conservation is protecting large, destructive species while at the same time meeting the needs of the people who share space with them. Typically, economically or socially marginalized groups disproportionately bear the costs of wildlife presence. Direct interventions designed to protect wildlife are sometimes politically unacceptable as they intend to prevent or stop behaviors that stem from people's economic activities or survival strategies. Indirect, market-based interventions focus instead on creating economic incentives for preserving wildlife and wildlife habitat. Two examples of economic incentives, eco-labeling and Payment for Ecosystem Services, both require reliable wildlife monitoring methods to determine if the indirect intervention is improving the condition of biodiversity or a species of concern. Individual identification of focal wildlife may offer certifiers a way to avoid pitfalls such as misidentifying a population sink as suitable habitat. Disadvantages of individual identification methods include higher costs, limitations on survey area size, and seasonal movements of animals as a potential confounding factor. In 2009, I undertook a 3-month camera trap survey of the Andean bear to assess the feasibility of individual identification using camera traps for verifying the success of conservation incentives. The survey took place on two private properties in the Nudo del Azuay watershed in Sangay National Park, Ecuador. I placed 18 trap stations into 17 cells of a 24 km^2 sampling grid for a total of 899 station days. I identified seven bears, two of which were present during a preceding camera trap study in

2008, meaning that two individual Andean bears persisted on both properties for at least ten months, along with eight bears which were only detected during one study period. Camera trapping has significant potential as an individual identification method because, along with ecological information, it provides photographs of charismatic individual animals that can be used for outreach to both producers and consumers.

Introduction

One of the most intractable problems in modern biodiversity conservation is protecting large, destructive species while at the same time meeting the needs of the people who share space with them (Distefano 2005; Treves et al. 2006; 2009). Living with and conserving wildlife often involves costs to human residents, including economic losses due to crop damage and predation on livestock, and possible injury or loss of life (Löe & Röskaft 2004). Examples include cattle depredation by jaguars and pumas in South America (Michalski et al. 2006), crop raiding by both birds and mammals and livestock depredation by wolves and leopards in India (Chhangani et al. 2008), crop raiding by elephants in Zimbabwe (Osborn & Parker 2002), and other situations across the world where humans and wildlife share limited space and resources, particularly around the borders of protected areas (Distefano 2005; Naughton-Treves et al. 2005).

Typically, economically or socially marginalized groups disproportionately bear the costs of wildlife presence. If problems of human-wildlife conflict are not addressed, people may come to see protected areas as an encroachment on their rights and wildlife presence as a burden (Goldstein et al. 2006; Knight 2000; Neumann 1998; Wilson 1997). These economic and political realities create direct and indirect threats to biodiversity and wildlife conservation.

Direct threats are defined as “the proximate human activities or processes that have caused, are causing, or may cause the destruction, degradation, and/or impairment of biodiversity targets” (Salafsky et al. 2007). The direct threats to populations of large carnivores of interest here are: (a) residential and commercial development, (b) agricultural expansion and intensification, and (c) consumptive use of "wild" biological resources including persecution or control of specific species (Salafsky et al. 2007).

Indirect threats are the "ultimate factors, usually social, economic, political, institutional, or cultural, that enable or otherwise add to the occurrence or persistence of proximate direct threats" (Salafsky et al. 2007), resulting in a negative effect on biodiversity. Indirect threats can be difficult to pinpoint and harder to combat, as they are often rooted in deeply entrenched economic or political conditions. However, interventions designed to combat direct threats, such as creating protected areas and restricting access to resources, can be disproportionately burdensome to people living with destructive wildlife. Direct interventions are often less socio-politically acceptable than indirect interventions, because they intend to prevent or stop behaviors that stem from people's economic activities or survival strategies (Treves et al. 2009). Market-based conservation initiatives, as an indirect intervention, target the lack of incentive for preserving wildlife and wildlife habitat, which is particularly acute in the cases of threatened species that cause economic damage or threaten human peace of mind or physical safety. Market-based conservation intends to provide incentives to conserve these species by improving market access or competitive advantage for producers who conserve wildlife and habitats and connecting their environmentally preferable products to environmentally conscious consumers (Ottman et al. 2006).

Market-based conservation faces challenges both in implementation and ideology. Because the neoliberal model of conservation through markets is based on a continuing cycle of consumerism and resource consumption, it worries many authors (Büscher 2008; McCauley 2006; Zimmerer 2006, 2007). "Green consumerism" is premised on the neoliberal urge to bring everything into the sphere of the market, including "existence values" for charismatic animals. For some authors, this implies that such animals have no intrinsic value and can therefore suffer "devaluation" similar to any other commodity when exposed to the capriciousness of the free market (McCauley 2006). Species extinction could result if immediate profit could be made from harvesting the last animals in a population, particularly if the cost of harvesting is minimal or incidental to other activities or goals (i.e. hunting while in the field caring for livestock)(Clark 1973).

But by the same token, if greater profits can be made by preserving threatened species and habitat than by exploiting them, initiatives that raise standards of living and encourage economic growth through conservation can redirect effort away from habitat-altering economic activities, giving both conservationists and rural people some much-needed breathing room (Ferraro 2001). From the point of view of many conservationists, inserting conservation into the sphere of the market may have drawbacks, but it is also preferable to the current model which generally ignores the value of ecosystems services and wildlife existence in favor of exploitation and development (Brown et al. 2007).

Eco-labels are a form of market-based conservation. They promise a price premium or enhanced market access to producers who meet certain conservation criteria. This can range from supporting conservation through donations, to following sustainable manufacturing practices, to conserving biodiversity. These correspond to three categories of eco-label – supportive, persuasive, and protective (Treves & Jones 2009). In theory, for eco-labels to be effective as a conservation strategy, they must succeed on several levels: they must offer a true competitive advantage, price premium, or other incentive to producers to make certification desirable and cost-effective to implement, and they must offer consumers reliable evidence that the eco-label contributes successfully to the preservation of threatened species. Monitoring of wild populations is essential for meeting this second goal, as will be discussed below.

Payment for Ecosystem Services (PES) programs are another form of market-based conservation. Ecosystem services, as defined in economic theory, are the tangible results of ecosystem processes (the continuous complex physical and biological cycles that underpin the functioning of the natural world) that directly improve or maintain human quality of life. These ecosystem services include flood prevention, water purification, and soil quality maintenance, among others. They support the production of more immediately tangible "ecosystem goods" such as forest products and food (Brown et al. 2007).

Including ecosystem services within economic theory represents an attempt to provide clear market signals for the preservation of the natural world by turning the recipients of these services into buyers, and turning the "suppliers" of the services – typically landowners whose land sustains the service or the public by way of environmental protection laws – into sellers. Ecosystem services are often damaged by other human economic endeavors such as mining or timber harvesting. Marketing ecosystem services provides a monetary incentive to refrain from activities that would be profitable to the human actor but ultimately costly to the ecosystem and to other people who benefit from the services it provides. Proponents of ecosystem services argue that even though the economic value of an intact ecosystem can be difficult to estimate, making the attempt is a step up from the "business as usual" model, in which its value is rarely recognized as being on a par with the value of development (Brown et al. 2007;

Fisher et al. 2008; Lant et al. 2008). Marketable services fare better, in terms of increasing or stable stocks, than non-marketable services or services that derive from natural capital not bounded by any clearly defined private property rights (Lant et al. 2008). For PES programs to be effective as a conservation strategy, they must also succeed on several levels – they must offer an incentive for conservation that is competitive economically with other potential land uses, and they must monitor the lands enrolled in the program to ensure that ecosystem functions are truly being preserved. As for eco-labels, monitoring of wild animal populations is essential for verifying the success of a PES program focused on biodiversity. Here I will focus on the design of wildlife monitoring methods using individual identification of focal wild animals for these two types of conservation initiatives.

Economic incentives are being used in Ecuador as a tool for preserving an iconic resident of the Andean cordillera: the Andean, or spectacled, bear (*Tremarctos ornatus*). Rural landowners in or near protected areas in the Ecuadorian Andes sometimes struggle to coexist with this large, destructive, and imperiled mammal (Flores et al. 2005; Galasso 2002; Goldstein et al. 2006; Sanchez-Mercado et al. 2008). The Andean bear is the only bear species native to South America. They live in a variety of habitats throughout the tropical Andes including páramo (high-altitude grassland), cloud (montane) forest, dry coniferous forest, and foothills, in an altitudinal range between 250 and 4750 m asl (Castellanos 2010). They are present in six countries: Venezuela, Colombia, Ecuador, Perú, Bolivia, and northeast Argentina (Paisley & Garshelis 2006; Rodríguez et al. 2003). Chapter 1 contains a detailed description of their biology.

The bear plays a role in pre-Colombian mythology as a mediator between existential states (e.g. day and night, this world and the underworld, civilization and wildness, the present and the future) and as a morally ambiguous link between human and animal, by turns violent and heroic, dangerous and protective (Herrera et al. 1992; Randall 1982). Those mythologies and attendant respect for the bear persist despite human-bear conflicts, particularly in Colombia, southern Perú, and northern Bolivia (Peyton 1999; Treves et al. 2009). Bernard Peyton (1999) writes, with some passion, "Everyone that identifies with spectacled bears, whether through humility or machismo, derives strength from this species to combat their deteriorating socio-economic conditions. A lot of hope for self-improvement will die with the extinction of spectacled bears in the wild."

Despite the Andean bear's charisma, which has earned it a starring role in many environmental education programs (Andrade 2004; Clark 2004; Quintero & Fernandez 2005), the bear is not universally popular. Some bears whose range extends into agricultural lands may raid crops or kill cattle (Flores et al. 2005; Goldstein et al. 2006). If depredation problems caused by a few individual bears are not dealt with, livestock owners may become hostile – not only to the problem bear, but to all bears, and the protected areas that are their refuge (Goldstein et al. 2006; Treves et al. 2006). To further conservation, in the Andes as elsewhere, the economic and social costs of living with wildlife must be offset and the dangers mitigated (Mishra et al. 2003). Reducing conflict with this imperiled bear and providing local producers with an incentive to conserve bear habitat on private land will be essential to Andean bear conservation, as ~18% of potential bear habitat is within protected areas (Castellanos et al. 2010). Interventions should not merely protect biodiversity in places that are *already* prohibitively difficult to access – this can lead to overestimates of the effectiveness of protected areas (Andam et al. 2008). Interventions should also deal adequately with areas under pressure from human activities.

Direct threats to the Andean bear include habitat loss and fragmentation, retaliatory hunting after crop raiding or predation on livestock, and hunting, particularly for the use of bear parts in traditional medicine (Kattan et al. 2004; Peralvo et al. 2005; Peyton 1999; Peyton et al. 1998; Quintero & Fernandez 2005; Rodríguez et al. 2003). Indirect threats that promote these conditions are myriad (Appendix 2.1). Local landowners lack incentive to preserve bear habitat. Insecure land tenure, failure of reform measures to redistribute land, and government recolonization programs that promote migration across the Andes encourage farmers to colonize bear habitat (Peyton et al. 1998). Contradictory laws allow extractive activities such as mining to continue in bear habitat, and the accompanying roads are axes from which agriculture expands (Peyton et al. 1998). Managers of protected areas have insufficient funding, leading to lack of infrastructure and trained personnel (Naughton-Treves et al. 2006; Peyton 1999). Protected areas in the tropics have expanded in both form and function over the last two decades. Many parks in Ecuador have been expanded to include more area of critical habitat or watershed, so park officials must now manage larger, more complex protected areas that encompass local people and their resource uses. Parks are no longer charged solely with biodiversity conservation, but also with improving human well-being and providing economic security (Naughton-Treves et al. 2006).

In this chapter, I offer a case study of the advantages and disadvantages of relying on methods of individual identification for verification of the persistence of individual

Andean bears on private lands encompassed by Sangay National Park, Ecuador (SNP). With any conservation action, monitoring should ideally answer three questions. First, was the conservation intervention carried out as planned? Second, did the conservation intervention reduce the threat to biodiversity? And lastly, if the threat was reduced, did the condition of biodiversity improve (Treves et al. 2006)?

In the case of eco-labels and PES programs, monitoring the first level is the simplest. Have products been certified? Were payments for ecosystem services distributed? These questions are relatively easy to answer. It is more difficult to determine if economic incentives for conservation increase tolerance for problem species and/or reduce killing of problem species (the second level). Threat-reduction monitoring demands social scientific measures of perceptions and human activities, and awareness of and respect for local traditions and sociopolitical norms, particularly in situations of power imbalance (i.e. if the researcher is seeking information on illegal activities)(For more on this, see Treves et al. 2006 and Neumann 2001).

I will focus here on the third level of monitoring; determining if the condition of biodiversity was improved. It is important to determine if eco-label certification or PES programs have actually protected Andean bears and their habitat. The continuing credibility of these incentives depends on showing a causal link between the economic incentive and improvements in the status and condition of the Andean bears and other threatened species on participating private lands. To assess the success of a conservation intervention, the results of the intervention can theoretically be compared to the "counterfactual," or what would have taken place in the absence of the intervention (Ferraro & Pattanayak 2006). Common methods for assessing success are subject to confounding effects: in non-random or volunteer tests, factors which affect the conservation outcome can also affect the probability of volunteering for or being selected for the program. Considering a property before and after an intervention can be subject to confounding factors such as policy or ownership changes or changes in the habitat that are seasonal or otherwise unrelated to producer practices (Ferraro & Pattanayak 2006; Treves et al. 2006).

The most robust method for determining the effect of any conservation intervention on biodiversity is an experiment in which an intervention is randomly assigned across participants. Generally this means comparing a participating property with a non-participating control that is similar in all other aspects (Ferraro & Pattanayak 2006). For many reasons this is challenging in practice, as randomization of benefits and interventions is not always possible or desirable. Ferraro et al. (2006) and Treves et al. (2006) provide a summary of quasi-experimental designs that can be applied to non-randomized interventions to assess effectiveness more accurately. Once proven methods of monitoring are in place, adding a quasi-experimental design should be a priority for organizations undertaking these interventions in order to collect much-needed information about the causal effects of the conservation actions they choose to take.

The case study I present here is a “descriptive indicator” (Ferraro & Pattanayak 2006) of the process of conservation rather than a test of the effectiveness of the indirect interventions in place at the study site. It is intended to illustrate the effectiveness of camera-trapping for individual identification of Andean bears and as a method for establishing baseline information about individual bears on the properties in the study site. It does not show whether or not properties enrolled in eco-label or PES programs were more effective refuges for the species of concern than comparable non-participating properties. I hope this research will inform future studies about the effectiveness of the economic incentives themselves, either through informing the design of wildlife monitoring methods for quasi-experimental studies or through continued comparisons of future biodiversity conditions to the baseline established here as the interventions proceed, with possible confounding factors taken into account.

Methods

Study Site

The study site is located in the eastern cordillera of Ecuador, on the southern edge of Sangay National Park (SNP). The park is one of the largest protected areas that supports Andean bears, and is thought to contain one of the largest populations of bears in Ecuador (Suarez 1998).

In 1992, SNP was extended from 2,719 to 5,177 km^2 to protect the headwaters of the Paute River (Peyton 1999). The study took place near the west of the new boundary, within the park. Elevations at the study site ranged from 2900 to 3680 m asl (Zug 2009). The terrain is rugged, with slopes up to 70%. The area is a patchwork of native montane forest, shrub and secondary forest, páramo, pasture, pine plantations, and cropland (FCT 2008). The study site extends into two sub-watersheds, the Mazar in the north and the Dudas in the south. Both are part of the Nudo del Azuay watershed, which in turn is a small part of the Paute watershed. The Paute includes a large hydroelectric dam that generates a significant proportion of the country’s electricity (FCT 2008; White & Maldonado 1991). At higher elevations within the watershed, the average temperature is

11ºC, with 1600 mm of precipitation per year. Mid-valley average temperatures are 18ºC and precipitation is lower, with 1200 mm per year. There are two distinct seasons: the dry season (Oct/Nov – Jan/Feb) and the wet season. The wettest months on average are June, July, and August (FCT 2008).

Individual and communal property rights were guaranteed when SNP park boundaries were extended over private lands (Government of Ecuador,1992 in Himley, 2009). However, landowners were given little or no support for dealing with problem wildlife. NGOs such as my partner organization, Fundación Cordillera Tropical (FCT), become involved at the local level in park outreach and conservation initiatives. FCT is involved in protection of the Nudo del Azuay watershed and its biodiversity, heading a "Green Schools" education initiative, organizing a farmer network called "Amigos del Sangay" as a means for the local population to have a voice in the management of the southern edge of SNP (FCT 2008), and attempting to initiate conservation incentive programs for area landowners within the Ecuadorian government's existing PES program, Socio Bosque (C. Schloegel 2010, pers. comm.).

The study took place on two private properties which were covered by SNP during the 1992 expansion. The first is a family-owned alpaca ranch which produces alpaca fiber and clothing under the name All Things Alpaca (www.wildlifefriendly.org/all-things-alpaca). All Things Alpaca is a Certified Wildlife Friendly property with rights to use that eco-label. The alpaca ranch covers approximately 1400 ha. There are on average 650 alpacas on the property, raised on 438 ha. Dr. Stuart White, one of the owners of All Things Alpaca, is the co-founder of FCT. Dr. White has identified Andean bears and pumas (*Puma concolor*) as species of concern on his land.

The other property included in the study was the neighboring community cooperative of Colepato. Colepato is a communal property of approximately 5000 ha supporting 32 cooperative members and 30 non-members (~400 people) who live, farm, and raise livestock on the property. The residents assumed leadership of the cooperative in 1971, but full ownership of the property was not granted until 1982 (Himley 2009). Much of their land is divided into even-sized lots assigned to cooperative members. Most lots are not developed or fenced, and it is not clear if they are individually titled and/or registered (FCT 2008). The main source of income is milk production, followed by cultivation of crops such as potatoes and peas (FCT 2008). Local people are also starting to seek new economic opportunities presented by the developing trade in ecosystem services, including forest preservation (Himley 2009). Colepato has recently entered into a pilot program for a payment for the protection of watershed services (PPWS) agreement with HidroPaute, an Ecuadorian hydroelectric company. HidroPaute has agreed to purchase the protection of watershed services, in the form of forest protection, from upstream users in an attempt to slow sedimentation and offset the rising costs of dredging the Daniel Palacios dam (Schloegel 2010). Colepato has also expressed interest in WF certification. Recently they have begun plans to scale up and market cheese and other artisanal products.

Camera Trap Models

Camera traps are an efficient method for detecting bears and a useful tool for inventorying large- and medium sized terrestrial rainforest mammals (Rios-Uzeda et al.

2007; Tobler et al. 2008). Individual identification of Andean bears using camera traps has been successful in the past (Rios-Uzeda et al. 2007; Zug 2009).

I used two models of passive infrared (PIR) motion-detecting digital cameras: (20) Reconyx® PC85 (RECONYX, Inc., Holmen, WI) and (8) CamTrakker® Digital Ranger (CamTrakker, Watkinsville, GA). I also tested one CamTrakker® MK-8 (CamTrakker, Watkinsville, GA), but did not include the model in the study. The Reconyx® PC85 has an integrated camera with a programmable interface. Time, date, temperature, moon phase, and user defined labels can be displayed on every photograph. This model has 1/5 s start-up trigger-speed and takes 1 to 10 photos per trigger event, with the option of instant re-triggering or delay settings of 1 to 3600 s. At night or in low light conditions, it takes black and white photos with an infrared flash. It runs on 6 C-cell batteries or 6 AA lithium batteries with adaptors. The CamTrakker® Digital Ranger uses a Sony® digital camera mounted inside a camera-trap housing. It has a 3-5 s start-up trigger-speed, with one photo per trigger and delay settings starting at 20 s. At night it takes color photos using an on-camera flash. It runs on 4 C-cell batteries (it will not use AA batteries with adaptors). The CamTrakker® MK-8 has an integrated camera with an on-board LCD screen for in-field picture viewing. It has a start-up trigger speed of <1 s, with one photo per trigger or a burst mode setting. It has both infrared and regular flash capabilities. It runs on a rechargeable battery pack.

Pilot study

Using camera traps in the páramo has proven difficult due to the numerous false triggers produced by the movement of tall grasses and shadows. These numerous false triggers cause two problems – they rapidly deplete the camera batteries and make analysis of the resulting hundreds of photos difficult and time consuming. In addition, the lack of discernible wildlife trails and sign in the páramo makes selecting a camera trap site more difficult (Rios-Uzeda et al. 2007; Zug 2009).

To explore ways in which different camera settings might be used to effectively monitor the páramo, I placed one CamTrakker®, two Reconyx® cameras on the Low sensitivity trigger setting, and two Reconyx® cameras on the High sensitivity trigger settings on the same tree facing the same section of páramo. None of the cameras recorded any false triggers during the week-long pilot study (6/14/09 to 6/21/09). I subsequently placed two trap stations in the páramo during the study, using one CamTrakker® and one Reconyx® on the Low/Med sensitivity trigger setting for each station. One of the Reconyx®, set up facing up-slope towards the páramo and mounted on a small tree on the edge of a forest patch, recorded <700 false triggers. The other, mounted on a dried puya inflorescence facing downslope into the páramo in the open, did not record any false triggers. Thus it may be possible to use camera traps effectively in the páramo under certain conditions, but more field testing with different methods and models is necessary before the technique will be reliable.

A week-long test of the CamTrakker® MK-8 conducted in Madison, WI resulted in software problems and poor picture quality. To test the model more rigorously in the field, we set it up along a heavily traveled trail to the study site. Though the model has several advantages over the CamTrakker® Digital Ranger, including being easier to set up and having fewer small parts, it did not perform well in foggy or low-light conditions, often producing a pure white photograph. In addition, the rechargeable battery pack and other features of its design meant that it weighed considerably more than the other models. I excluded it from the camera trap study.

Camera Trap Study

From May 24 to Aug. 24, 2009, I placed 18 trap stations into a 24 km^2 sampling grid, with each cell measuring 1 km^2. I sampled 17 cells of the 24. I systematically selected station locations based on evidence of bear sign and wildlife trails (Torres 2006; Zug 2009). To maximize coverage of the study site, I moved several camera trap stations into adjacent unsurveyed cells. For further details, see Chapter 1.

To maximize the number of individual bear photos with identifiable characteristics, I programmed both camera trap models at their fastest trigger settings: the CamTrakker® at a 20 s delay between triggers with continuous shooting day and night, and the Reconyx® at five photos per trigger on rapidfire mode (no delay between photos) and no delay between triggers. I set the sensitivity of the Reconyx® to High. The only exceptions were the two Reconyx® cameras I placed at the páramo stations. In an attempt to minimize possible false triggers, I set the sensitivity at Low/Med.

Camera traps were set between 50 and 125 cm off the ground, adjusted based on the terrain to aim at approximately Andean bear shoulder height (60-90 cm), and tested using the aiming functions of both models during set-up. Cameras were secured to trees using bungee cords and either a bike lock with a combination lock or padlock, or a Python Professional® cable lock from Master Lock Company LCC. In most cases I faced the cameras towards each other on a wildlife trial, with one facing up the trail and the other down the trail. If a bear entered the site along the trail in either direction, his or her facial markings would have a good chance of being captured by the cameras. To encourage the bears to cross camera viewpoints, I baited each station with Ultimate Bear Lure® (Wildlife Research Center, Inc., Ramsey, MN), which has been used successfully to attract Andean bears (Zug 2009).

I used Chi-square tests and logistic regression to investigate camera trap characteristics which might have been related to the bear disabling the camera, including height of the camera, direction the camera was facing, angle at which the camera was mounted to the tree, type of camera, and year. I used median tests and Spearman's ρ tests to investigate the same features in relation to the bear manipulating the camera, using percentage of bear visits during which the bear manipulated the camera as the response variable.

Individual Identification

My data set for individual identifications included all the photographs of bears taken in both 2008 by Zug and myself in 2009. To individually identify the bears, I first separated the photographs into sets, with one set containing all photos from a bear visit to a station. If more than one bear was present during a visit, I further separated each set into photographs of each bear based on times, angles, and photo series that contained only one individual. Using these photo sets, I made a composite drawing of each bear showing the front and both sides of the head as completely as possible (Appendix 2.2). Using the composite drawings as a tool for analysis, I designated key identifying features for each individual.

I used the simple matrix method of Zug (2009) as a systematic method to compare all trapping occasions pair-wise to identify trapping occasions that had captured the same bear. I required that three or more key features be the same to conclude that an individual was the same as a previously identified bear. I used Student's t test to compare the success of different station types for individual identification.

To reduce observer bias, I designed a "blind" test in which I juxtaposed 2-3 of the most representative photos (most clearly showing identifying features) from each trapping occasion with photos from every other trapping occasion. I presented all these juxtapositions as a PowerPoint presentation to seven independent reviewers who had no foreknowledge of individual bear identity. I also included a pre-test consisting of photos of known (captive) bears, to assess observer skill. For each paired set of photos in the pre-test and the observer bias test, I asked the observers to choose from the following answers, to which I assigned a point value: "Definitely the same" = 2, "Probably the same" = 1, "Unable to determine" = 0, "Probably different" = -1, or "Definitely different" = -2. I planned to eliminate observers that either failed to identify a significant number of the bears which were the same, misidentified bears that were different as the same bear, or gave definitive answers in cases with insufficient information (i.e. at least one of the photos was cropped so that the bear's distinguishing marks were not visible). One observer was eliminated due to poor results on the pre-test (<90% of answers within the range of possible answers – some questions had multiple answers that I deemed acceptable).

When the answers of all the observers were summed, higher positive numbers indicated greater confidence that the bears were the same, lower negative numbers indicated greater confidence that the bears were different, and numbers close to zero indicated an inability to determine whether the bears were the same or different. Given six participants, the results were on a scale from –12 to +12. If the paired photos received a summed score of 6 or higher, meaning that most of the observers identified the bear as the same and did not identify it as different, I considered the observer bias test to confirm my identification of the bear.

On some occasions in both 2008 and 2009, individual identification was difficult because of blurry picture quality, differing camera angles, wetness of fur, changing light conditions, partial face and/or chest shots, or pictures of bears that did not show their defining characteristics (Zug 2009). In 2009, a new problem presented itself – on two occasions, two bears traveling together entered and exited the frame in rapid succession, giving the impression of one bear. On these occasions, the observer bias test was particularly useful, as I could remove the bears from the context of the trapping occasion and determine if the reviewers perceived them as the same or different based solely on their facial markings.

Results

I set up 18 trap stations for a total of 899 station days (24 h)(Figure 2.1). I photographed bears during 11 visits at 7 stations (39%). All stations but one were sites at which bears had been photographed during 2008. No station recorded more than two bear visits during the 2009 study period.

Throughout our combined studies (June 26 - Dec. 17, 2008, Zug, and May 24 – Sept 3, 2009, Jones), we deployed four types of trap station: one Reconyx®, one

CamTrakker®, a station with one of each (mix), and a station with two Reconyx®. I found no significant difference between the number of bears detected per active station day for any of the station types (p=0.6, X^2=1.85 n=35). However, for success at individual identification of bears, there was a significant difference between station types. Two Reconyx® allowed me to individually identify a bear significantly more often than one CamTrakker® (p=0.01, n=35, t=2.04). There was less difference between two Reconyx® and one Reconyx®, but the difference approached significance (p=0.08, n=35, t=2.04). Interestingly, there was no significant difference between trap stations with one camera and stations with a mix of camera types (p=0.22 for 1 CamTrakker®, p=0.57 for 1 Reconyx®, n=35, t=2.04).

The bears appear to be curious about the cameras and often manipulate them, sometimes pulling them out of alignment or changing the field of view. In extreme cases they disabled the camera, either by breaking it or leaving it facing the ground. A bear manipulated a camera during 21 out of 28 visits in 2008 (75%), and manipulated ≥1 camera during 6 out of 11 visits in 2009 (54%). A bear disabled a camera (facing it towards the ground) during 4 out of 28 visits in 2008 (14%), and 2 out of 11 visits (breaking the camera) in 2009 (18%). The bears appeared more likely to disable a CamTrakker® (p=0.07, X^2= 3.19, n=28). Across camera types, bears were more likely to disable a camera that was ≥80 cm from the ground (no trap was higher than 125 cm; p=0.04, X^2= 4.04, n=27). However when corrected for camera type, height was not significant. No camera characteristics were predictive of the camera being manipulated by a bear.

Bear visits only occurred between 0800 and 1700. The briefest series was one trigger. The longest series was thirty triggers, during which the bear was recorded pulling on the other camera, eventually rotating it 90° around the trunk of the tree on which it was mounted. The CamTrakkers had a latency period of 20 s between triggers while the Reconyx had a latency period of <1 s between triggers. Intervals between bear visits ranged from 3 – 17 days.

Individual identification

In 2008, when one camera trap was deployed at each station, 57% of bear visits included shots of the face or chest with potentially identifiable features. Only 25% of bear visits resulted in individual identification (Zug 2009). Following Zug (2009) and Rios-Uzeda et al. (2007), I placed two cameras opposite each other at each trap station in 2009, in hopes of photo-capturing a bear as it both entered and exited the site. Of the 15 bears photographed during the 11 bear visits in 2009, 13 were identified, increasing the success rate to 87%. Of the remaining two visits, one consisted of a single photo of a bear passing the cameras at high speed, with no identifiable features, and the other consisted of photos of the paws and chest, allowing species identification but not identification of the individual bear.

The bears themselves affected the detection probabilities of trap stations. In 2009, in all cases when one camera recorded a bear visit and the other did not, it was subsequent to bear manipulation of the latter camera (with the exception of one camera that malfunctioned). It is likely that some bear visits were missed in 2008 following bear manipulation. Therefore, placing two cameras at a trap station is important for increasing the chances of identifying an animal and for minimizing loss of active station days due to manipulation of the cameras. Similar issues have been reported for other Reconyx® camera models used to study brown bears in Turkey (Cagan 2010). It is possible that human scent on the camera entices the bear to investigate. To minimize these incidents in future, precautions should be taken to remove human scent from the traps, including using rubber gloves during set-up and rubbing the traps with duff or dirt (Kays & Slauson 2008; Meek 2010). This will help prevent loss of data, trap days, and expensive equipment due to bears manipulating and/or breaking the cameras.

In 2008, Zug identified five individual bears (not including the cub photographed with the adult Bear 3). I identified seven individuals in 2009, two of which had been previously detected in 2008 (Figure 2.2). In short, I failed to recapture three bears identified in 2008. The observer bias test confirmed all the identifications made by Zug and myself with the exception of a bear visit on 8/5/08 to camera trap station (Ct) 14. We believe this bear to be F/5 – however among participants in the observer bias test opinion was divided, with about half indicating it was the same bear and half indicating it was a different bear. This bear was not identified as any of the other bears during the observer bias test. With the added information from 2009, we were able to identify F/5 on 10/1/08 at Ct14, which was confirmed by the observer bias test – this bear was previously unidentified. So while the identification as F/5 on 8/5/08 is questionable, we do know that F/5 was present in the study site during October 2008. Therefore, ten bears were detected in the 17 km^2 study area, at least two of which were present for both trapping periods.

I re-identified bears A, B, and F/5 at more than one station. Bear F/5 appeared at three stations, as did bears A and B traveling as a pair. Throughout our combined study periods, F/5 appeared five times at three different stations (or four times at three different stations if the disputed sighting is eliminated) and G/4 appeared twice at two different stations. Ct11 was visited by six unique individuals and one unidentified bear, Ct15 was visited by an adult bear and cub and one other unique individual, Ct16 was visited by two individuals, Ct03 was visited by two individuals and five unknown bears, and Ct14 was visited three times by the same individual (twice if a disputed identification is excluded). On three occasions, the same pair of bears was photographed together (A and B). On one other occasion, two different bears were photographed within five minutes of each other (C and D)(Figure 2.1)(Table 2.1).

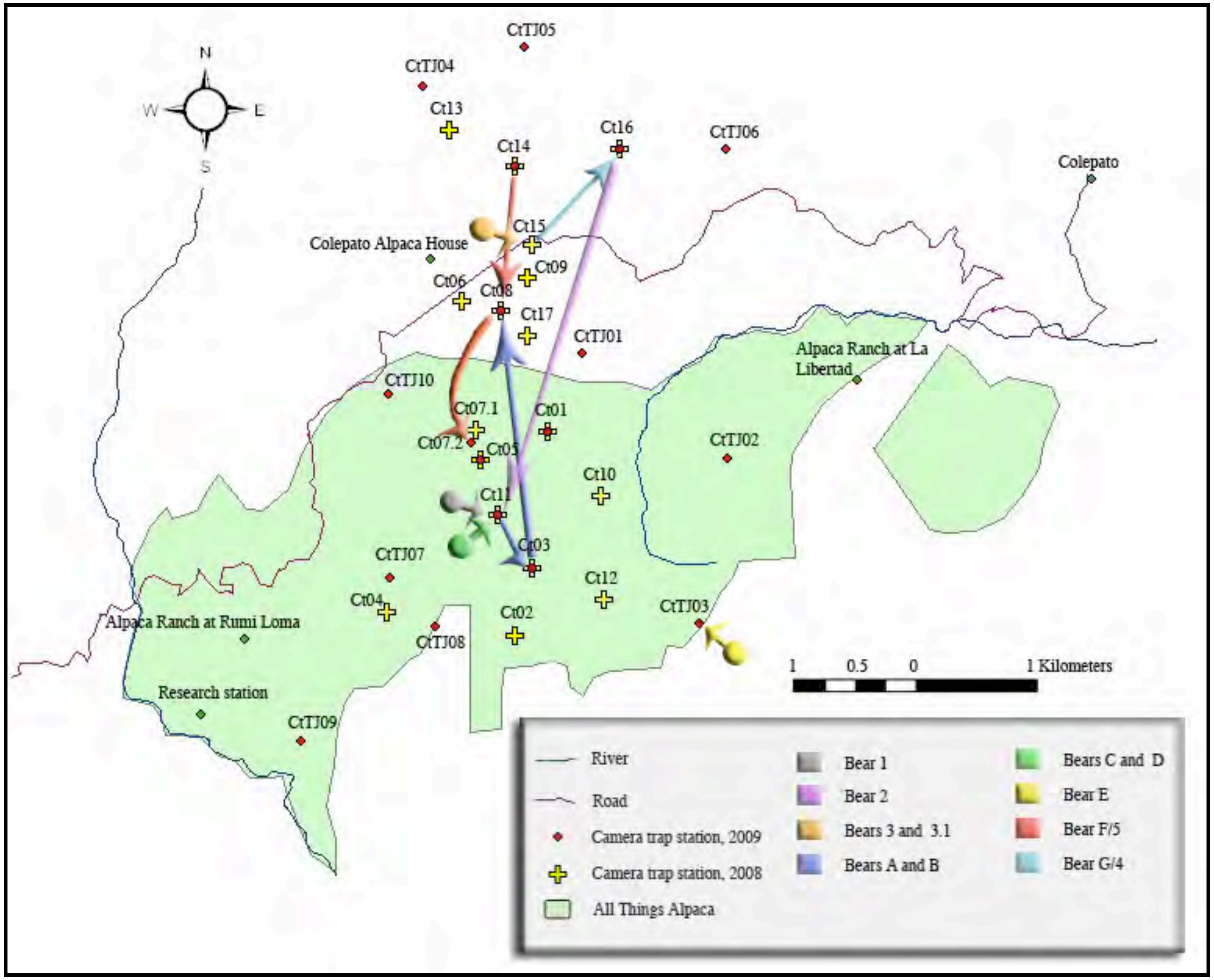


Figure 2.1 Locations of bear sightings. Arrow direction indicates the consecutive order in which an individual bear visited different trap stations. Circles indicate bears that were only photo-captured at one trap station. Trap stations to the north of the All Things Alpaca property line are on Colepato land (Credit: Taylor Jones, Alvin Rentsch).

Table 2.1 Identified and unknown (X) bear presence at camera trap stations during the trapping periods of 2008 and 2009.

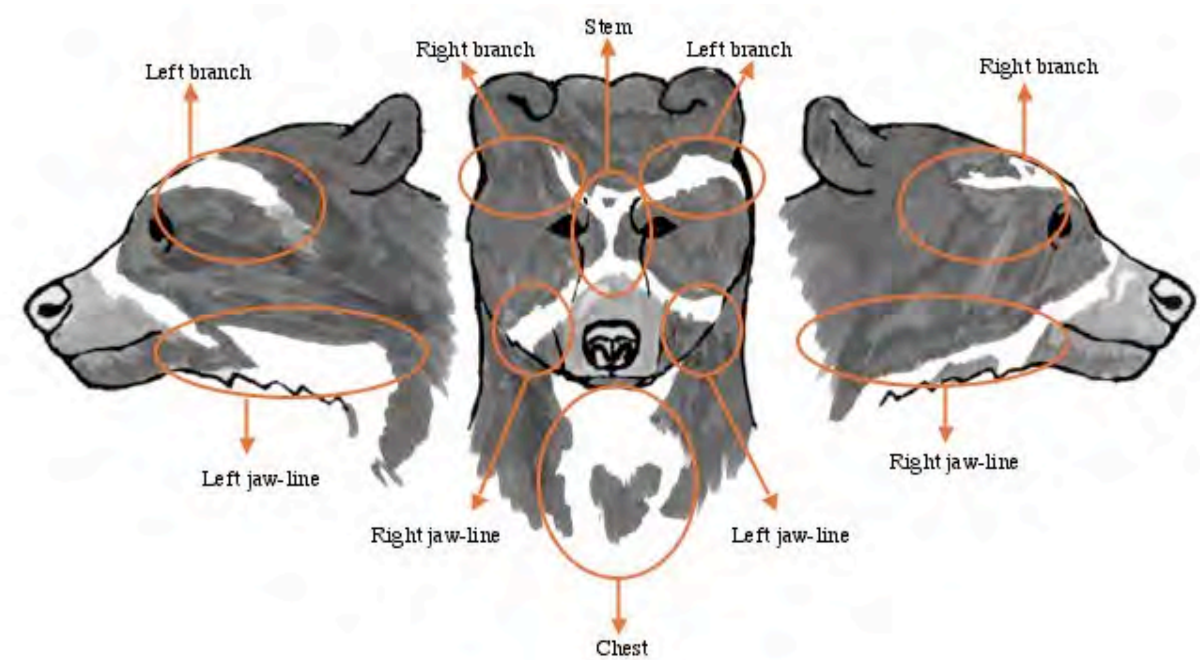
	Aug. 2008	**Sept. 2008**	**Oct. 2008**	**Nov. 2008**	**Dec. 2008**	**June 2009**	**July 2009**	**Aug. 2009**	**Total**
Ct01			X	X	X				**3**
Ct02		X	X						**2**
Ct03	X,X	X		X		(A, B)**, X			**6**
Ct04									**0**
Ct05		X	X						**2**
Ct06[1]									**0**
Ct07.1		X	X						**2**
Ct07.2								F/5*	**1**
Ct08		X						(A, B)**, F/5*	**3**
Ct09									**0**
Ct10			X						**1**
Ct11				1, 1	2, X	(A, B)**	(C, D)**		**6**
Ct12									**0**
Ct13				X					**1**
Ct14	F/5[2]*, X		F/5*				F/5*		**4**
Ct15		(3, 3.1)**		G/4*					**2**
Ct16			2, X	X		G/4*			**4**
Ct17									**0**
CtTJ01									**0**
CtTJ02									**0**
CtTJ03							E	X	**2**
CtTJ04									**0**
CtTJ05									**0**
CtTJ06									**0**
CtTJ07									**0**
CtTJ08									**0**
CtTJ09									**0**
CtTJ10									**0**
Total	**4**	**6**	**8**	**7**	**3**	**4**	**3**	**4**	**39**

*Bears designated with both a letter and a number were present for both study periods.
**Two bears in parenthesis indicate two individuals traveling together. This is counted as one bear visit as the two bears are not independent of each other.

1. Shaded rows indicate stations located on Colepato land. All other stations are located on All Things Alpaca.
2. This identification is unconfirmed by observer bias testing.

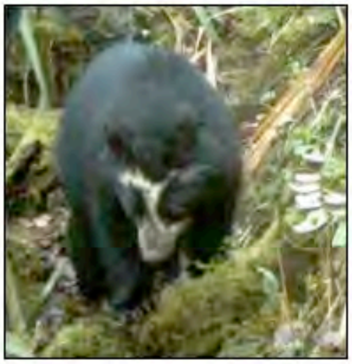
Figure 2.2 Individual Andean bears identified during 2008 and 2009, with key identifying features

Terminology



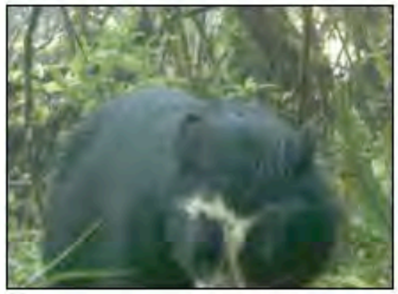
Bear A. Key individual identification features: (1) right branch thick with zig-zag pattern, (2) left branch thin and faint, (3) thick stem, (4) two black dots in stem.

Ct03, 6/21/09, 15:05



Features: 1,2,3,4

Ct11, 6/21/09, 8:42



Features: 1,2,3,4

Ct08, 8/8/09, 16:52

Features: 1,2,3

Bear B. Key individual identification features: (1) right branch thicker at base, narrows and lightens as it extends below right ear, (2) left branch short, with small fork at the end, (3) thick, asymmetrical stem, (4) spot below left ear with faint connection to the left branch, (5) black stripe within white pattern on left jaw-line.

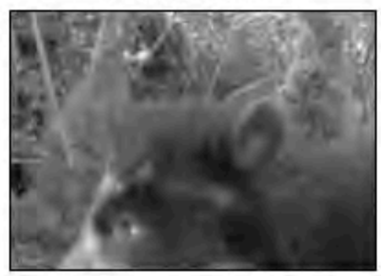
Ct11, 6/21/09, 8:42

Features: 1,2,3

Ct03, 6/21/09, 15:05

Features: 1,2,3,4,5

Ct08, 8/8/09, 16:52



Features: 1,2,4

Bear C. Key individual identification features: (1) right and left branches symmetrical , short, and thick, (2) thick stem, (3) lack of markings around ears.

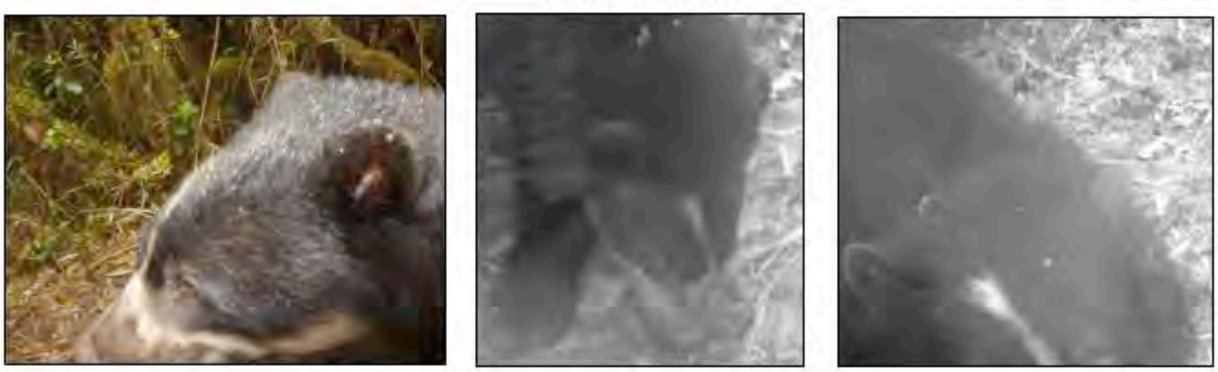
Ct11, 7/7/09, 8:35

Bear D. Key individual identification features: (1) branches almost non-existent, (2) thick stem, (3) spot below right ear, (4) white stripe on right jaw-line.

Ct11, 7/7/09, 8:42

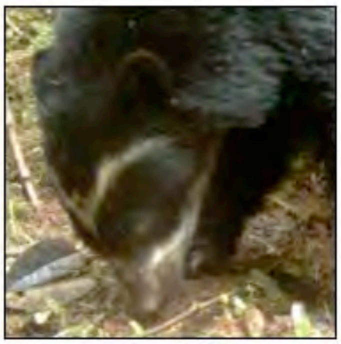
Bear E. Key individual identification features: (1) lack of branches, (2) stem thickens and angles to the right as it extends towards the right ear (3) lack of markings around ears, (4) white stripe on left jaw-line.

CtTJ03, 7/30/09, 8:09



Bear F/5. Key individual identification features: (1) right branch shorter than left branch, (2) left branch thickens in the middle and extends below left ear, (3) black spot in thick white diamond at the top of the stem, (4) thin stem, (5) white stripe on right jaw-line, (6) zig-zag patterning on left jaw-line.

Ct07.2, 8/6/09, 8:40

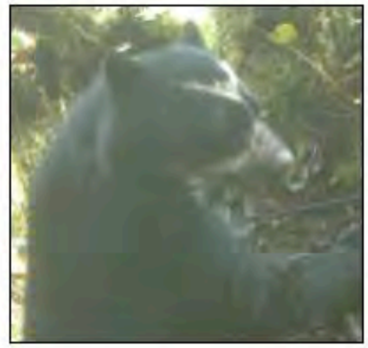


Features: 1,2,3,4

Ct14, 7/27/09, 15:25

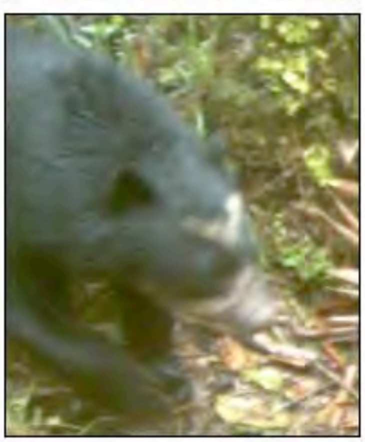
Features: 1,2,3,4,6

Ct08, 8/5/09, 9:16



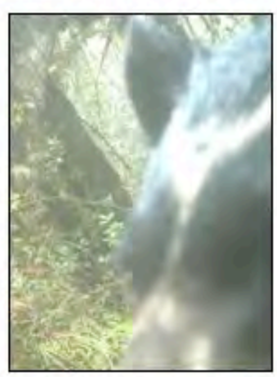
Features: 1,2,3,4,5,6

Ct14, 10/1/08, 16:12 (Photos: B. Zug)



Features: 2,3,4,5

Ct14, 8/5/08, 12:07. Not confirmed by observer bias test (Photos: B. Zug)



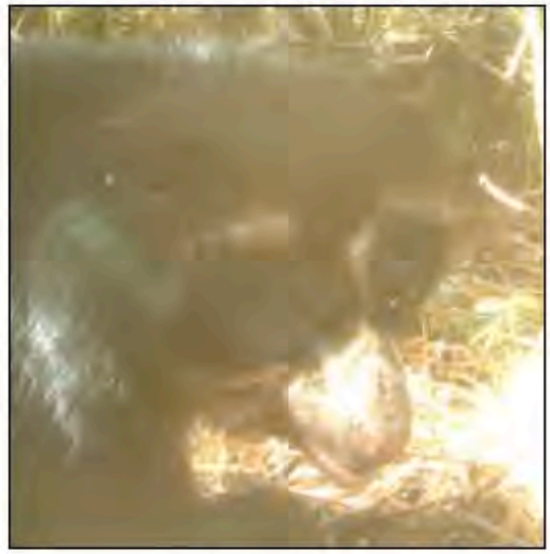
Features: 1,3,4,5

Bear G/4. Key individual identification features: (1) right branch has large break from stem to beneath ear, (2) left branch extends past ear, (3) thin stem which thickens at the junction with the left branch, (4) black gaps in white pattern on right jaw-line, (5) white stripe on left jaw-line.

Ct16, 6/18/09, 8:31

Features: 1,2,3,4,5

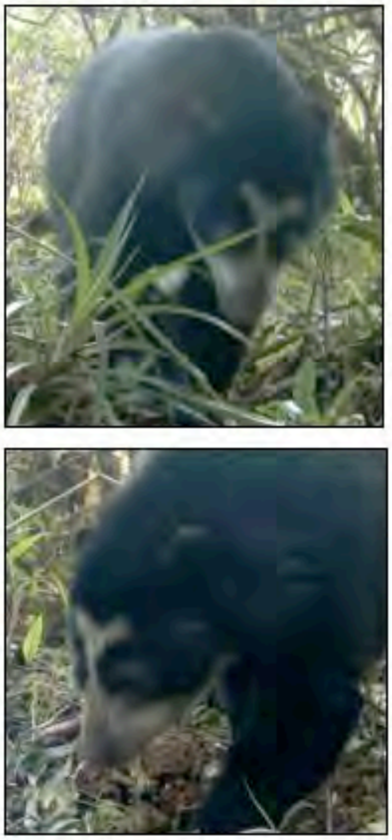
Ct15, 11/27/08, 9:13 (Photo: B. Zug)



Features: 1,2,3,4

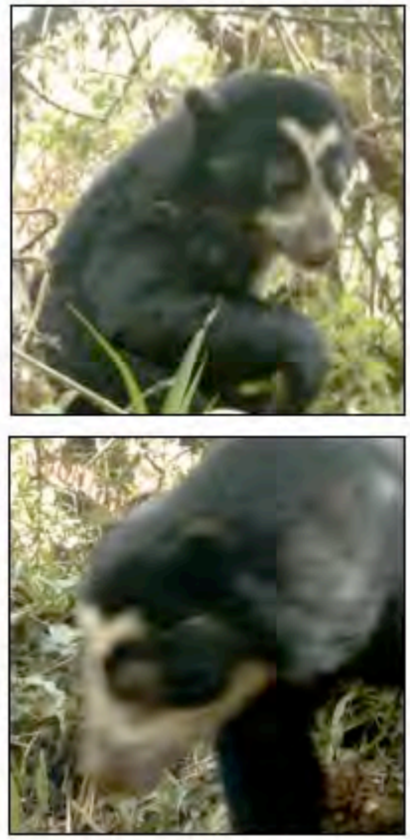
Bear 1. Key individual identification features: (1) both branches short and thick, ending before the ears, (2) black spot in the top of the stem,(3) thick stem, (4) white stripe on right jaw-line

Ct11, 11/8/08, 8:42 (Photos: B. Zug)



Features: 1,2,3,4

Ct11, 11/9/08, 13:41 (Photos: B. Zug)



Features: 1,2,3,4

Bear 2. Key individual identification features: (1) right branch ends in hook down towards right eye, (2) break in left branch below left ear, (3) circle around left eye, (4) thick stem with notch between eyes, (5) white stripe on right jaw-line, (6) large black stripe in white markings under left jaw-line.

Ct11, 12/6/08, 11:25 (Photos: B. Zug)

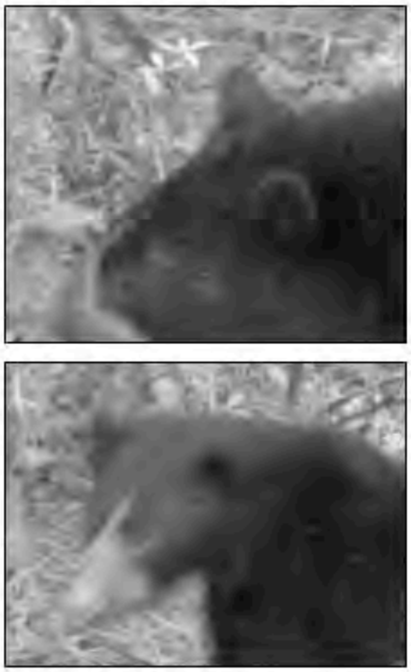
Features: 1,2,3,4,5,6

Ct16, 10/29/08, 9:40 (Photo: B. Zug)

Features: 1,4,5

Bear 3. Key individual identification features: (1) lack of branches, (2) short stem which thins as it extends towards the brow (3) two faint dots below left ear (disputed), (4) no other markings around ears.

Ct15, 9/15/08, 16:36 (Photos: B. Zug)



Bear 3.1. Key individual identification features: unable to distinguish. It cannot be determined whether this bear is the same as any of the other bears.

Ct15, 9/15/08, 16:36. (Photos: B. Zug)

Other species

Camera traps detected other animals as well as Andean bears. In 2009, I photo-captured six species of mammal (Tirira 2007)(Table 2.2)(Appendix 2.3) and eight species of bird (Ridgely & Greenfield 2001)(Table 2.3)(Appendix 2.4). Two domestic dogs were photographed at one station in the cloud forest (Ct14) and domestic alpacas were photographed at one station in the páramo (CtTJ10).

Table 2.2 Summary of photo-captured mammal species

English Common Name	Spanish Common Name	Scientific Name	Independent Photos	IUCN Status*
Andean bear, spectacled bear	Oso andino, Oso de anteojos	*Tremarctos ornatus*	11	Vulnerable
Little spotted cat	Oncilla	*Leopardus tigrinus*	3	Vulnerable
Little red brocket deer	Venado colorado enano	*Mazama rufina*	2	Vulnerable
Mountain coati	Coatí andino	*Nasuella olivacea*	2	*Data deficient*
Andean white-eared opossum	Zarigüeya andina de orejas blancas	*Didelphis pernigra*	1	Least concern
Puma	Puma	*Puma concolor*	1	Least concern

[a] Unidentified rodentia species (13) [b] Domestic alpaca (1) [c] Domestic dog (1)
*IUCN 2010

Table 2.3 Summary of photo-captured bird species

English Common Name	Spanish Common Name	Scientific Name	Independent Photos	IUCN Status*
Andean snipe	Becasina andina	*Gallinago jamesoni*	9	Least concern
Tawny antpitta	Gralaria leonada	*Grallaria quitensis*	6	Least concern
Tawny-breasted tinamou	Tinamú pechileonado	*Nothocercus julius*	3	Least concern
Andean guan	Pava andina	*Penelope montagnii*	2	Least concern
Undulated antpitta	Gralaria ondulada	*Grallaria squamigera*	1	Least concern
Ocellated tapaculo	Tapaculo ocelado	*Acropternis orthonyx*	1	Least concern
Pale-naped brush-finch	Matorralero nuquipálido	*Atlapetes pallidinucha*	1	Least concern
Stripe-headed brush-finch	Matorralero cabecilistado	*Buarremon torquatus*	1	Least concern

[a] Unidentified bird species (3)
*IUCN 2010

Discussion

Wildlife Friendly Eco-labeling at the Study Site

The Wildlife Friendly Enterprise Network, established in 2007, promotes Certified Wildlife Friendly (WF) products from many countries locally, regionally, and internationally through the web and other outlets. The WF eco-label aims to verify that wild animals survived or reproduced in and around the participating properties, making it a potentially "protective" eco-label (Treves & Jones 2009). However, high consumer confidence in the claims of the eco-label, and the attendant willingness to pay the higher prices asked, comes at a cost. Effective verification of wildlife survival may increase consumer confidence, but it also raises operating costs for the producer. WF must invest in reliable monitoring programs to ensure that certified products protect threatened species. The high cost of field verification would lower the incentive for producers to participate, and might raise the price of eco-labeled products. But certification remains desirable for certain businesses, depending on industry- and location-specific variables (Treves & Jones 2009).

A protective eco-label such as Wildlife Friendly incentivizes conservation in four main ways: it recognizes ongoing conservation efforts, augments clientele in local and regional markets, allows producers to access reliable niche markets at all scales, and allows producers to charge premium prices by including conservation as part of their product's value. For these reasons, certification may appeal to producers living in the habitats of threatened species who want higher value for their products and/or access to profitable niche markets.

The WF label recognizes and rewards the work of producers who would be practicing wildlife conservation on their land with or without an incentive (i.e. All Things Alpaca, S. White, 2009, pers. comm.). The label has facilitated access to local and regional markets for food producers: hotels and restaurants near Angkor Wat in Cambodia carry WF Ibis Rice, and retail outlets in the USA and southern Africa, including the Johannesburg airport, carry WF Elephant Pepper. Making a purchase that contributes to wildlife preservation and to the economic vitality of rural communities appeals to many middle- and upper-class consumers who want to reduce their environmental impact and are willing to pay premium prices to do so. For example, clothes from WF clothing company Wildlife Works in Africa, marketed as eco-conscious high fashion, have been promoted by such celebrities as Oprah Winfrey and Charlize Theron (Espinoza & Mandel 2003).

WF depends on a two-part certification process. In phase one, producers file an application for internal WF review. The initial application is free, and the fee for the second round of certification is $100 (www.wildlifefriendly.org). If the application is accepted, the producer enters phase two. After two years, each certified producer is expected to pass an independent wildlife-monitoring test to document survival of the focal species over time on the producer's land (Treves & Jones 2009). Full implementation of this procedure is underway; therefore WF is considered borderline between a persuasive and protective eco-label.

Payment for Ecosystem Services Projects at the Study Site

Ecosystem services can be particularly important in a developing country such as Ecuador, where the struggle for short-term subsistence is often counterproductive to long-term environmental (and therefore human) health and well-being. In the Andes, mountain ecosystems and the services they provide are threatened by rapidly expanding agriculture, road-building, live-stock grazing, and pine plantations (Buytaert et al. 2006; Jokisch & Lair 2002; Naughton-Treves et al. 2006).

Forest clearing offers higher crop productivity than replanting existing fields because it makes available moist, fertile soil, where diseases and crop pests are limited and competition from weeds is initially reduced. Because of this, farmers may often choose forest clearing over replowing fallow land or intensifying production, despite it requiring two to three times more labor (White & Maldonado 1991). Only 7% of the original distribution of montane forests remains in Ecuador (Valencia 1995, in Andrade 2004). Unless agriculture can be intensified on existing lands in a way that is economically attractive to farmers, or other incentives are made available for leaving forests intact, primary forest will be difficult to maintain (White & Maldonado 1991). The Andean páramo is also threatened by cattle grazing, cultivation, and pine planting (Buytaert et al. 2006).

Protecting forests, páramo, and the watersheds that they maintain will be critical to the continued economic vitality of Ecuador (Buytaert et al. 2006). Andean watersheds are crucial for providing adequate water for hydropower systems, irrigation, and human consumption (Buytaert et al. 2006; Peyton 1999). Conservation of natural landscapes is also important to maintaining tourism at profitable levels (Buytaert et al. 2006; Yerena 1998). The link between preservation of the Andean bear and preservation of Andean watersheds has been emphasized by many authors (Cuesta 2000; Peyton 1999; Yerena 1998). This argument is made because bears require large, diverse habitats containing intact forest and páramo, which is also true of healthy watersheds. But there is also some evidence that bears contribute to healthy, native forest dynamics through seed dispersal (Castellanos 2010; Torres 2006; Young 1990) and debarking trees. Debarking leads to the death and fall of trees, opening up large clearings that are used by slower-growing canopy trees (Castellanos 2010). Bear trails may also have an impact on the ecosystem (Chapter 1, Castellanos 2010). Further research is needed on the contribution of the bear to ecosystem dynamics in both the forest and páramo.

The Paute watershed, where my study took place, provides water flow to hydroelectric projects run by the Ecuadorian company HidroPaute. Steep slopes and the effects of deforestation make erosion and subsequent siltation one of the biggest environmental problems in the area; it also impacts electricity generation (White &

Maldonado 1991). The life of hydroelectric projects in Ecuador, such as a dam at Amaluza, have been seriously curtailed by sedimentation, and electric companies have been involved with soil conservation since 1982 when the Instituto Ecuatoriano de Electrificacion (INECEL) created a special watershed management organization (White & Maldonado 1991). INECEL prioritizes protecting native vegetation from clearing. Soil loss from native vegetation may be one hundredth of the soil loss generated when ground cover is removed and the land is converted to agriculture without soil conservation measures (White & Maldonado 1991). Concerned about the cost of clearing sedimentation from their hydroelectric dams, HidroPaute recently agreed to pay to implement a Payment for Protection of Watershed Services (PPWS) program with upstream resource users in the Nudo del Azuay watershed (Schloegel 2010).

Interpretation of Results

The individual identification data collected during our study in the Nudo del Azuay could have several ecological interpretations. There is some evidence that female bears have smaller home ranges (~34 km^2) than male bears (~150 km^2)(Castellanos 2010). Therefore one or two of the bears could be resident males, and the others could be females with home ranges that overlap the male's larger one (Cuesta 2000) or transient animals moving through the properties in search of food, territory, or mates. Alternatively the study area could be a mortality sink, and the two recaptured bears simply survived for a year. Their survival does indicate that the bears are not being relentlessly persecuted, and supports the conclusion that these properties are adequately meeting their habitat needs in the short term (Zug 2009). Long-term and frequent communications with trusted members of the community indicate strongly that bears are not being hunted in the area (C. Schloegel, FCT, 2010, pers. comm.). The recaptured animals, whether male or female, do not appear to be defending exclusive territories given spatial overlap indicated by the number of different bears photographed at the same station at different times. However, the temporal sequence of bear visits does not support temporal overlap – no bears returned to a trap station after a visit by a different bear (Figure 2.1). Further study of conspecific interactions in this species would be valuable.

I conclude that camera trapping can be successful for identifying individuals between trapping occasions separated by up to 10 months, that the use of two camera traps per station has higher reliability than one camera for individual identification, and that two individual Andean bears persisted on both properties: F/5 for at least 10 months from 10/1/08 – 8/6/09 (possibly for a year if the sighting on 8/5/08 was indeed F/5), and G/4 for at least 7 months from 11/27/08 – 6/18/09. Eight other bears were only identified during one study period. Three individuals from 2008 were not recaptured. Four individuals were only seen once. We confirmed the impression held by residents of the study site that that there are many bears present on the properties, and that some bears return repeatedly to the same areas. My finding that six different bears came to one station speaks to the potential difficulty of discriminating residents from transients, distinguishing individuals based on their locations, and estimating density and abundance in this species in this ecosystem.

Conclusions and Recommendations

Camera trapping is a promising technique for monitoring. The initial investment is high, with reliable, high-quality digital units costing between $450 and $650 each (www.reconyx.com). This type of expense should be considered carefully when designing monitoring schemes. On the other hand, after the initial investment, digital camera traps are relatively inexpensive to deploy, with their only continuing expenses being attractants and batteries (Kays & Slauson 2008). They can be easily transferred from one location or project to another, making them convenient for organizations with ongoing monitoring projects that do not overlap geographically or temporally. And camera traps can be set up by members of the communities involved in the projects or by eco-label verification personnel with proper training (Zug 2009).

The fact that camera traps monitor individuals in a specific area rather than one individual animal can make them better suited to monitoring a specific property than techniques such as radio-collaring. Because Andean bears are wide-ranging animals, it would be difficult to know if a captured bear was a resident on the property of interest before collaring it. In fact, transient bears might have higher capture probabilities if they are less cautious of novel things (i.e. culvert traps) than residents (Séquin et al. 2003). It is extremely difficult to monitor Andean bears with radio collars, as the bears are hard to capture, and once collared, the mountainous terrain makes relocating the bears difficult (Castellanos 2003; Paisley & Garshelis 2006). GPS or satellite collars might be more effective (Castellanos 2004), but the cost and difficulty of implementation makes these methods unfeasible for widespread use in economic incentives.

For a species like the Andean bear, identifying individuals allows us to determine if individuals persist on a property over time or whether the subpopulation in the study area suffers high turnover rates. Because this is a long-lived species which uses a wide variety of habitats (Cuesta 2000), and little is known about the bears' territorial or dispersal behavior in the wild (Rodríguez et al. 2003), simply ascertaining the presence of the species does not mean the study area supports a stable set of residents who are reproducing successfully.

Without individual identification, a mortality sink may be misidentified as suitable habitat or a densely settled area. A mortality sink is an area containing a subpopulation in which mortality exceeds births, causing said subpopulation to depend on immigration from a source to maintain itself. A source is a subpopulation where the birth rate exceeds the death rate, producing net emigration (Pulliam 1988). Importantly, "attractive sinks," where resources attract immigrants but high mortality is difficult for animals to detect, are often associated with human activities (Delibes et al. 2001). High turnover due to pressure from hunting or illegal killing can halt growth by preventing adult recruitment. In such situations, local immigration to a small area can mask an overall decline in the larger regional group of connected subpopulations (the metapopulation)(Robinson et al. 2008). The risk of metapopulation decline due to sinks is especially high in small protected areas with high edge-to-interior ratios (Balme & Hunter 2004; Woodroffe & Frank 2005; Woodroffe & Ginsberg 1998). An apparent high turnover rates of individuals in a study site may indicate a sink on the property, and could be considered a warning sign of problems with the intervention.

On the other hand, the limited area of camera traps can be a disadvantage when studying a wide-ranging species, in that high turnover rates may indicate mortality *outside* the property of interest, emigration, or seasonal shifts in habitat usage. Once an animal leaves the property of interest, mortality cannot be easily distinguished from emigration without additional evidence (Balme & Hunter 2004). The participants in conservation incentive schemes might lose "their" animals in adjacent areas despite following best practices on their own lands. The Andean bear also shifts its habitat usage during different times of the year according to food availability (Cuesta 2000). For example, in Perú, bears were observed to use the páramo primarily between February and April, when fruits were scarce (Troya et al. 2004). If the first period of surveying coincides with a period of abundance, and the second period does not, the resulting dearth of previously identified individuals, or any individuals at all, might reflect seasonal movements rather than failure to conserve the species on a participating property. To distinguish between mortality and emigration or seasonal movements, a mortality study using collared animals would be more informative (Balme & Hunter 2004).

Though camera traps are effective for detecting the presence of individuals, it is more difficult to obtain information about population size, reproductive success, seasonal movements, or home range size. Further information on each of these subjects is needed to more confidently assess the state of my study population. Theoretically, camera trapping could provide an estimate of Andean bear population size using simple capture-mark-recapture methods (Jackson et al. 2006). When animals can be individually identified, mark-recapture methods are the most reliable for determining population size (Jennelle et al. 2002). But meeting the necessary requirement of a closed population may not be feasible in the context of monitoring on a single property. Open-population mark-recapture models may be applicable to carefully designed camera trapping studies (Amstrup et al. 2005). Quantifying the number of individuals detected at a station and inferring changes in population density from changes in counts of unique visitations may also be possible, but limited understanding of the statistical properties of this type of index may make it unreliable (MacFarland 2009). Bear behavior may also influence detectability and bias results. In some instances, dominant animals are underrepresented in the photographic record (Larrucea et al. 2007). In a study of coyotes, transient and subordinate animals were more readily photographed by camera traps than resident, dominant animals because they were not familiar with the locations of the cameras or their association with human presence (Séquin et al. 2003). We do not know enough about how bears share territory with conspecifics to make inferences about different capture rates for animals of different ages, sexes, or status. Without better knowledge of Andean bear home range size and behavior in the wild, studies aimed at estimating changes in population size and/or density will be difficult to design, particularly for use in a small area.

Camera trapping can confirm the persistence of individual animals over time on a property of interest. One advantage of camera trapping over other methods of individual identification is the pictures of individual animals that result. For both eco-labeling and PES programs, camera trap photos of the focal species can be used as outreach tools, both for consumers of eco-labeled products and for producers and people enrolled in PES programs. For marketing eco-labeled products, the dissemination of photos of a charismatic animal could help to build a consumer constituency for the label and/or the products of individual producers. Digital photos of threatened wildlife and the producers sharing their land have been posted (http://www.nelson.wisc.edu/people/treves/Home.html) and could be added to the WF website (www.wildlifefriendly.org), inviting the scrutiny of consumers and involving them in a narrative of conservation as a supporter of both the wildlife and the certified businesses themselves.

For producers coexisting with wildlife, creating a connection with the individual animals they are conserving could provide inspiration and continued incentive for their conservation practices. A growing body of evidence suggests that involvement of landowners in the research process will raise their tolerance for wildlife on their properties (Treves et al. 2006). The relative ease with which camera traps can be set up and used, and the interest generated by the photos (Zug 2009), makes participation in wildlife monitoring accessible to local people. Presentations of the resulting photos will increase the awareness of, and possibly affection for, the species among residents of the communities within the study area, especially among those residents working directly with the project. A near-term increase in producers' sense of ownership of their wildlife, combined with the long-term market incentives offered by WF certification or income from PES projects, could lead to higher tolerance for the bear and other large carnivores. Raising tolerance promises to increase interest in non-lethal deterrence, lower human causes of wildlife mortality, and promote efforts to restore habitat. It is possible that measures of population size, density, or survival of the focal wildlife species will not be reliable due to characteristics of the species and the study site such as difficult terrain, low population density, and elusive behavior. In that case, other measures of the success of economic incentives may focus on attitude changes and related behavioral shifts. More research is needed on this aspect of the incentive process, particularly social scientific study.

With these advantages and disadvantages in mind, I would recommend camera trapping as a useful and accessible monitoring method, particularly in situations where photographs of individual animals could serve an important outreach purpose. Verification methods using camera traps should be tailored to the life-history of the target species. For an animal like the Andean bear, I would recommend monitoring in the same habitat type each year, at the same time of year, to avoid confounding the results with seasonal movements. However, it would be important to first collect information on detectability during all seasons (Larrucea et al. 2007). For example, during seasons of high dispersal rates, dispersing animals may move through a study area only once, leading to photo-capture of a larger number of individuals than are resident in the study area. If the data from such a study is intended for use in mark-recapture analysis, photo-capturing during a time of high dispersal rates may lead to overestimates of the population size (Larrucea et al. 2007). I also believe that true verification of the persistence of individual animals will take more than two study periods – it would need to be a continuous process over the life of the eco-labeling or PES project, possibly with a longer interval between monitoring periods (e.g., the WF eco-label recommends a period of 2 years between verifications).

For both eco-labels and PES programs, certifiers should articulate explicitly what sort of information they need to verify compliance, and the wildlife monitoring teams must understand which monitoring tools will be most effective for collecting that information. In the case of eco-labeling programs that use Andean bears as a focal species, bear condition (persistence of individuals over time or some other measure of survival or reproductive success) should be measured directly to determine whether the incentives have succeeded in their biodiversity conservation goal. For PES programs, attempting to conserve and measure "biodiversity" as a whole is difficult, as monitoring programs can only survey a limited subset of biological diversity. One option is to use a surrogate species or suite of species to represent biodiversity, with the assumption that protecting the surrogate species will protect a broader array of biodiversity (Jennelle et al. 2002; Lawler & White 2008). Since the Andean bear is endemic to a specific elevation range in the Andes, uses diverse habitats, and is geographically rare, it is often nominated as an "umbrella," "surrogate," or "indicator" species for Andean biodiversity (Clark 2004; Cuesta 2000; Rodríguez et al. 2003). There is some support for the efficacy of the bear in this capacity (Chapter 1). Until more information becomes available, bear populations should be measured together with a suite of other species that could be considered indicators of biodiversity, such as frogs.

Because of some of the pitfalls inherent in wildlife monitoring in a limited area, the results of wildlife monitoring should not stand alone as the determinant of whether or not to renew certification or PES enrollment. Rather, they should be combined with analysis of producer practices. If individual animals do not appear to be persisting on the producer's land, procedures such as a probationary study period to determine possible causes should be implemented rather than simply repealing certification or PES enrollment. Certainly, if the measures taken by producers are not creating the desired results for conservation, corrective measures should be taken. But more can be learned if certification or PES enrollment is seen both by the certifier and the producer as an ongoing process of education and adjustment rather than a punitive measure of success or failure.

If eco-labels or PES programs provide the funding and incentive for long-term studies of individual animals on specific properties, countless lessons could be learned for conservation from both successes and failures. In the case of the Andean bear, camera trapping could provide much-needed species information for an improved management plan. At the same time, it could be used as part of a strategy to provide economic incentives for conserving this occasionally destructive and difficult-to-live-with species. Though many eco-labeling projects are heavily subsidized, we can continue to create networks and markets for eco-labeled products (Mishra et al. 2003) and integrate ecosystem services into local, national, and global markets. The goal of eco-label and PES projects will be met when best practices for wildlife become economically self-sustaining. Exploring and fine-tuning the most accurate and inexpensive monitoring methods for each species of concern is one step towards fulfilling the potential of these projects.

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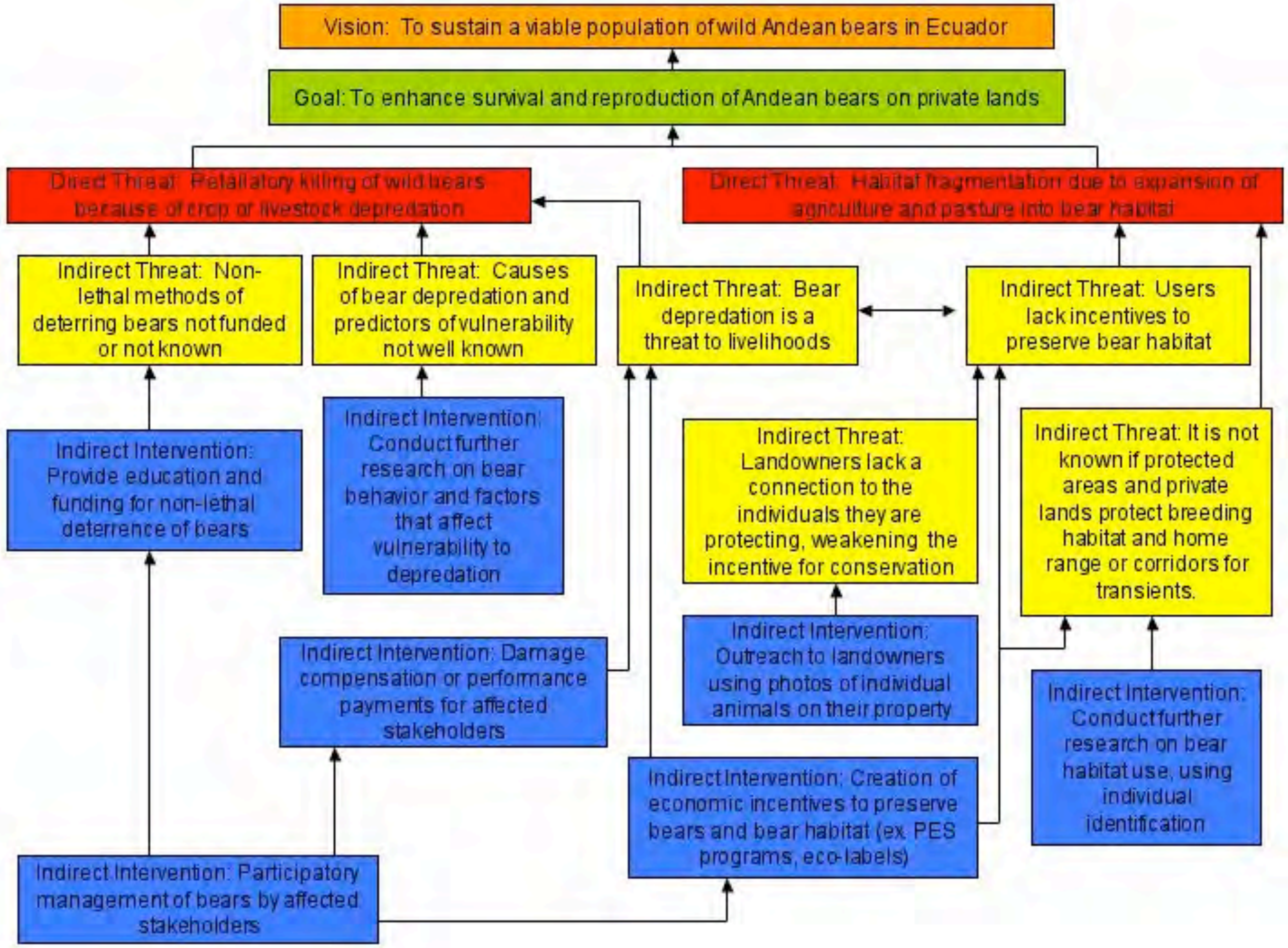
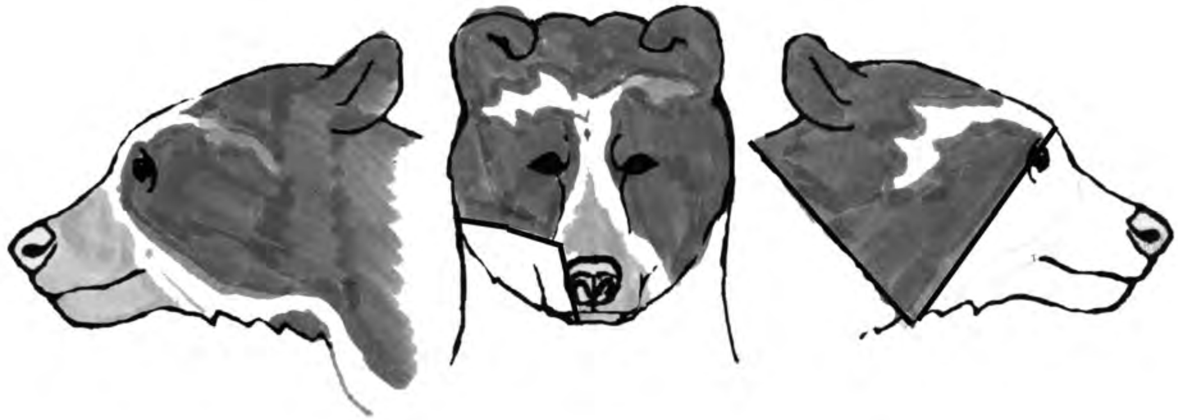
Appendix 2.1 Conceptual model of direct and indirect threats to Andean bear populations and indirect conservation interventions

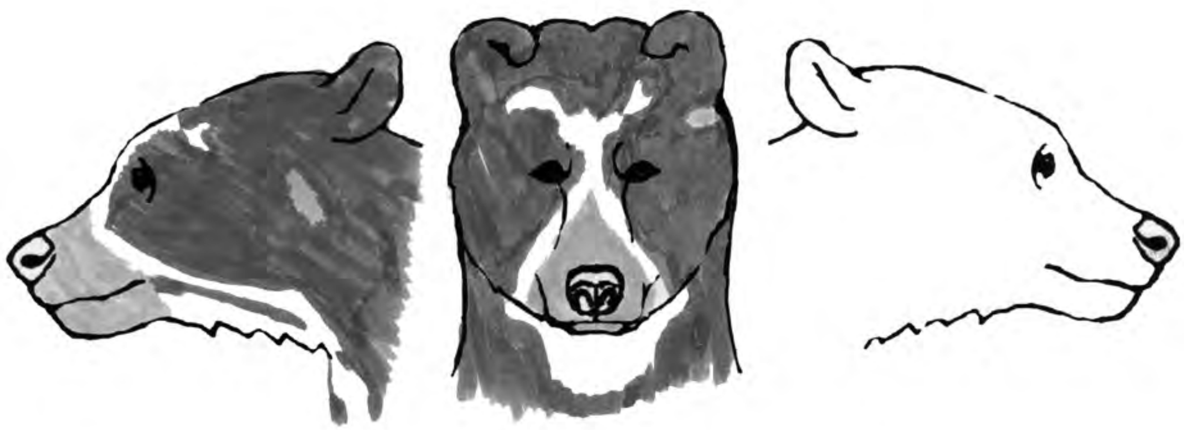


Credit: Taylor Jones, Adrian Treves

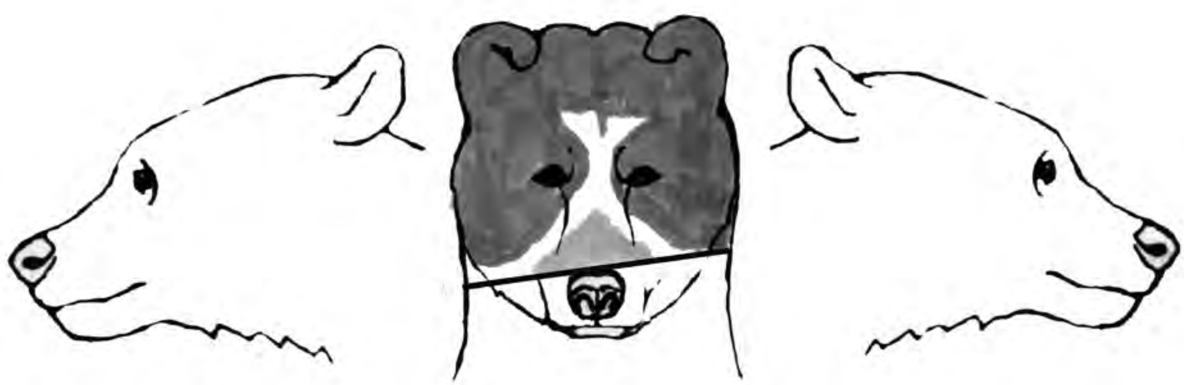
Appendix 2.2 Composite drawings of bears compiled from camera trap photos



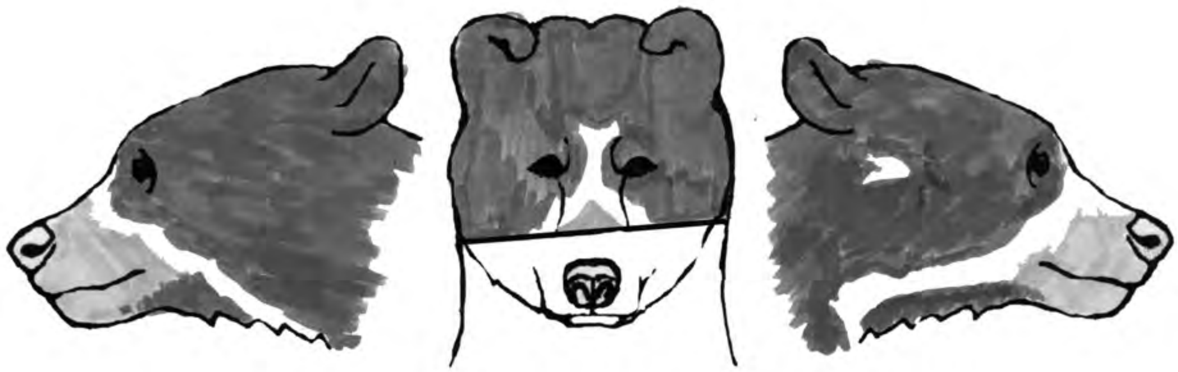
Bear A



Bear B



Bear C



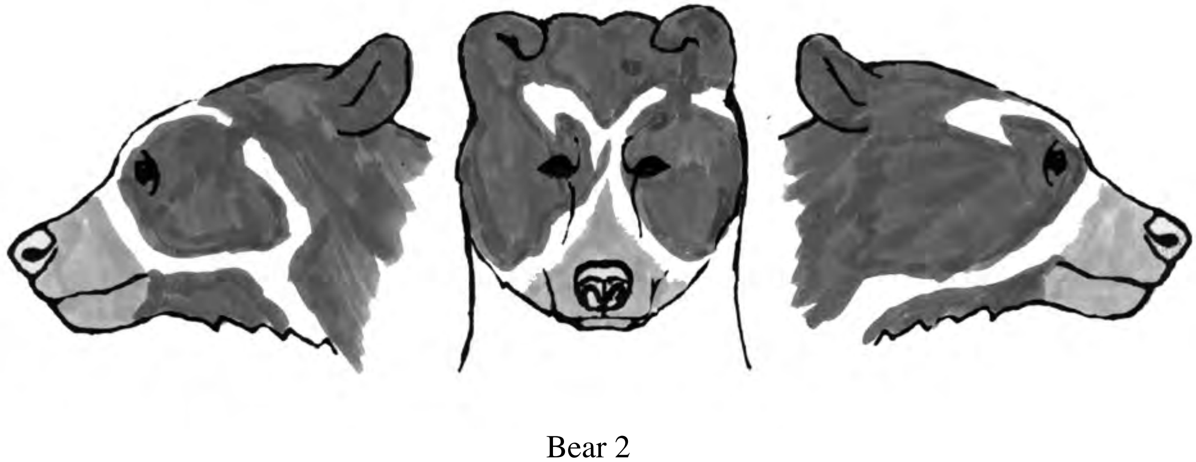
Bear D

Bear E

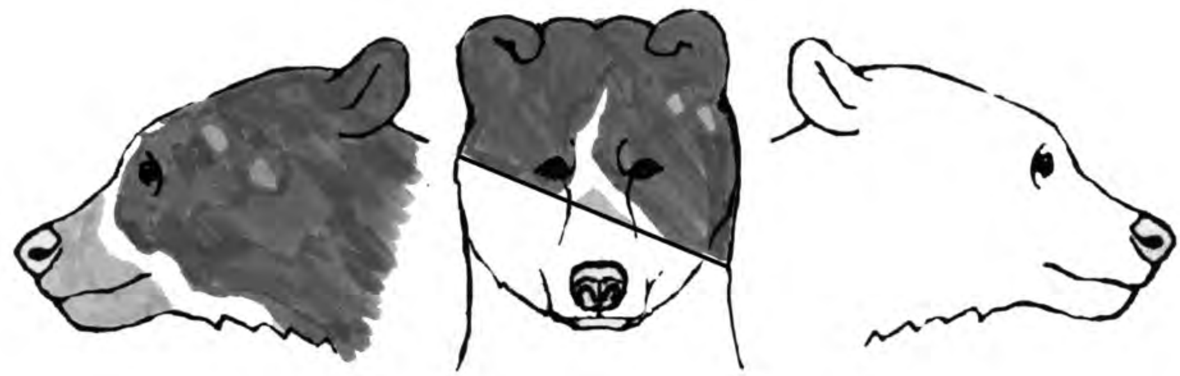
Bear F/5

Bear G/4

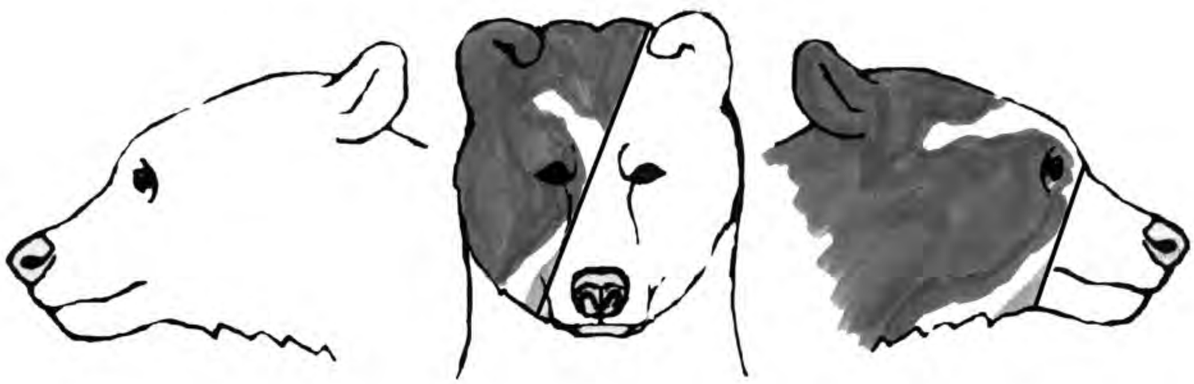
Bear 1



Bear 2

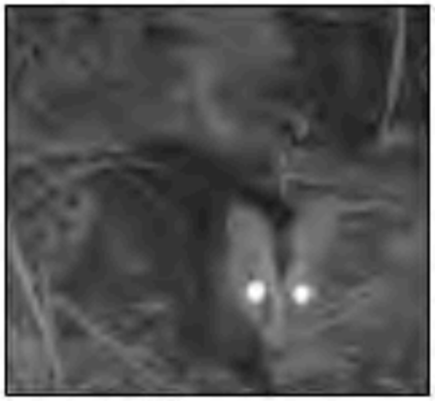


Bear 3 (Blurry picture quality)



Bear 3.1 (Cub, blurry picture quality. Unable to determine if this bear is the same as any of the other bears)

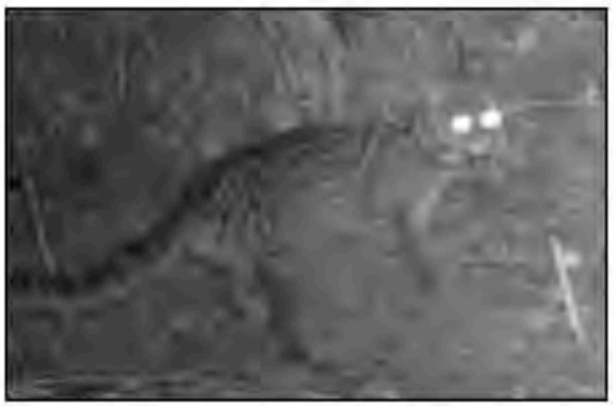
Appendix 2.3 Mammal species photo-captured in 2009



Andean white-eared opossum (*Didelphis pernigra*), CtTJ05, 7/12/09, 19:22

Little red brocket deer (*Mazama rufina*), CtTJ06, 7/11/09, 20:52

Puma (*Puma concolor*), CtTJ09, 7/26/09, 8:49



Little spotted cat (*Leopardus tigrinus*), Ct07.2, 7/11/09, 00:56

Mountain coati (*Nasuella olivacea*), CtTJ05, 7/19/09, 4:22

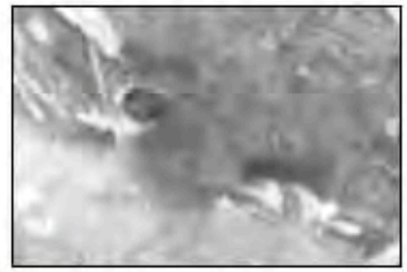
Appendix 2.4 Bird species photo-captured in 2009

Andean snipe (*Gallinago jamesoni*), Ct11, 7/3/09, 10:50

Andean guan (*Penelope montagnii*), Ct01, 6/11/09, 15:07

Tawny-breasted tinamou (*Nothocercus julius*), CtTJ01, 7/22/09, 12:48

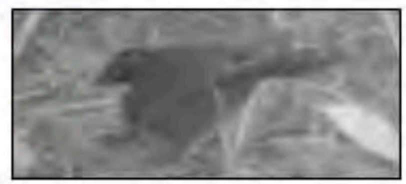
Ocellated tapaculo (*Acropternis orthonyx*), CtTJ03, 8/3/09, 17:09



Pale-naped brush-finch (*Atlapetes pallidinucha*), Ct03, 5/29/09, 16:12

Tawny antpitta (*Grallaria quitensis*), Ct11, 6/23/09, 9:57

Undulated antpitta (*Grallaria squamigera*), Ct14, 7/25/09, 14:18



Stripe-headed brush-finch (*Buarremon torquatus*), Ct07.2, 6/15/09, 7:10

Research and Management Recommendations

Researchers

The potential of individual identification for research on Andean bears has only begun to be explored. Camera trapping is particularly useful in situations where photographs of individual animals could serve an important outreach purpose. This study has confirmed the efficiency of using two Reconyx® cameras per station if one has a goal of individual identification, with an 87% success rate. For best results, researchers requiring individual identification should use two cameras positioned to face in two directions along a wildlife trail, at the shoulder height of the bears. These cameras should be set at minimum start-up time and maximum trigger speed if individual identification is sought. It is ideal if the camera can be set to take multiple pictures at each trigger. Care should be taken to remove human scent form the cameras after they are set up, as this may be one reason bears move or destroy cameras. A bear-proof box such as the one made by Reconyx® (Heavy Duty Bear Box, $149.99, www.reconyx.com/co/basket.php#Security%20Enclosures) may be a good investment considering the cost of replacing a camera unit.

Ultimate Bear Lure® appears to be effective at drawing bears into the stations, as bears visited the stations nearly four times as often as the second most commonly sighted large mammal (little spotted cat, *Leopardus tigrinus*). In 2008 no bears were photo-captured while using a fish- and blood-based lure, and when stations were switched over to the commercial lure, the capture rate was five times higher than the next closest mammal species (puma, *Puma concolor*)(Zug 2009). However I did not test this assertion experimentally by comparing similar sites on bear trails with and without lure.

Nor can I conclude whether a home-made fruit-based lure would be as effective, and possibly more economical.

I successfully replicated Zug's (2009) method for identifying bears. I elaborated upon her method of creating a composite drawing of the bear by including a view of both sides of the head as well as the front and dividing the face into different "zones" that could be compared to each other. ID books or databases could be created with these "mug-shots" for different properties, and could be compared across different sites to determine if adjacent property owners "share" certain bears. The "mug-shots" are not sufficient for a positive ID, but they are a quick-and-dirty method for determining possible re-identifications. One difficulty with identifications of individuals over longer time periods is that markings may change as bears age – further information on this issue is being analyzed (Zug, in progress).

Creating an efficient independent review process was important to correct for observer bias. We presented sets of photographs from each visit, and from each bear in a visit that the primary investigator believed to be different. Letting the observer compare each set to all the others allowed a complete and methodical confirmation or rejection of the primary investigator's conclusions. We found this method to be more informative and user-friendly than presenting observers with the raw data and asking them to draw their own conclusions from the entire photo set. We found that in the latter situation, even experts in bear ID miss bears because of misleading contextual information (i.e. two bears visit a station at the same time but never appear together in the frame). A similar test could be created with hard-copy photographs in the absence of computers and/or the PowerPoint program. It is important to include a pre-test consisting of known bears, with questions specifically designed to elicit certain answers (the same bear, different bear, unable to determine) to eliminate unskilled observers. I found that the one observer who scored <90% on the pre-test also consistently differed from other respondents' identifications of bears on the observer bias test. I would recommend narrowing the list of possible answers to "same bear," "different bear," and "unable to determine," as the inclusion of the "probably the same" and "probably different" categories introduced an element of subjectivity which made judging observer accuracy more difficult.

Though camera traps are effective for detecting the presence of individuals, it is more difficult to obtain information about population size, reproductive success, seasonal movements, or home range size. Further information on each of these subjects is needed to more confidently assess the state of my study population. Seasonal movements and home range size could be best assessed using GPS collars (Castellanos 2004). Reproductive success, sex, and estimates of relatedness could potentially be explored using DNA testing from hair snares or scat samples (Davison et al. 2002; Garshelis 2006; Ruiz-Garcia et al. 2005; Woods et al. 1999). DNA testing from feeding remains could potentially be used to identify bears that raid crop fields (Saito et al. 2008). For certain projects DNA testing may prove preferable over the long term, and could be combined with camera trapping in the first years to verify identifications.

When animals can be individually identified, mark-recapture methods are the most reliable for determining population size (Jennelle et al. 2002). Determining population size using simple capture-mark-recapture methods is theoretically possible with this species, but meeting the necessary requirement of a closed population may not be feasible in the context of monitoring on a single property. Open-population mark-recapture models may be applicable to carefully designed camera trapping studies (Amstrup et al. 2005).

Information on Andean bear detectability at the small scale of this project confirms that bears are likely to be photographed on well-worn trails, and are associated with greater wildlife abundance. Bears tend to travel widely in search of food, so it makes sense that the best place to photograph them on any given property of interest is along the routes they travel. A bear may use a trail for many reasons, none of which may be related to resources or microhabitat found at a trap station along the route. For a clearer picture of bear habitat use, as opposed to detectability, it would be interesting to survey the locations of food resources on a property, their seasonal availability, and the proximity of bear photo-capture events to food resources at different times of the year.

Wildlife managers, private landowners, and conservationists

Economic development is increasingly incorporating environmental concerns, and vice versa. Private landowners interested in conservation may be able to seek incentives or aid from several sources: government or private-sector PES programs, eco-label certification, community conservation initiatives, and park outreach programs, among others. These initiatives all represent attempts to make conservation profitable, rather than burdensome, for local communities. For large carnivores, this often means managing human-wildlife conflict from a variety of angles. Participatory planning, research on non-lethal deterrents, damage compensation payments, education, and incentives for preserving wildlife have all been marshaled to raise human tolerance for carnivores (Andrade 2004; Bulte & Rondeau 2005; Mishra et al. 2003; Treves et al. 2006; Treves et al. 2009; Vineyard & Torres 2004)

In the case of the Andean bear, human tolerance will be a large factor in the survival of the species. To that end, it will be important to determine if initiatives designed to raise tolerance actually succeed, and ultimately influence behavior. Though there is a wide variety of information about attitudes and behavior towards wildlife, evaluating the connections between conservation interventions, attitude changes, and behavioral changes is difficult (Gore et al. 2008). In the case of camera-trapping, one could ask if familiarity with individual bears through photographs is associated with greater willingness to implement non-lethal control methods or other conservation practices. For eco-labeling, PES programs, and other economic initiatives, program evaluations should be designed to minimize confounding factors (Ferraro & Pattanayak 2006) and answer (a) whether the program was carried out successfully, (b) whether the threats to biodiversity were minimized, and (c) whether the condition of biodiversity improved (Treves et al. 2006).

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INDIVIDUAL IDENTIFICATION AND HABITAT USE OF ANDEAN BEARS ON PRIVATE LANDS IN THE ECUADORIAN ANDES

By

Becky Zug

A thesis submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

(Conservation Biology & Sustainable Development)

at the

UNIVERSITY OF WISCONSIN-MADISON

2009

ABSTRACT

Global carnivore populations are declining. Their large spatial requirements and low densities make them particularly vulnerable to conflicts with humans, who represent one of the most significant sources of mortality for many of these species. Large carnivores are often the targets of persecution due to real or perceived threats to private landowners but conservation on private lands may be important when wildlife is far-ranging or protected areas are too small to contain viable populations. Retaliation against carnivores poses an added threat around protected areas where private properties could act as mortality sinks. To determine if private lands are playing a significant role in conservation we need to understand if large carnivores are finding safety and resources on those lands. In two chapters I examine evidence from Ecuador in support of the potential for conservation of Andean bears on private lands. I also discuss the utility of camera traps to assess the presence of carnivores in human-modified landscapes.

Chapter 1 establishes individual identification of bears on private lands to build a foundation for determining abundance, density, and the survival of individuals over time. I present a systematic and replicable method for identifying individual Andean bears from camera trap photographs. These identifications can be used to begin to distinguish stable territories from dispersal areas (corridors). This will also establish a basis for the long-term monitoring of this population that will help to prioritize habitat protections and management regimes that can

promote bear conservation. I also report a high short-term concentration of bears in the study area.

In Chapter 2, I analyze photo-capture results, microsite surveys, and landcover data to determine where bears were found on these properties and how this relates to human use and habitat features. I examine evidence for habitat use and possible attraction to and avoidance of landscape features and human activities on private lands to illuminate the role of private properties in conservation planning.

To JP

ACKNOWLEDGEMENTS

I would like to thank my advisor, Dr. Adrian Treves, for going above and beyond in supporting me and this project. I also thank my committee members, Dr. Lisa Naughton and Dr. Josh Posner, for sharing with me their extensive knowledge of the landscapes and people of South America, and Dr. Dave Garshelis for his advice over the past three years.

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I would also like to thank the community of Colepato for allowing me to conduct this research on their land. I would especially like to thank my field assistant, Don José Ojeda, for his unparalleled skill as a guide in these forests.

Thank you to all of the folks at Rumi Loma for their advice and encouragement and for enduring a cold, wet field season with humor and creativity.

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This project would have been impossible without the generous support from the Carnivore Coexistence Lab, the Doris Duke Charitable Foundation, the Latin American, Caribbean and Iberian Studies Program, the International Bear Association, the Nelson Institute for Environmental Studies, and a TRANSLINKS award from USAID, the Wildlife Conservation Society, and the Land Tenure Center.

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Most of all I would like to thank JP for his enduring sense of humor, endless patience, constant encouragement, and for being willing to learn more about bears than he ever asked to.

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CHAPTER 1:
THE USE OF INDIVIDUAL IDENTIFICATION TO STUDY ANDEAN BEARS (*TREMARCTOS ORNATUS*) ON PRIVATE LANDS IN ECUADOR

ABSTRACT

Worldwide, large carnivores are the targets of persecution due to real or perceived threats to people. Human tolerance for Andean bear (*Tremarctos ornatus*) presence on private lands would help connect distant protected areas and promote land uses that do not threaten bears. Identification of individuals builds a foundation for estimating population dynamics, verifying landowners' efforts to conserve bears, and for distinguishing areas used by resident bears from those used by transients. In 2008, I conducted a 4.5-month camera trap study of Andean bears on private lands in Cañar province, Ecuador. I deployed seventeen camera traps over 2,472 trap nights. I photo-captured bears at 12 of the 17 stations (71%) on 28 independent occasions. Sixteen (57%) occasions included face or chest photos with identifiable features. I developed a systematic method for identifying individual wild Andean bears from camera trap photos. I identified four adult bears with absolute certainly (100%) and one with relative certainty (75%), estimated by inter-observer reliability tests. A cub was also photo-captured. I found photos from camera traps to be an effective way to identify individual bears but also found ways to increase identification rates. In addition, bears were photo-captured between 0600 and 1700 h, supporting previous findings that Andean bears are diurnal in protected populations. I also photo-captured six species of birds and six other species of mammals, including pumas (*Puma concolor*), Andean foxes (*Pseudalopex* *culpaeus*), margay (*Leopardus wiedii*), and mountain coatis (*Nasuella olivacea*). Participation in payments for ecosystem services is growing and private land conservation efforts are increasing interest in monitoring methods that can evaluate claims that private lands support biodiversity. Camera trap methods meet this need and photos can help landowners feel ownership over the wildlife on their property.

RESUMEN

Los carnívoros grandes son perseguidos, en el Mundo entero, dadas amenazas reales o percibidas hacia la gente. Tolerancia hacia la presencia del oso andino (*Tremarctos ornatos*) en propiedades privadas ayudaría a conectar zonas protegidas distantes y a promover un uso de las tierras que no amenace a los osos. La identificación de individuos crea una fundación para obtener dinámicas de población, verificar los esfuerzos de propietarios hacia la conservación, y distinguir entre áreas de residencia y las de traslado. En el año 2008, realicé un estudio de osos andinos de 4.5 meses utilizando trampas de cámara en tierras privadas en la Provincia de Cañar, Ecuador. Utilicé diecisiete cámaras en 2.472 noches-cámara. Foto-documenté osos en 12 de las 17 estaciones (71%), en 28 ocasiones distintas. Dieciséis (57%) ocasiones incluyen fotos de cara o pecho con facciones identificables. Desarrollé un método sistemático para la identificación individual de osos silvestres usando las fotos de las trampas-cámara. Identifiqué a cuatro individuos con confianza absoluta (100%) y uno con confianza alta (75%), utilizando pruebas de confianza en grupos. Un osezno también fue documentado. Descubrí que las fotos de trampas-cámara son una manera efectiva de identificar

individuos y también para incrementar las tasas de identificación. Además, los osos fueron foto-capturados entre las 0600 y 1700 hh, confirmando conclusiones previas que los osos son diurnos en poblaciones protegidas. También foto-documenté seis especies de pájaro, y seis mamíferos adicionales, incluyendo pumas (*Puma concolor*), zorros andinos (*Pseudalopex culpaeus*), margay (*Leopardus wiedii*), y coati andinos (*Nasuella olivácea*). El crecimiento de pagos por servicios ambientales y esfuerzos de conservación están creando mayor ínterés en métodos para monitorear el soporte de biodiversidad en tierras privadas. Los métodos de trampas-cámara llenan esta necesidad mientras las fotos ayudan a los propietarios a sentirse dueños de la vida silvestre en sus propiedades.

INTRODUCTION

Large carnivore populations are in global decline (Michalski 2006). Low densities and large spatial requirements make them particularly vulnerable to conflicts with humans. Conservation on private lands may be important when protected areas are too small to maintain viable populations and wildlife frequently crosses boundaries into human-settled lands. Contact with humans accounts for a large proportion of mortality in many species of large carnivores (Woodroffe & Ginsberg 1998).

Conflicts between humans and bears are a significant cause of declines in global bear populations, the Andean bear (*Tremarctos ornatus)* among them (Servheen et al. 1999). The Andean —or spectacled— bear is the only ursid in South America and is threatened throughout its range. In 1977, the Convention on International Trade in Endangered Species of Flora and Fauna (CITES) added the Andean bear to Appendix I, prohibiting international trade. In 1982, the International Union for the Conservation of Nature (IUCN) red-listed the species as “vulnerable” and “at high risk of extinction in the wild” (IUCN 2001). The Andean bear is listed as “endangered” in Ecuador’s *Libro Rojo de los Mamíferos del Ecuador* (Cuesta & Suarez 2001). Habitat loss and fragmentation and retaliatory killing, due to crop raiding and livestock predation, are the two primary threats to Andean bear populations (Peyton 1999). With ranges that extend past protected areas and into human settled lands, Andean bears are illegally hunted throughout the Andes (Yerena 1998). In Ecuador, the use of and trade in Andean bear parts (e.g., gall bladders, paws, fat, bones, skulls, claws) pose an additional threat to bear populations (Adams & Mazariegos 1994). The major gaps in our scientific knowledge of the species, such as reproduction, population dynamics, and habitat use, makes conservation planning difficult (Rodríguez et al. 2003). For example, it is not fully understood how Andean bears use the páramo (high altitude grasslands). Peyton (1980) suggested bears struggle to survive in these areas due to a lack of nutrients but a telemetry study in Bolivia by Paisely & Garshelis (2006) found no evidence of this. While the latter study does not directly conflict with Peyton's work, it does bring to question what role the páramo plays in Andean bear ecology. In Ecuador, bears have been seen traveling through large expenses of páramo (S. White, pers. comm.). This may indicate they are using the páramo for travel as well as a source of food. More extensive research is needed to fully understand the role of this habitat. Despite these gaps in our knowledge of Andean bear ecology, their need for diverse habitats, significant area requirements, iconic status and ecological role as a seed disperser, make Andean bears an important focal species for conservation and management of Andean ecosystems (Peralvo et al. 2005; Peyton 1999).

Ultimately, the survival of wild populations of Andean bears will depend on human tolerance. As human activities continue to expand into and fragment bear habitat, human-bear conflicts are likely to become more frequent. As such, lands managed by private individuals without strictly enforced legal protections for wildlife (private lands hereafter) will play an increasingly important role in the long-term survival of the species. In 1999 <20% of Andean bear range was estimated to be inside legally protected areas (Peyton 1999), highlighting the importance of private lands in the success of Andean bear conservation efforts. To date, studies involving Andean bears on private lands have focused primarily on conflict (cattle attacks and crop raiding) while behavior studies focused on Andean bears in protected areas. Potential behavior adjustments associated with large carnivores living in close proximity to humans is well known but still relatively understudied (Beckmann & Berger 2003). Grizzly bears (*Ursus arctos*), sun bears (*Ursus malayanus*), and Asiatic black bears (*Ursus thibetanus*) have all been reported on private lands (Fredriksson 2005; Gibeau et al. 2002; Oi 2009) as have other species of large carnivores such as gray wolves (*Canis lupus*), European lynx (*Lynx lynx*), and pumas (*Puma concolor*) (Herfindal et al. 2009; Polisar et al. 2003; Treves et al. 2004). In their study on American black bear (*Ursus americanus*) behavior associated with a novel food source (urban garbage), Beckmann and Berger (2003) found significant changes in behavior ranging from reduction in activity hours per day, a shift to nocturnal activity, and shorter denning periods.

As a first step toward understanding Andean bear behavior on private lands, I present in this chapter a systematic and replicable method for identifying wild individuals from photographs. Andean bears are perhaps most noted for the beige-colored patterning around their eyes and on their muzzle and chest. This ornate patterning is unique to each bear (Roth 1964). As demonstrated with other elusive species around the world, individual identification can be used to develop life histories, estimate population size. and determine distribution (Henschel & Ray 2003; Jackson et al. 2006; Karanth 2006). Camera trap photos are also an effective way to engage local communities and potentially foster stewardship for wildlife conservation on their properties (Kays & Slauson 2008).

By identifying individual Andean bears on private lands we can begin to determine survival over time in order to distinguish stable territories from areas used transiently (Larrucea et al. 2009; Maffei et al. 2004). If private lands serve as corridors for long-range movements (e.g., dispersal) one would recommend different management than if those lands can provide stable resources for the establishment of territories. For example, curbing mortality might be sufficient for dispersal corridors but habitat protections would also be needed if private properties provide breeding habitats. My study also establishes a baseline for long-term, wildlife monitoring in the area and a systematic method to identify individuals. I report and discuss lessons learned about camera trapping in the Andes and how the outputs (photos of wildlife) affected the interested landowners.

STUDY AREA

I conducted this study on two contiguous private properties located in the Nudo del Azuay region of southern Ecuador. Both properties are within the southern section of Sangay National Park (SNP). In 1992, SNP boundaries were extended over private lands and little, if any, assistance is provided to help landowners mitigate conflicts with wildlife. The park boundary now runs through the center of the properties (Figure 1.1). I surveyed the area to the west of this boundary, within the confines of the park. Elevation of the study area ranges from

2900–3680 m asl with steep and rugged topography. Land cover consists of a combination of páramo, montane evergreen and cloud forests, livestock pastures, agricultural land (including pine plantations) and smallholder private residences (Jokisch 2002). A more detailed description of the site is available elsewhere (see Chapter 2).

The northern half of the study area covers approximately 5000 ha (Achig & Santillán 2009) and is owned by the Colepato Community Cooperative (Colepato). Thirty-two cooperative members and 30 non-members (~400 people) live, raise livestock, and farm parts of this land. The southern half of the study area is an approximately 1400 ha alpaca ranch with one owner (Chapter 2). Large portions of both properties are forested. During this study I surveyed approximately 4 km^2 of forest on each property.

Throughout the project I worked closely with Fundación Cordillera Tropical (FCT), a local NGO based out of Cuenca, Ecuador. FCT has a strong relationship with the Colepato community and together they are involved in several ongoing conservation projects. During the pilot study I traveled with FCT staff members to the Colepato community to propose the project and ask for permission to conduct bear research on their land. The community unanimously granted me permission and I hired a community member, Don José Ojeda (J.O.), as a field guide for the duration of the project. I had been granted permission to work on the alpaca ranch before the project began.

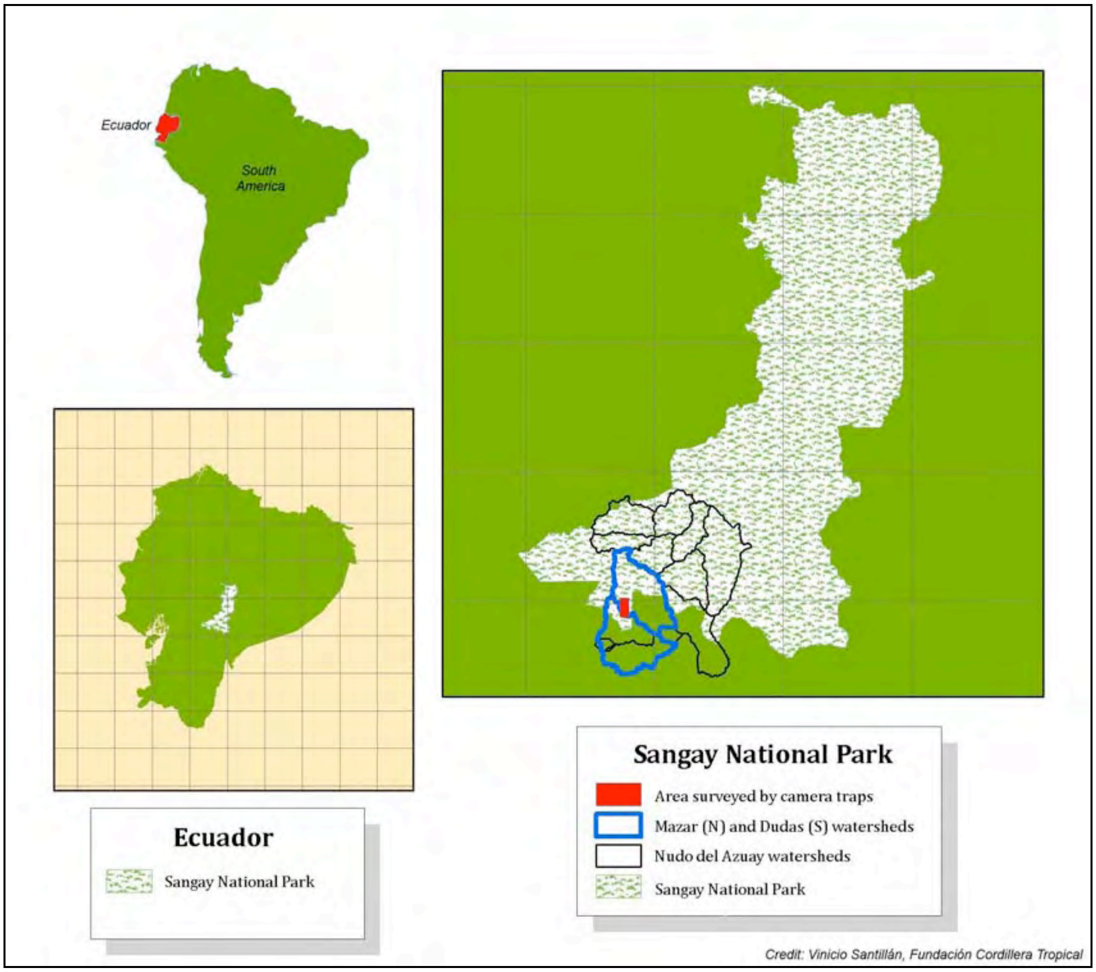

FIGURE 1.1 The study area in relationship to Sangay National Park and surrounding watersheds.

MATERIALS & METHODS

I adapted the camera trapping methods from those used to study tigers (*Panthera tigris*), jaguars (*Panthera onca*), leopards (*Panthera pardus*), and Andean bears (Henschel & Ray 2003; Karanth 1995; Rios-Uzeda et al. 2007; Silver 2004; Silver et al. 2004). Camera-trapping has revolutionized the study of elusive species (Carbone et al. 2001; Karanth 1998; Kelly 2008; Pettorelli et al. 2009) but techniques and equipment are still being formulated and certain habitats (e.g., wet forests, open grasslands) have proven difficult to survey. I aim to contribute to the growing knowledge of digital camera traps as a tool for the study of elusive carnivores, identification of wild individuals, and camera trapping under diverse and difficult conditions. I developed my data collection sheets based on variables collected by Cuesta et al. (2003) and from snow leopard (*Uncia uncia*) studies conducted by Jackson et al. (2005).

Camera trap models

I used two models of passive infrared (PIR) motion detection digital camera traps for this study: (7) Reconyx® PC85 (RECONYX, Inc., Holmen, WI) and (10) CamTrakker® Digital Rangers (CamTrakker, Watkinsville, GA). The Reconyx® PC85 has a 1/5 s start-up trigger speed and takes high resolution (3.1 megapixels) photos at one frame per s with an instant re-trigger and a programmable delay setting of zero to 3600 s. This model takes black and white photos at night with a covert infrared flash. The CamTrakker® Digital Ranger has a 3-5 s start-up trigger speed, takes one photo per trigger, and has several options for delay settings starting at 20 s. This model uses a Sony brand digital camera placed inside the camera trap housing and takes color photos at night with an on-camera flash (Figure 1.2).

FIGURE 1.2 Camera traps mounted on trees (Reconyx® on left, CamTrakker® on right).

Pilot Study

In June 2008, I conducted a two-week pilot study at the research site. The goals of the pilot study were: 1) to test a sample of the camera traps under field conditions, 2) to test a homemade scent lure and lure set-up, 3) to survey habitat types rapidly, and 4) to look for bear sign as an indicator of future camera trap placement. I used a total of five camera traps to test accuracy and trigger settings for each model: three to test field conditions and two at the research camp positioned along a wildlife trail.

During the pilot study I was primarily concerned with how the camera traps would perform in the páramo. The páramo within the study area was a mix of *subpáramo*, a mosaic of small trees, shrubs, and shrubby grasslands, and *grass* *páramo*, composed mainly of bunch grasses (Luteyn 1992). Moving vegetation will trigger camera traps, exhausting batteries and filling the memory cards. I selected field sites that were within or immediately adjacent to large areas of páramo, that lacked forest cover, and that had bear sign such as a trail through grass or feeding remains. I used a bungee cord to mount each camera trap on a tree in the páramo and secured each trap with a heavy-duty lock. The limited number of camera traps (n=17) precluded the use of three camera traps per station as recommended by Rios et al. (2007).

Both camera trap models tested well under field conditions but using camera traps in the páramo proved difficult due to the constant movement of tall grasses and shadows. Hundreds of false triggers were recorded at each of the field sites and the camera trap batteries were depleted within a few days, similar to the Bolivian study (Rios-Uzeda et al. 2007). Based on these results and the uncertainty involved when predicting where a bear might walk in a large open area, I decided not to place camera traps in the páramo. The two camera traps tested in camp confirmed that the slower start-up and trigger times for the CamTrakker® model resulted in photos of the subject leaving the frame and fewer photos overall. In contrast, the Reconyx® model tended to have more photos of the subject entering the frame. From this I chose to place the camera traps facing trails, rather than pointing across them, to photo-capture approaching animals. I programmed the CamTrakker® model at the fastest trigger setting (20 s delay between photos, continuous shooting day/night). The extremely fast start-up and re-trigger speeds of the Reconyx® caused some concern that the batteries would be depleted quickly. As a result, I programmed this model to take three photos per trigger with a delay of one s between photos and five s between triggers.

At each camera trap site I tested two homemade bear lures that were mixed by a previous biologist (T. Smucker) for a hair snare study at this site. The first lure consisted primarily of rotten fruits and the second lure was a combination of rotten fish and cattle blood. Both lures had been left in plastic drums in the sun for six months. To protect the scent lure from rain, I tied a sponge inside a plastic cup and hung the plastic cup upside down from a tree in front of the camera trap. I wanted to use both scent lures at each site so I hung two cups next to each other to avoid mixing the lures. When I revisited the sites the scent lure cups did not show any damage from wind or wildlife. Lack of rain during the pilot study made it impossible to test how the camera traps and the lure cups would hold up to moisture. My sign surveys indicated frequent bear presence in a variety of habitats but the only photo-captures during the pilot study were of a South American white-tailed deer (*Odocoileus sp.*) and several semi-feral horses. On several occasions the camera traps at camp took photos of Andean foxes (*Pseudalopex culpaeus*). There were no photo-captures of bears during the pilot study so I could not confirm the effectiveness of the homemade lure.

Camera Trap Study

Because of delays caused by heavy rains during the study period, dense fog, rugged topography, the density of the forest, and obtaining permission to work on Colepato property, the distribution of all camera traps was not completed until August 11, 2008. Hence camera-trap days varied markedly across stations. Subsequently, I hired and trained an Ecuadorian biologist to check the camera trap stations (Vinicio Santillán, V.S.). V.S. and J.O. visited each camera trap station monthly from September-December 2008.

From July–August 2008, I systematically placed 16 camera traps within an 8 km^2 sampling grid. I based the sampling area size on estimates of Andean bear home ranges (Castellanos 2004; Paisley 2001). Topography and forest density limited the size of the area I could readily survey. I divided the grid into eight 1 km^2 cells that were further quartered into 0.25 km^2 sub-cells. With the help of J.O., I set-up two camera trap stations within each grid cell, each occupying a randomly selected, separate sub-cell. On average, the camera trap stations were 0.7 km apart (0.3-1.3 km). Camera trap stations ranged from elevations of 3186 to 3501 m. Sixteen camera traps were located in the Mazar watershed and one camera (Ct04) was located in the Dudas watershed (Figure 1.1).

I selected camera trap locations within sub-cells based on evidence of bear activity or a trail used by wildlife (Goldstein et al. 2008; Goldstein & Marquez 2004; Henschel & Ray 2003). All camera trap stations were located in areas with tree cover. I collected data on camera trap locations by major topographic and vegetation characteristics as well as proximity to human structures and areas of human activity (see Chapter 2).

Traps were set 45-72 cm off the ground (Andean bear shoulder height is approximately 60-90 cm), facing an animal trail. The lens faced away from direct sun because of false triggers caused by sun and shadows. J.O. and I cleared the area immediately in front of the trap of brush and tested the aim of the camera trap using the aiming functions on both models. We then recorded bear sign (feeding remains, scat, claw marks, etc.) (Tirira 2007; Torres 2006) and cleared this sign within 10 m of the CT. It can be difficult to determine the "freshness" of bear sign, so clearing the area allowed us to detect new sign on subsequent visits.

I hung lure 1.8-2.1 m off the ground to encourage the bear to look up and show their chin and chest patterns. Based on the results of the pilot study, in July-August I changed all of the stations from the homemade lure to Ultimate Bear Lure® (Wildlife Research Center, Inc., Ramsey, MN). I conducted a Wilcoxon Sign-Rank matched pairs test and determined that freshness (time since the lure was put out) did not have a significant effect on bear visits to camera trap stations (see Results). I set-up a 17th camera trap without scent lure in a small forest patch outside of the sampling grid, along an easily accessible ridge trail used seasonally by researchers and students. This allowed for the collection of additional data until this replacement camera was needed. To prevent rain and moisture from damaging the camera traps I used desiccant packets in each trap and replaced these approximately every four weeks. I used a removable silicon sealant on the exterior rim of the CamTrakker® housing to reinforce the factory seal that I felt was insufficient. Typically, camera trap models were randomly selected for each location but due to the increased time required by the sealing process I tended to use the Reconyx® camera traps for stations located further from camp. I conducted a t-test and determined that camera trap models did not differ in photo-captures of bears (see Results). During each site visit we exchanged memory cards, changed the batteries and the desiccant, refreshed the scent lure, and conducted transects for bear sign (tracks, scat, feeding remains, etc.). The transects were 10 m long, starting north and alternating directions (north, south, east, west) at each subsequent visit. These transects were originally designed to calculate detection probability in an occupancy study. However, later I decided not to conduct this analysis on this data. V.S. then entered the data into a spreadsheet, which he e-mailed to me along with the camera trap photos, within two weeks of each field trip. This allowed me to monitor the project and make adjustments as needed.

Individual identification of bears

Each visit by a bear to a camera trap station results in one or more photos. I considered each bear visit to be one "hit" regardless of the number of photos taken. Partial shots of the face and/or the chest, blurred images, or photos of the body without any identifiable markings often hampered individual identification of bears. As a result of only one camera trap at each station, all photos of a hit came from the same angle. To identify individuals I often had to assemble pieces of many photos to get a clear idea of a bear's pattern. This was impossible when only one photo was taken during a visit to a trap station. On multiple occasions portions of the bear's face were not photographed. Uncertainty in identification was confounded by lighting, angle, distance from the camera or flash, and wetness of fur. To account for this I focused on differences between photographs that could not result from these conditions. For example, the color of the body fur could appear brown to black based on how wet or dry the bear was. I found the presence, absence, or break in patterning to be diagnostic on the following body parts: between and around the eyes, in front of the ears, and along the sides of the muzzle. I had too few photos of the chest to use this feature in identification but I believe it could also be a useful identifier with more camera traps at each station.

To overcome the uncertainties mentioned above, I followed a three-step identification process. First, I reviewed all hits with identifiable features and constructed a composite sketch for each occasion a bear visited a trap (Appendix 1.1). This allowed me to collect all patterning information in one place, on a simple line drawing. I then used the composite picture to create a list of key identifying features for each hit. I termed the patterning between and around the eyes as "Y," the patterning between the eyes as "stem," and above the eyes as "branches." More sophisticated methods of individual identification, such as three-dimensional surface modeling software that accounts for angle and lighting (Conservation Research, www.conservationresearch.co.uk), is available for other species (Hiby et al. 2009). This type of software may warrant development for Andean bears if there are many hits or characteristics are too similar. For the purpose of this study this type of tool was unnecessary.

Second, I used a simple matrix to compare all composite pictures (each signifying one hit), pair-wise, to answer the repeated question, "Is this the same bear?" (Appendix 1.2). In the left-side column, I indicated when a new bear was identified. To identify an individual I required that at least three key features were different from those of previously identified bears. In the body of the matrix I responded Y (yes= positively the same bear), M (maybe= could be the same bear, could be different bears), and N (no= definitely not the same bear). I then tallied the left-side column for number of individual bears and gave each individually identified bear a code (B1-B5). I used the "Y's" in the center of the matrix to determine multiple occurrences of the same bear and discarded the "M" responses. I then developed a capture history database for each identified adult bear (Karanth & Nichols 2000).

Finally, to counter observer bias, I developed a "blind" technique and asked a group of independent reviewers (n=3) to repeat steps one and two. To account for inter-observer variability, I measured selectivity (when an observer identifies the same bear as I did) and specificity (when the observers could not identify a bear I could not identify) across observers.

RESULTS

I deployed 17 camera traps for a total of 2,472 trap nights (24 h). I photo-captured bears in 28 hits at 12 stations (71%) (Table 1.1). One series of photos included a larger bear and a cub that I treat as a single individual for purposes of minimum count. After correcting for effort the two properties only showed a weak tendency to differ in bear sightings (χ^2=2.78, p=0.1). Combined results from site visits on both properties show we found sign 75% of the time bears were photo-captured and 60% of the time when no bears were photo-captured.

I found that the camera trap model had no significant effect on the number of bears photo-captured per camera trap night (n=17, df=14.3, t=-0.22, p=0.83). However, camera trap model did have a significant effect on the ability to identify individuals. All (100%) of my individual identifications were with photos from the Reconyx® model. Bears damaged two stations (Ct08 and Ct10). We replaced the camera trap at Ct08 with the unit from temporary station Ct02. Photos from station Ct08 confirmed a bear damaged the camera. We were unable to replace the unit at Ct10 and it did not provide photos of the animal that damaged it. The damages to the camera trap were consistent with those at station Ct08 so I recorded one hit for bear presence at this site. Individual stations had 0-4 hits. Ct03 and Ct11 both had 4 hits from bears. Ct04, Ct06, Ct09, Ct12, and C17 photo-captured no bears. Ct06 and Ct09 did not photo-capture any wildlife.

Bear hits occurred only between 0600 and 1700 h. The briefest series was one photo when a bear passed in front of the trap. The longest series was 77 photos, lasting 27.5 min when a bear sat down in front of the camera. The average hit lasted

2 min. Intervals between hits at most stations ranged from 6-73 days apart. Ct03, Ct11, Ct16, and Ct14 each got multiple hits from bears within two, two, three, and four days, respectively. The temperature recorded by the Reconyx® traps during hits ranged from 3°-14°C (37°-52°F).

The most frequent sign found during the surveys were feeding remains, trails, and footprints. Occasionally we also found scat, claw marks, and ground beds. There were no photos of the bears looking directly at or trying to retrieve the lure and no lure cups were damaged or moved. I found no evidence that bears visited camera traps more often early in the month than later in the month, as one might expect if lure freshness were a factor. Paradoxically, I found a weak, reverse effect ($n=25^*$, df=24, Z=60.5, p=0.04). This unexpected result could reflect human presence at the site, delaying bear visits, or could be the result of odor dissipation over time (discussed below).

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[*] Two hits occurred at Ct02, which did not have scent lure. One hit occurred as the result of a bear destroying Ct10. There were no photos recovered so a hit date could not be determined.

TABLE 1.1 Summary of bear hits by camera trap station/property and month.

	Alpaca Ranch									Colepato Community Cooperative										
	Ct01	Ct02	Ct03	Ct04	Ct05	Ct07	Ct10	Ct11	Ct12	Ct06	Ct08	Ct09	Ct13	Ct14	Ct15	Ct16	Ct17	**TOTAL**	Alpaca Ranch	Colepato
August			2											2				**4**	2	2
September		1	1		1	1					1				1			**6**	4	2
October	1	1			1	1	1							1		2		**8**	5	3
November	1		1					2					1		1	1		**7**	4	3
December	1							2										**3**	3	0
Total # of Hits	3	2	4	0	2	2	1	4	0	0	1	0	1	3	2	3	0	**28**	18	10

*The camera traps were removed mid-December 2008.

Individual identification

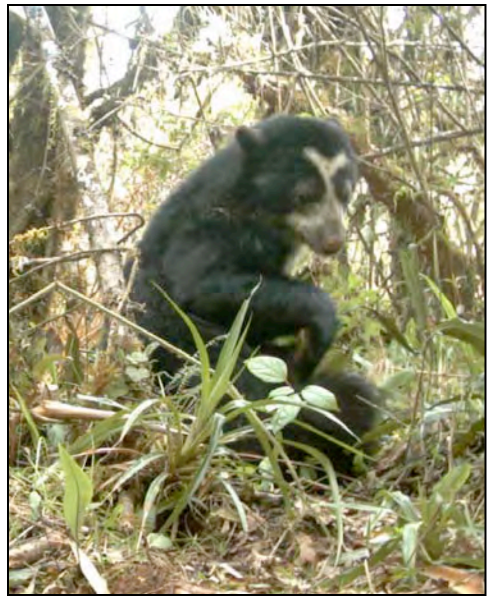
Of the 28 bear hits, 16 (57%) included photos of the bear's face or chest with identifiable features. The remaining 12 hits (43%) included only photos of paws, legs or other body parts that identified the species but not the individual. Only seven (25%) of all hits resulted in individual identification. From these photos I identified five bears (B1-B5) (Figure 1.3). I assigned the cub code B3.1 to indicate it was photographed with bear B3. Of all hits by bears, three independent observers identified the same bears 71% of the time I did (sensitivity) and did not identify a bear 90% of the time I did not identify a bear (specificity). The three observers discriminated the four bears B1-B4 from each other (100%, n=3). B5 was less certain. The photos of B5 show distinct differences between the thickness of the stem (beige fur pattern on the bridge of the muzzle) and that of the most similar bear, B1. The identification of B5 was verified by only two of the three observers (66%).

I re-identified only B1 and B2 at more than one station (Figure 1.4). B1 was re-identified at the same station (Ct11) 29 hours later. B2 was first identified at Ct11, then re-identified 38 days later >2 km away at Ct16.

Bear 1 (B1). Key identification features: (1) symmetrical "Y" between eyes with (2) thick stem and (3) thick branches, (4) black spot in center of "Y", (5) lack of white pattern near ears and (6) around outside of eyes. *Re-identification*: (1), (2), (3), (4), (5), (6).

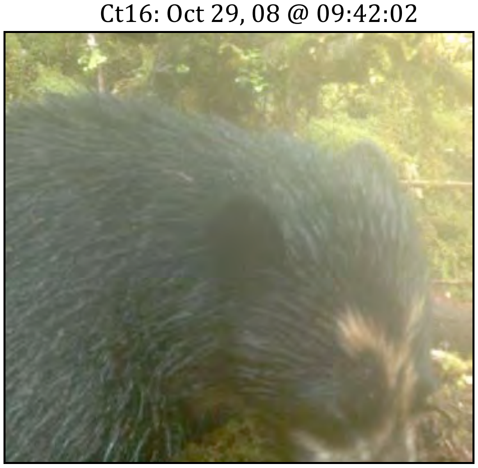
Ct11: Nov 8, 08 @ 8:42:40

Ct11: Nov 9, 08 @ 13:55:42



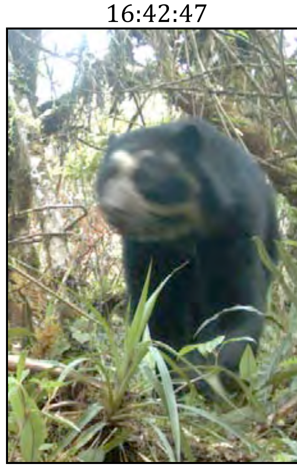
Bear 2 (B2). Key identification features: (1) asymmetrical "Y" between eyes with (2) black notch in stem of "Y", (3) hook on branch of right eye, (4) lack of full circle around right eye, (5) large circle around left eye, (6) break in pattern above left eye. *Re-identification*: (2), (3), (4).

Ct16: Oct 29, 08 @ 09:42:02

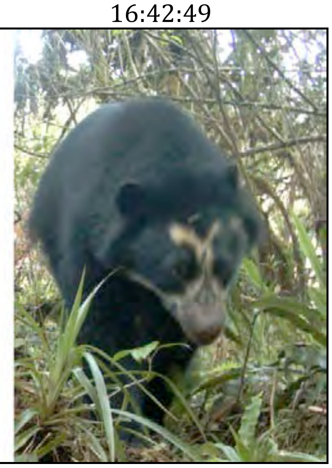


Ct11: December 6, 2008 @

16:42:47



16:42:49



Bear 3 (B3). Key identification features: (1) thin stem between eyes, (2) "Y" lacks branches, (3) no pattern around eyes or (4) in front of the ears. *Not re-identified.*

Ct15: September 15, 2008 @ 16:36:52

Ct15: September 15, 2008 @ 16:37:12*

**B3.1 visible in this photo*

Bear 4 (B4). Key identification features: (1) asymmetrical "Y" between eyes with (2) thin stem, (3) break in pattern above right eye, (4) line pattern below right eye, starting at muzzle (5) freckles on right-side of muzzle. *Not re-identified.*

Ct15: November 27, 2008 @ 09:14:57

Ct15: November 27, 2008 @ 09:14:59

Bear 5 (B5). Key identification features: (1) roughly symmetrical branches of "Y" with (2) a thin stem, (3) black spot on right eye branch of "Y", (4) lack of pattern in front of ears and (5) around eyes, (6) some patterning visible on neck. *Not reidentified.*

Ct14: August 5, 2008 12:07:37

Ct14: August 5, 2008 @ 12:07:41

FIGURE 1.3 Camera trap photos of five individually identified bears and their identification features.

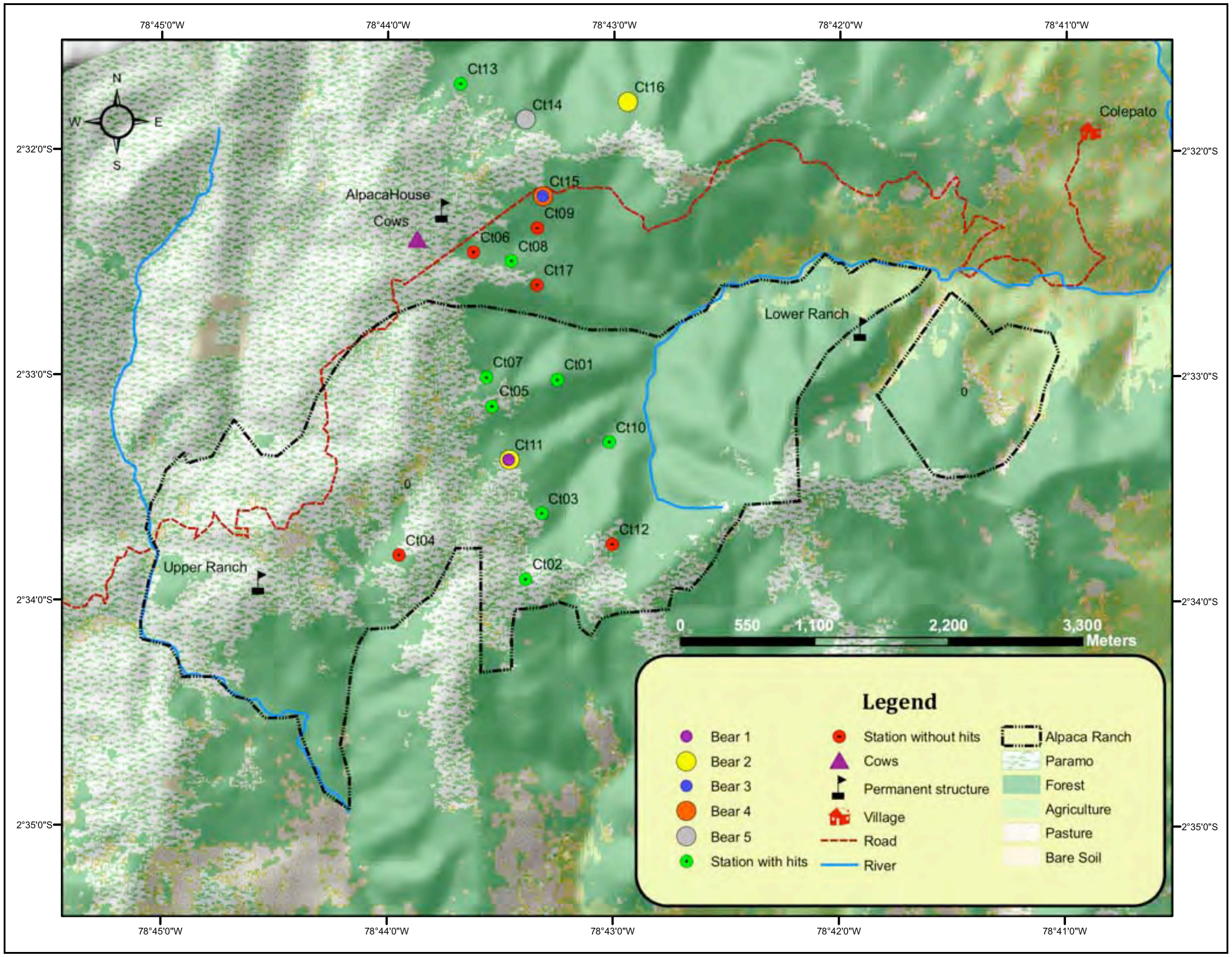


FIGURE 1.4 Camera trap sampling area, hits from all bears, and locations of identified individuals. Camera trap stations north of the alpaca ranch boundary are on Colepato community property. *Credit: Becky Zug & Alvin Rentsch*

Other species

Camera traps also provided photos of other species (Appendix 1.3): six species of birds (Ridgely & Greenfield 2001) and six other species of mammals (Tirira 2007) (Table 1.2). Because the camera traps were set-up to photo-capture bears, smaller mammal and bird species could have been missed. Bears were photo-captured 4.5 times more often than pumas (*Puma concolor*), the second most frequently photo-captured species. Semi-feral horses were also present on the alpaca ranch but either stayed in the páramo or did not travel far enough into the forest to be photo-captured. Ct02 was along a ridge trail and was the only location to photo-capture horses. Bears were photo-captured twice at this site and a puma once.

TABLE 1.2 Summary of all photo-captured wildlife species with their international (IUCN) and Ecuadorian conservation status (excluded for birds).

English Common Name	Spanish Common Name	Scientific Name	Hits	IUCN Status*	Ecuadorian Red List**
Mammals					
Andean bear, Spectacled bear	Oso andino, Oso de anteojos	*Tremarctos ornatus*	28	Vulnerable	Endangered
Mountain lion, Cougar, Puma	Puma	*Puma concolor*	6	Least Concern	Vulnerable
Mountain coati	Coatí andino	*Nasuella olivacea*	5	*Data Deficient*	*Data Deficient*
Margay	Tigrillo	*Leopardus wiedii*	2	Near Threatened	Near Threatened
Little red brocket deer	Venado colorado enano	*Mazama rufina*	4	Vulnerable	Near Threatened
Mountain paca	Guanta Andina	*Cuniculus taczanowskii*	4	Near Threatened	*not listed*
Andean fox, Culpeo	Lobo de páramo	*Pseudalopex culpaeus*	1	Least Concern	*not listed*

[a] Unidentified mammals: small, <1 kg (8), medium-sized, 1-15 kg (2), deer species (2); [b]Semi-feral horses (3);
[c] Other species photo-captured only during pilot study: South American white-tailed deer (*Odocoileus sp.*).
*(IUCN 2009)
**(Tirira 2001)

English Common Name	Spanish Common Name	Scientific Name	Hits	IUCN Status*
Birds				
Andean snipe	Becasina Andina	*Gallinago jamesoni*	5	Least Concern
Undulated antpitta	Gralaria ondulada	*Grallaria squamigera*	4	Least Concern
Tawny-breasted tinamou	Tinamú pechileonado	*Nothocercus julius*	3	Least Concern
Ocellated tapaculo	Tapaculo ocelado	*Acropternis orthonyx*	1	Least Concern
Rufous antpitta	Gralaria rufa	*Grallaria rufula*	1	Least Concern
Tawny antpitta	Gralaria leonada	*Grallaria quitensis*	1	Least Concern

[a] Unidentified bird species (4)
*(IUCN 2009)

DISCUSSION

At least four or five adult bears and a cub were present on the two study properties during this time period. This might have been a short-term concentration of bears or a series of transients. These results provide a starting point for understanding how private lands can play a role in Andean bear conservation. Individual capture histories can help us to determine what types of private lands and management regimes are associated with resident or transient bears, corridors or home ranges. When properties are found to be corridors for dispersing bears, conservation-minded landowners might wish to prioritize protection from hunting and other forms of lethal interaction with people. Properties found to be home ranges for bears might also require stricter habitat protections and long-term, non-lethal protections of livestock and crops. For example, if resident bears are experiencing high human-caused mortality rates on private lands, conservationists will need to provide owners with more support in finding non-lethal alternatives. If transient bears are using private lands as corridors to more suitable habitat, conservation planners will want to ensure that pathways remain unobstructed.

The re-capture of two bears suggests these private properties are meeting their needs at least in the short-term. The photo-capture of the cub confirms that camera traps can provide some data on the reproduction of wild individuals but cannot provide other natural history information such as sex, reproductive rate, or heredity. Information about reproduction and survival on private lands would be important for determining if private lands are supporting the conservation of Andean bears. As such, other research methods warrant consideration (see discussion below).

In addition to individual identification, camera traps collected data on bear ecology. Bear visits occurred only between 0600 and 1700, which corroborates a conclusion about diurnal activity in Andean bears from a radio-telemetry study in Bolivia (Paisley & Garshelis 2006) not nocturnality, as originally thought (Peyton 1999). The extent to which Andean bears change their circadial pattern in response to humans or other threats is unclear at present. We also photo-captured six species of birds and six other species of mammals, including pumas, margay, mountain coati, and Andean fox. Thus these properties appear suitable for multiple species of carnivores. Five of the seven (71%) total species of mammals photo-captured are carnivores with varying habitat and feeding requirements (Tirira 2007). Camera traps provide evidence to support the notion that by conserving Andean bears and their habitat, we might conserve other species of wildlife. On both properties, at every site a bear was photo-captured at least one other species was photo-captured. Further studies on these properties might explore if landowners are having problems with other species of carnivores (this has already been confirmed for pumas and Andean foxes: S. White, unpub. data) and if so, whether conservation plans should incorporate multiple species.

Individual Identification of Andean bears

Individual identification can be used to estimate a minimum number of individuals, develop life histories, estimate population size and distribution, and document some aspects of behavior, all of which leads to more effective management and conservation plans. Although individual identification of Andean bears was not possible from all camera trap photos, the 100% agreement of independent reviewers on four out of five of the bears identified in this study show that this method could be effective. Below I suggest several ways to improve individual identification and possible alternative methods to address problems I was not able to overcome.

Future camera trap studies of this species would benefit greatly from the use of multiple, rapid start-up/trigger camera traps at each location. Almost half of the bear photos (43%) showed only unidentifiable body parts. Multiple traps at one site would be able to capture the opposite side of the bear and should significantly increase the overall identification rate (25% in this study). Because 100% of individual identifications came from Reconyx® camera traps, the use of similar camera trap models (with rapid start-up and trigger times) is highly recommended (see Appendix 1.4 for a comparison of camera trap models). Reliance on the lure to position the bear in front of the camera trap was not a successful method of capturing facial patterning. Different positioning could be tested but the number of camera traps and camera trap model were better predictors of obtaining photos useful for individual identification. I photo-captured bears only after I switched stations from the homemade lure to the commercial lure. This combined with a bear capture rate almost five times higher than the next closest species (pumas) provide strong evidence that the bears were attracted to the commercial lure. The consistent, slightly higher number of photos later in the month may indicate that bears were initially deterred by human scent left at a site or that the odor of the lure dissipated through the forest over time. I conclude that the lure was successful in attracting bears to the camera trap sites but not an effective method of positioning them relative to the camera lens.

The methods I developed to identify individual Andean bears from photos can be used to re-identify bears at this location and be replicated in other locations. However, my matrix method may become tedious when used to compare large amounts of photos. Developing a method that separates composite drawings into smaller subgroups could solve this problem. For example, classifying a composite drawing by presence/absence of markings in key areas of the face (e.g., left eye, right eye) would initially separate photos that are significantly different from each other. A matrix could then be used to compare composite photos within these subgroups.

The independent reviewer process is important to correct for observer bias. The review process should be calibrated to account for varying levels of reviewer experience with identification of individual animals. Prior to looking at camera trap photos independent reviewers could be pre-tested for accuracy on photos of known (captive) individuals. Reviewers who do not score above a set level (e.g., 90%) should be dismissed. In their study on pumas, Kelly et al. (2008) used a rigorous method of comparing reviewer comments to account for reviewer bias across sites in different countries. By developing a tiered level of markings (obvious, less obvious, subtle) and then sorting the identifications by three categories (positive, tentative, and not possible to tell) reviewer responses were accepted or discarded based on percent agreement/disagreement between sites. This method could be combined with the above pre-test on captive bear identification when there are many independent reviewers or when data are combined from multiple locations.

The presence of the cub raises an interesting question if individual identification is to be used in Andean bear research: Do the facial patterns of Andean bears change over time? Historically, biologists thought patterning changed as the animal aged and was linked to gender, heredity and geographic origin (Roth 1964). However, Roth (1964) disputed these earlier claims based on his observations of captive populations, stating that patterning remained consistent from birth, except for slight fading with age. He also concluded that variations are not connected to gender or heredity. He proposed patterns could be linked to geographic origin but without more information on where the captive bears originated he could not be conclusive about this claim. My own informal inquiry into this topic has been inconclusive. There is some indication from captive populations that Andean bears may get more gray or white hair around the eyes and muzzle as they age (S. Silver, Bronx Zoo, pers. comm.). Lack of facial patterning on bears in the Intag region of northern Ecuador (A. Castellanos, pers. comm.) indicates that there could be some local factors (e.g., genetic relationships) that account for patterning. However, there has been little if any recent research that focuses specifically on this topic. Without more information about if and how facial patterns change and whether genetics plays a role in patterning, it is hard to know if identification of bears as cubs will be helpful in identifying them as adults.

Recommendations and alternative methods

Researchers may want to consider combining camera traps with other research methods. Although I was successful in identifying individual bears, I was only able to identify bears in 25% of all visits and I was not able to obtain data on movements between camera trap stations, relatedness, sex, or connectivity to other bear populations. Camera traps can be expensive to purchase and repair, time consuming to set-up and check, and may not be the best method to collect all types of data. For example, I was unable to survey the páramo due to false triggers and difficulty in determining where bears would travel in this open terrain. Páramo use is an understudied aspect of Andean bear ecology and camera traps may not be a suitable approach to address this question. Genetic analysis from hair or scat samples would potentially be a more effective method of collecting individual identification data from this type of habitat. Genetic analysis can also provide data on relative abundance, paternity/relatedness, sex, population genetics, and species identification (Schwartz & Monfort 2008). Hair snares have been effective in collecting hair samples from other species of bears (Kendall et al. 2009; Robinson et al. 2009; Schwartz & Monfort 2008). High individual identification success rates and information about heredity and population connectedness might make this a more appealing research method.

Both genetic and dietary information can be collected from scat samples (Farrell et al. 2000). Scat in both the páramo and the cloud forest can be extremely difficult to find because it degrades quickly in the frequent rain. Scat detection dogs could be used to overcome this obstacle (MacKay et al. 2008) and may in fact be more effective at detecting wildlife than camera traps or hair snares (Long et al. 2009). Scat detection dogs can be expensive, require an additional set of logistic considerations, and may exceed the costs of a camera trap study. However, high detection probability and success rate could compensate for extra costs and time/effort expended.

Global Positioning System (GPS) collars could be used to address questions about home range, time budgets, and more specifically, how bears are using the páramo and their movements near human settlements. GPS collars have been used successfully to study other species of bears (Waller & Servheen 2005; Yamazaki et al. 2009) but can be expensive, time consuming, and lost or broken collars can result in partial or total loss of data. GPS collars are an invasive research tool that can cause stress to both the animal and the researcher. While the above methods lack some of the benefits for landowners that camera traps provide (e.g., photos of the wildlife on their property) limited funding and resources require researchers to apply those methods most appropriate to their species, location and the questions they hope to answer.

Although I did not ask local landowners to help with identification, they may have also been able to contribute to the process. Andean bears in this area are rarely close enough to identify an individual positively but facial patterns may differ significantly enough to separate some individuals from others at a distance. This would also be an excellent way to involve local people in the project and use local knowledge to contribute to data collected from camera traps. Involving the Colepato community from the beginning of this study (through community meetings and the hiring of a Colepatan field assistant) contributed significantly to the success of this project. I strongly recommend that researchers working on private lands continue to work directly with the local landowners and ensure that the results are presented to the community at the conclusion of the study.

Camera trap photos and community involvement

In May 2009, I traveled back to Colepato to present my results at the weekly community cooperative meeting. This study was one of several on their property in 2008 and the community was frustrated because they had not been informed of the results from any of the studies. They felt negatively toward allowing any additional projects on their land, feeling they did not benefit from them (S. White, pers.

comm.). I used an LCD projector to show them every picture of wildlife on their property. These photos sparked conversation between community members and many questions confirming the locations of photo-captured wildlife. They recognized most species and used local names to identify each one (e.g., puma = gran bestia). One comment indicated that it was not uncommon to find pumas in areas with bamboo, although they did not indicate a reason for this. They claimed there were many more than three bears on their land (at the time B5, the fourth bear identified on their land, had not yet been confirmed). A population estimate may more closely match the community's notion of the number of bears on their property and could, in turn, inspire more confidence in the accuracy of the data produced by biologists. Overall, the community was very excited about the photos of the wildlife and about the wildlife in general. They showed a large amount of local knowledge of the species and where they are located on their property. Despite their openly expressed doubts about the usefulness of research, they responded positively. Indeed a week later the community allowed my colleague (T. Jones) to begin a follow-up study of bears on their land. This response supports the notion that camera trap photos can help gain the interest of local communities and by allowing them to become familiar with individual bears, photos can promote stewardship for their conservation (Jackson et al. 2005).

Despite historical conflicts, Andean bears are culturally significant to the Colepato community and are celebrated in local stories. Attitudes toward a particular species can be shaped by its cultural significance, potential usefulness, or its potentially destructive behavior. Protecting wildlife outside of park boundaries requires incorporating local perspectives if conservation planning is to be successful (Naughton-Treves & Salafsky 2003). When asked in an informal survey, most people stated that they want the bears to remain on their land (Achig & Santillán 2009). In addition to several research and education projects conducted by FCT, Colepato is currently involved in a Payment for the Protection of Ecosystem Services (PPES) project with Ecuador's largest producer of hydro-electric power, CELEC-Hidropaute. Through this program Colepato will be rewarded for conserving wildlife, bears in particular, on their land. Positive experiences with wildlife (e.g., photos) can also make communities feel ownership over the wildlife on their land, which can result in increased protection and higher tolerance for wildlife. My study provided the initial data for this PPES program. Re-identification of the same bears in an ongoing study (T. Jones 2009) would provide evidence that wildlife is being protected.

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Appendix 1.1 Example of composite drawing of bear (right) compiled from camera trap photos (left).

Appendix 1.2 Matrix used to compare photo-captured bears.

Reviewer Name:	**Date:**

As you review the bear photos please answer the following question for each folder as compared to every other folder: Are these photos of the same bear? <u>Answer choices</u>: **y** = (yes) positively the same bears; **m** = (maybe) could be the same bear (not definitely different bears); **n** = (no) definitely different bears. If the photos have no identifiable characteristics, highlight that row and column in blue. **As you fill in the worksheet bold the number of the folder in the column on the left where you have identified a new bear. Give each new bear a unique symbol (i.e. 14$). Repeat this symbol every time you identify that same bear in a new folder.** This will help when we tally how many bears you have indivdiually identified.

Folder	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21.1	21.2	22	23	24	25	26	27
1	y																											
2		y																										
3			y																									
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26																											y	
27																												y

** Folder #21 has a photo of a mother and cub. Use column 21.1 for the mother 21.2 for the cub.*

APPENDIX 1.3 Other species of wildlife photo-captured by camera traps.

(clockwise from top left): margay (*Leopardus wiedii*) Ct03, July 31 @ 4:14 AM; puma (*Puma concolor*) Ct16, September 12 @ 19:38 PM; Andean fox (*Pseudalopex culpaeus*) Ct04, December 1 @ 8:52 AM; mountain paca (*Cuniculus taczanowskii*) Ct17, July 31 @ 21:31 PM; mountain coati (*Nasuella olivacea)* Ct15, July 24 @ 4:15 AM; little red brocket deer (*Mazama rufina*) Ct05, August, 18 @ 16:34 PM.

APPENDIX 1.4 Comparison of camera trap models used in this study.

	Reconyx® PC85	CamTrakker® Digital Ranger
Advantages	• 1/5 second start-up time • Able to change batteries and memory card while trap is still mounted on tree • Digital screen displays status of memory card and batteries • Batteries can last for several months • Flexible settings • Imprints time, date, temperature and preprogrammed title on photos • Very easy to use	• Display screen for on-site viewing of photos • Photos are clearly focused and in color • Straight forward and easy to use
Disadvantages	• Black and white night photos • Photos are slightly blurry if animal is moving quickly • Difficult to fix malfunctions on-site	• Slow start-up time (3-5 seconds) • Long delay between triggers (≥ 20 seconds) • Limited flexibility with trigger and delay settings • Requires extra sealant in wet conditions, application and removal is time intensive • Must be removed from tree to change batteries and check memory card • Camera and housing contain multiple pieces that must be removed and kept track of during site checks

CHAPTER 2: PRIVATE LAND FEATURES ASSOCIATED WITH ANDEAN BEAR PRESENCE

ABSTRACT

Global carnivore populations are in decline, with the Andean bear (*Tremarctos ornatus*) among them. Private lands may play a key role in connecting protected areas and providing suitable habitat. To determine if Andean bears are finding safety and resources on private lands, I deployed 17 camera trap stations for 2,472 trap nights on two privately owned properties under different land management regimes in Cañar province, Ecuador. During the 4.5-month study I photo-captured bears on 28 occasions and detected fresh bear sign during 35 of 61 (57%) camera trap site visits. Neither indicated the bears had a preference for either property. I collected microsite data and mapped landcover and human use on these properties. I used Akaike's information criterion for small sample sizes to identify the strongest predictors of four variables: frequency of photo-captured bears, frequency of bear sign, frequency of photo-captured non-bear species, frequency of all species photo-captured. The distance between a camera trap station and the narrow, unpaved road was a strong, positive predictor of frequency of photo-captured bears. The distance between a camera trap station and the alpaca ranch was a strong, negative predictor of frequency of bear sign detected during site visits and the most significant predictor for this response variable. Presence of bamboo was also a significant correlate of bear sign but needs more rigorous investigation. The presence of bears was a significant predictor of the presence of

other species, suggesting that by protecting Andean bears we help to conserve other Andean wildlife.

RESUMEN

Las poblaciones de carnívoros están cayendo mundialmente, entre ellas las del oso andino (*Tremarctos ornatos*). La propiedad privada puede tener una función importante al conectar zonas protegidas y proveer a los osos de un hábitat adecuado. Para determinar si los osos encuentran seguridad y recursos en tierras privadas, utilicé 17 trampas-cámara durante 2.472 noches-cámara en dos propiedades privadas con diferentes sistemas de manejo de tierra en la Provincia de Cañar, Ecuador. Foto-documenté osos en 28 ocasiones y encontré señal fresca de oso en 35 de las 61 (57%) visitas a los sitios de estudio en 4.5 meses. Ni la señal ni la foto-documentación indicaron preferencia de una propiedad sobre la otra. Recogí datos de micro-sitio e identifiqué en un mapa el suelo cubierto contra el de uso humano. Utilicé el criterio de información de Akaike (AIC_c) para determinar las funciones con mayor poder de predicción para cuatro variables: frecuencia de osos foto-documentados, frecuencia de señal, frecuencia de otras especies foto-documentadas, y frecuencia total de especies foto-documentadas. La distancia entre la trampa-cámara y un camino resultó ser un buen método de predicción de la frecuencia de osos foto-documentados. La distancia entre cámaras y la hacienda de alpacas fue un predictor fuerte y negativo de la frecuencia de señal encontrada. La presencia de bambú (*Chusquea*) también muestra una relación fuerte con señal pero requiere de mayor corroboración. La presencia de osos es un vaticinador

importante de la presencia de otras especies, lo cual sugiere que al proteger al oso andino podemos ayudar a conservar a mas vida silvestre andina.

INTRODUCTION

Conservation on private lands may be important when wildlife is far-ranging or protected areas are too small to contain viable populations. Both conditions arise for many large carnivores. Conflicts between large carnivores and landowners can result in lethal retaliation (Kissui 2008; Michalski 2006; Woodroffe 2001), posing an added threat around protected areas. To determine whether private lands are serving a useful conservation purpose we need to understand if large carnivores are finding safety and resources on those lands. This requires fine-grained data on land features associated with large carnivore presence or absence.

Retaliatory killing due to livestock predation and crop raiding is one of the greatest threats to the survival of Andean bears, an IUCN-listed vulnerable species (Goldstein et al. 2008). Human tolerance for Andean bear presence on private lands may be critical to connect protected areas and ensure the long-term survival of the species. First steps in conserving Andean bears include understanding how they are using private lands and determining if different land management regimes impact bear presence.

Andean bears use a wide variety of habitats from cloud forest to páramo (high altitude grasslands) (Peyton 1985), but populations in the northern Andes are being fragmented and isolated by landscape transformation (Kattan et al. 2004). In Ecuador, threats to Andean bears are increasing as human populations continue to settle on the Andean slopes and convert cloud forest to agricultural land. This not only destroys bear habitat but also blocks wide-ranging, seasonal movements associated with food availability (Cuesta et al. 2003). Although 15 protected areas in

Ecuador contain bears, habitat loss in and around these areas threatens to isolate bear populations further (Suarez 1999). Private lands with suitable bear habitat and owners who are tolerant of bear presence could play a critical role in connecting protected areas and conserving viable populations. In addition, Andean bears can act as a focal species for conservation due to large spatial requirements and use of diverse habitats (Rodríguez et al. 2003). By protecting Andean bears, other wildlife and habitats might also be protected. For example, the páramo ecosystem is unique to the northern Andes, with extremely high levels of plant diversity and endemism. The páramo region is a major source of drinking water for many large cities in the Andes and supplies water to lower elevations (Balslev & Luteyn 1992). This ecosystem is fragile, slow to recover from disturbances, and increasingly under pressure from humans (Luteyn 1992). Although the full extent to which Andean bears use the páramo is not fully understood, it is evident that this habitat plays a role in their ecology and thus their conservation (Cuesta et al. 2003; Peyton 1980; Troya 2004).

In Ecuador, owners of large, montane properties commonly practice agriculture at lower elevations, leaving the páramo largely un- or under-used (pers. obs.). Suitable habitat for Andean bears is associated with large tracts of páramo and large tracts of cloud forest, therefore maintaining connectivity between these habitats could be an important conservation strategy (Cuesta et al. 2003; Peralvo et al. 2005). Private lands might help fill this need when large tracts occur between protected areas. However, Andean bears have been known to raid crops and attack and kill cattle (Flores et al. 2005; Galasso 2002; Goldstein et al. 2006).

Despite its “endangered” status in Ecuador, Andean bears, like some other bear species (Fredriksson 2005; Normua et al. 2004; Oi 2009; Treves et al. 2009) may be considered a nuisance on private lands. Lethal retaliation for crop raiding and livestock attacks is one of the primary threats to the survival of Andean bear populations. In general, large carnivores are unlikely to persist on private lands unless hunting is controlled (Naughton-Treves & Salafsky 2003). Private lands could act as mortality sinks when wildlife crosses protected area borders (Kauffman et al. 2007; Michalski 2006; Naughton-Treves & Salafsky 2003). Communities who only have negative experiences with wildlife are unlikely to be interested in their conservation (Naughton-Treves & Treves 2005). Conserving Andean bears on private lands will depend on mitigating these conflicts. A better understanding of how Andean bears are using private lands will help to prioritize management strategies for bear conservation.

Here I examine evidence for microsite use and attraction to and avoidance of landscape features to determine the role of private properties in conservation planning. To accomplish this I use a camera trap study and microsite analysis to understand Andean bear microsite use on two privately owned properties under different land management regimes. Andean bear presence has been reported anecdotally for both properties but systematic information about microsite use in this area is lacking.

STUDY AREA

The study was conducted in Cañar Province on the eastern cordillera (mountain range) of Ecuador. The study area (2°33'S, 78°43'W) has steep and rugged topography with elevations from 2900 to 3680 m. Landcover consists of a combination of *subpáramo* (a mosaic of small trees, shrubs, and shrubby grasslands) and *grass páramo*, (Luteyn 1992), montane evergreen and cloud forests, livestock pastures, and agricultural land. A 3000 m circular buffer from the center of the study area showed five landcover classes: forest (48.9%), páramo (47.8%), agricultural fields (2%), pastures (0.8%), and bare soil (0.5%). Annual precipitation is between 2500 and 3000 mm and the mean monthly temperature is between 8°C and 20°C (46-68°F)(Jokisch 2002).

During July-August 2008, I surveyed approximately 8 km^2 of bear habitat on two contiguous private properties inside the Sangay National Park (SNP) in southern Ecuador (Figure 2.1). In 1992, SNP boundaries were extended over private lands and the park boundary now runs through the center of both properties. I conducted the study to the west of this boundary, within the confines of the park. Both properties are privately managed despite being within the park. Indeed, the official announcement of the park expansion allowed individuals and communities to maintain their land rights within the southern extension (Government of Ecuador 1996 in Himley 2009). Government officials did not visit these properties to asses the new park boundary until several years after the new designation (Himley 2009).

The northern half of the study area overlaps the approximately 5000 ha property (Himley 2009) owned and occupied by the 32 members (individuals and families) of the Colepato Community Cooperative (Colepato). Prior to the first agrarian reform law passed in Ecuador in 1964, this land was a state-owned hacienda that rented subsistence farming plots to indigenous farmers. In 1971, residents assumed leadership of the cooperative (administrative, internal governance, and parcels of land were appointed to households) but full ownership of the property was not granted to the cooperative until 1982 (Himley 2009). At the time of the study, 30 non-members (individuals and familiers) also lived on the property but were not considered joint owners and did not have decision-making power. In total, it is estimated that approximately 62 families (~400 people) live on the 5000 ha Colepato land (C. Schloegel, pers. comm.).

The southern half of the study area overlaps an approximately 1400 ha alpaca ranch. The alpacas at this site are raised for wool. On average this property has 650 alpacas that are raised on a total of 438 ha. The operation is split into three locations with approximately 550 (85%) productive, young alpacas on 88 ha at the two lower sites (combined and referred to as La Libertad for the purpose of this chapter) and approximately 100 (15%) castrated males on 350 ha at the higher site in the páramo (referred to as Rumi Loma). In 1985, the landowner brought 60 alpacas to this property from Chile.[1] The goal was to reintroduce this native camelid species as an alternative to introduced livestock (e.g., cattle, sheep) in order to preserve grass cover and reduce soil loss in the watershed. Alpacas are better adapted to living at this altitude and digesting native plant species, resulting in reduced foraging pressure and less damage to native grass species than introduced

[1] In 1980 there were only 200 alpacas (many mixed with llamas) in Ecuador (Paucar 1987 in White & Maldonado 1991).

livestock (White & Maldonado 1991). The alpacas on this property are grazed in open pastures during the day and corraled at night to protect them from predators, Andean fox (*Pseudalopex culpaeus*) and puma (*Puma concolor*) (White & Maldonado 1991). The alpacas at La Libertad are put into a night corral with high fencing designed specifically for protection from pumas. At the time of this study the alpaca ranch had two permanently and two occasionally occupied residences (<3 families total on 1400 ha). At La Libertad, the owner and his four family members occasionally stay in a house on the property and a full-time ranch manager and his family live on-site. At least 1-2 people live at Rumi Loma and manage the alpacas at this site. There is also a camp (four grass-walled structures) located near Rumi Loma that is used seasonally by researchers and students.

FIGURE 2.1 View of the study area from the páramo. Colepato land is to the north (left) side of the valley with cleared pasture visible in the background. The alpaca ranch is to the south (right) side of the valley. Páramo bunch grass can be seen in the foreground.

METHODS

Camera Trap Study

I adapted camera trapping methods and data collection sheets from those used to study similarly cryptic large carnivores around the world (Henschel & Ray 2003; Jackson et al. 2005; Karanth 1995; Rios-Uzeda et al. 2007). I used two models of passive infrared (PIR) motion-detection, digital camera traps for this study: Reconyx® PC85 (RECONYX, Inc., Holmen, WI) and CamTrakker® Digital Ranger (CamTrakker, Watkinsville, GA). I found no difference in frequency of bear photo-captures by camera trap model (n=17, df=14.3, t=-0.22. p=0.83). A full description of survey methods and equipment is available elsewhere (Chapter 1).

In July-August 2008, I systematically placed 16 camera traps within an 8 km^2 sampling grid. I divided the grid into eight 1 km^2 cells that were further quartered into 0.25 km^2 sub-cells. With the help of a field assistant from Colepato (Don Jose Ojeda, J.O.) I set-up two camera trap stations within each grid cell, each occupying a randomly selected, separate sub-cell. I based the sampling area size on estimates of Andean bear home ranges from Paisley (2001) and Castellanos (2004). My placement of camera traps was also limited by topography and forest density. Due to the inherent danger of traversing steep slopes, I set up no camera traps in such terrain.

I selected camera trap locations within grid cells based on evidence of bear activity and/or along a wildlife trail (Goldstein et al. 2008a; Goldstein & Marquez 2004; Henschel & Ray 2003). Each station consisted of one camera trap secured to a tree along with a scent lure (Ultimate Bear Lure ®, Wildlife Research Center, Inc., Ramsey, MN) suspended from a tree in front of the trap. This was to increase the probability of photo-capturing a bear that was present at the camera trap site. A Wilcoxon Sign-Rank matched pairs test to determine if lure freshness, time since lure was put out, correlated with photo-captured bears revealed no evidence that bears visited stations more often when the lure was fresh (n=25*, df=24, Z=60.5, p=0.04). This indicates that bears were not drawn to a trap site only to investigate the lure.

I set each station within a representative sample of habitat in this area, excluding páramo because environmental factors frequently caused false triggers during the pilot study (see Chapter 1). A 17th camera trap was set up without scent lure in a small forest patch along a well-used and easily accessible ridge trail outside of the sampling grid. I took UTM points and elevation measurements at each station. I surveyed camera trap locations for microsite features (Table 2.1) and recorded set-up details (e.g., camera trap height, model). J.O. and I surveyed and cleared the area of bear sign (feeding remains, scat, claw marks, etc.) (Tirira 2007; Torres 2006). It can be difficult to determine the "freshness" of bear sign so clearing the area allowed us to detect new sign on subsequent visits. In August, I hired and trained an additional field assistant, Vinicio Santillán (V.S), to check the camera trap stations every four weeks until mid-December 2008. During each site visit we changed the memory card, batteries and desiccant packet, refreshed the lure and walked a transect to record new bear sign. Transects were 10 m long, starting north

*Two hits occurred at Ct02, which did not have scent lure. One hit occurred as the result of a bear destroying Ct10. There were no photos recovered so a hit date was could not be determined.

and alternating directions (north, south, east, west) at each subsequent visit. These transects were originally designed to estimate detection probability in an occupancy framework but later I decided not to use this method of analysis.

TABLE 2.1 Microsite features collected at each camera trap station

Category	Feature
Reason for site selection	trail intersection, bear sign
Wildlife trail visibility	high, low
Topographic features	ridgeline, valley floor, stream bed, hill-slope
Slope	severe, moderate
Vegetation category	páramo, ecotone, forest
Major vegetation type	pine forest, primary forest, secondary forest, grass páramo, scrub páramo, bamboo, puya field, nacran (*Poaceae sp.*)
Surrounding vegetation type	see above
Frequency of human presence at camera trap station	daily, once/week, multiple/week, once/month, rarely, never
Human use of area	rangeland, farm, road, well-defined trail, research site, no human use

Each visit by a bear to a camera-trap station (Ct#) lasted from <1 to 27.5 minutes and resulted in 1-77 photos of that bear. Each visit is referred to as a "hit." I cataloged each photo by camera trap site, date, and time. I analyzed photos of other species in the same way. Bears damaged Ct08 and Ct10. We replaced the camera trap at Ct08 with the unit from temporary station Ct02. We were unable to replace the unit at Ct10. Line transects and the camera trap photos at each station were used for analysis, i.e., separate stations are the replicates for my study. For each station I recorded the presence/absence of bear sign per visit and the number of independent bear photos per camera trap-day.[2] I used these two measurements as my response variables.

Spatial Analysis

I used ArcView 9.3 ® (ESRI, Redlands, CA) to plot camera trap locations on a map and to extract slope, elevation (masl), and aspect from a 30 x 30 m digital elevation model (DEM) (Souris 2009) (Table 2.2). I used ASTER images (February 23, 2007) of landcover, land use, roads, and population centers (Fundación Cordillera Tropical/The Nature Conservancy/HidroPaute S.A. 2007; Fundación Cordillera Tropical 2008; UDA - CG Paute 2009) to measure distances from camera trap stations to major landscape features and areas of human influence. Including elevation in the distance measures often doubled those measured planimetrically, attesting to the dramatic topography of the area. To test the significance of mixed landcover, I measured percentage of landcover from the ASTER images in 100 m circular buffers around each camera trap station. This showed only two landcover classes: "páramo" and "forest." Variations within these landcover classes were impossible to distinguish using the ASTER images. All camera trap stations were in the forest but some were close to the edge, where the landcover changed from forest to páramo. "Forest" was a broad grouping that included primary and secondary forests and pine plantations. "Páramo" included both grassy and scrub páramo.

[2] Independent is defined as at least 12 hours between visits to a particular station. All bear hits were independent.

TABLE 2.2 Landscape features and predictors used in microsite modeling.

Category	Descriptive feature
Distances to:	forest edge, closest camera trap station, closest town, closest road (Colepato to Quesaries), closest river point, Colepato pasture with cows present, Colepato alpaca house, Alpaca ranch (La Libertad), Alpaca ranch (Rumi Loma), research camp, closest camera trap station
% landcover:	forest, páramo

Statistical Analysis

Response and predictor variables were chosen after a review of Andean bear literature and from field observations (Cuesta et al. 2003). The presence of Andean bears at camera trap stations was my response variable indicating microsite use. Presence was indicated by both photo-captures of bears (hits) and new bear sign (scat, footprints, feeding remains, etc.) found during the transects. I divided each response variable by total number of trap nights or total site visits, as appropriate, to account for variation in the sampling effort and time intervals. In total I evaluated four response variables: BEAR HITS (bear hits/camera trap nights), BEAR SIGN (bear sign/number of site visits), NON-BEAR SPECIES (non-bear species/camera trap nights), and TOTAL WILDLIFE (total wildlife hits/camera trap nights). I used 30 predictors (including primary and secondary forests, distances to significant landscape features, etc.) (Appendix 2.1) from each camera trap station for univariate testing hence I set the final criterion for significance at $p<0.025$. I analyzed the data with JMP 8 ® (SAS Corp., Cary, NC). I tested all variables for normal distribution with a Z test. I used a Pearson's correlation matrix to detect collinearity between continuous predictor variables (Appendix 2.2). I discarded variables that exhibited high collinearity ($r>0.7$). With the remaining predictors, I ran univariate tests to identify associations between predictors and response variables. I used a Spearman's ρ test to filter out the continuous predictors and a median test with normal approximation to filter out categorical predictors, both with a criterion of $p \leq 0.20$. I used this value to avoid making Type II errors and ensuring I had sufficient predictors to make later multivariate evaluations informative. I used non-parametric median test or the t-test assuming unequal variance for the only response variable (TOTAL WILDLIFE) that was not normally distributed.

With the predictors that survived univariate tests (Table 2.3), I used generalized linear models (GLM) for multivariate analysis of each response variable separately. I included 2nd degree interaction terms in the four GLMs. To determine which models were best, I used the negative log likelihood to calculate the Akaike Information Criterion for small samples (AIC_c). AIC_c allowed me to select the most appropriate model for the data without keeping more predictors than was necessary (Burnham & Anderson 1998). Stepwise, I removed the weakest predictors one by one and recalculated the negative log likelihoods until all predictors were removed. I retained models with $\Delta AIC_c < 2$ where ΔAIC_c is the difference between each model and the best model (Mazerolle 2006). If there were two or more models that met this criterion, I calculated a consensus model using the weighted averages of each one. This model-averaging step can reduce bias and increase precision (Burnham & Anderson 2002). Finally I fitted the model-averaged coefficients from the consensus model in a last GLM to report degrees of freedom (df), chi-squared, and p-values.

TABLE 2.3 Descriptions of significant predictors found in the univarite tests.

Predictor Name	Description
ASPECT	Direction of slope (extracted from ArcView)
BAMBOO	Unusually dense amounts at this camera trap site (as compared to other sites)
BAMBOO(V)	Unusually dense amounts near-by but not directly at the station (as compared to other sites)
COWS	Distance from camera trap station to Colepato cows pasture in the páramo
CT HEIGHT	Height of the camera trap measured from the bottom of the camera trap to the ground.
FOREST EDGE	Distance from camera trap station to the forest edge
GRASSY PÁRAMO(V)	Unusually dense amounts near-by but not directly at the station (as compared to other sites)
INTERSECTION	Several wildlife trails cross at this site
LA LIBERTAD	Distance from the camera trap to the lower alpaca ranch where the majority alpaca are raised
NACRAN	(*Poaceae sp.*) Unusually dense amounts at this camera trap site (as compared to other sites)
% FOREST	% landcover in 100 meter buffer zone surrounding the camera trap (extracted from ASTER images in ArcView)
ROAD	Distance from the camera trap station to a one-lane dirt road that runs across both properties
SECONDARY FOREST	Type of forest at the camera trap station
SIGN AT SET-UP	Bear sign present when the station was set-up
SLOPE	Degree of slope (extracted from ArcView)

RESULTS

Camera Trap Study

I deployed 17 camera traps for a total of 2,472 trap nights. The cameras recorded 28 hits from bears. The frequency of photo-captures of bear did not show a significant preference for either property (n=17, df=1, χ^2=2.8, p=0.096). The alpaca ranch had an extra station (Ct02 for 60 days) that received two hits from bears. Fresh sign found during site visits was fairly evenly distributed between the two properties (n=16, df=1, χ^2=0.14, p=0.71).

Through variation in facial patterning I was able to identify five individual bears, one photographed with a cub (Chapter 1). I also identified six other species of mammals (Tirira 2007) and six species of birds (Ridgely & Greenfield 2001) photo-captured by the camera traps (Chapter 1, Table 1.2).

Spatial Analysis

BEAR HITS were predicted by BAMBOO (n=17, Z=1.97, p=0.05), ROAD (Spearman ρ=0.4, p=0.11), ASPECT (Spearman ρ=-0.35, p=0.16), COWS (Spearman ρ=0.35, p=0.16), and SLOPE (Spearman ρ=-0.34, p=0.19) (see Table 2.3 for univariate definitions). ROAD and COWS were highly correlated because the cow pasture lay along the road (ρ=0.81, p=0.0001). Because the presence of the road was more statistically significant and is a permanent feature of this site, I removed COWS as a predictor to avoid collinearity. In the multivariate analysis, three models best predicted BEAR HITS. The best models contained one or more of the predictors: SLOPE, ROAD, and SLOPE x ROAD (Table 2.4). The summed AIC_c weight for these models was 64%. BEAR HITS was significantly predicted by the consensus model (n=17, df=13, χ^2=131.49, p<0.0001). BEAR HITS was also highly correlated to both TOTAL WILDLIFE (Spearman ρ = 0.7, p =0.002) and NON-BEAR SPECIES at each station (Spearman ρ=0.6, p=0.01).

BEAR SIGN was predicted by BAMBOO (n=16, Z=1.86, p=0.06), % FOREST (Spearman ρ=0.42, p=0.10), and LA LIBERTAD (Spearman ρ=-0.41, p=0.12). Percent forest and páramo were perfectly collinear because the 100 m buffers around the camera trap stations showed only these two landcover classes. Because the role of forests in Andean bear ecology is better understood than the role of páramo, I used % FOREST as the predictor and did not include % PÁRAMO in the multivariate tests. The two best models contained LA LIBERTAD and one also included BAMBOO. The summed AIC_c weight for these models was 76%. BEAR SIGN was significantly predicted by the consensus model (df=13, χ^2=5.45, p=0.02).

TOTAL WILDLIFE was predicted by CT HEIGHT (n=17, ρ=0.47, p=0.06), INTERSECTION (Z=1.76, p=0.08), FOREST EDGE (ρ=-0.45, p=0.08), NACRAN (Z=1.74, p=0.08), GRASSY PÁRAMO(V) (Z=-1.64, p=0.10), SECONDARY FOREST (Z=1.39, p=0.16), and SLOPE (Spearman ρ=-0.35, p=0.17). CT HEIGHT reflects methods rather than microsite use. Camera traps placed higher on trees were typically aimed more toward the forest floor, allowing for more photos of smaller animals. I eliminated this predictor from the multivariate tests but used the residuals of TOTAL WILDLIFE regressed on CT HEIGHT to eliminate any effect it might have had on the model. The two best models contained the predictor GRASSY PÁRAMO(V) and one also included SLOPE. The summed AIC_c weight for these models was 85%. However, TOTAL WILDLIFE was not significantly predicted by the consensus model (df=14, χ^2=3.95, p=0.05).

NON-BEAR SPECIES: The only predictor for NON-BEAR SPECIES was BAMBOO(V) and it was not significant (df=1, χ^2=3.32, p=0.07).

Table 2.4 Akaike's Information Criterion for small sample sizes (AIC_c) and consensus models for three response variables: BEAR HITS, BEAR SIGN, and TOTAL WILDLIFE.

BEAR HITS

Number of Predictors	Negative Log Likelihood	K	n	AIC_c	Variable Removed	Δ AIC	AIC weight	%	Sum Δ AIC	Total %	Weighted %	SLOPE	ROAD	SLOPE x ROAD	Intercept
6	-60.70	7	17	-94.95	none	14.22	0.00082	0.000367	2.23	0.64	0.30	-0.00050	0.000005	-0.0000006	0.015
5	-60.70	6	17	-100.99	ASPECT	8.17	0.01681	0.007534			0.70	0.00000	0.000005	-0.0000008	0.005
4	-60.56	5	17	-105.67	ASPECT x ROAD	3.49	0.17444	0.078188				0.00000	0.000000	-0.0000007	0.008
3	-59.41	4	17	-107.49	ASPECT x SLOPE	1.67	0.43362	0.194363							
2	-58.51	3	17	-109.16	SLOPE	0.00	1.00000	0.448235							
1	-55.91	2	17	-106.97	ROAD	2.20	0.33337	0.149429							
0	-54.41	1	17	-106.56	SLOPE X ROAD	2.60	0.27192	0.878117							

BEAR SIGN

Number of Predictors	Negative Log Likelihood	K	n	AIC_c	Variable Removed	Δ AIC	AIC weight	%	Sum Δ AIC	Total %	Weighted %	LA LIBERTAD	BAMBOO	Intercept
6	-9.25	7	16	9.50	none	17.78	0.00014	0.000073	1.89	0.76	0.30	-0.00013	-0.06500	1.04
5	-9.24	6	16	2.85	% FOREST	11.13	0.00383	0.002025			0.70	-0.00154	0.00000	1.12
4	-9.00	5	16	-2.00	BAMBOO X LA LIBERTAD	6.28	0.04335	0.022927				-0.00111	-0.01976	1.10
3	-8.47	4	16	-5.30	BAMBOO x % FOREST	2.97	0.22613	0.119595						
2	-7.31	3	16	-6.62	% FOREST x LA LIBERTAD	1.66	0.43672	0.230972						
1	-6.60	2	16	-8.28	BAMBOO	0.00	1.00000	0.528878						
0	-3.57	1	16	-4.85	LA LIBERTAD	3.42	0.18063	0.095530						

TOTAL WILDLIFE

Number of Predictors	Negative Log Likelihood	K	n	AIC_c	Variable Removed	Δ AIC	AIC weight	%	Sum Δ AIC	Total %	Weighted %	GRASS PARAMO	SLOPE	Intercept
5	-42.40	8	17	-50.80	none	24.63	4.49E-06	0.000002	2.58	0.85	0.46	-0.01440	-0.00235	0.03690
4	-42.37	5	17	-69.29	NACRAO	6.13	4.66E-02	0.018095			0.22	0.00000	-0.00152	0.02872
3	-42.29	4	17	-73.24	INTERSECTION	2.18	3.36E-01	0.130485			0.32	0.00000	0.00000	0.00000
2	-41.64	3	17	-75.42	SECONDARY FOREST	0.00	1.00E+00	0.387940				-0.00656	-0.00141	0.02324
1	-39.43	2	17	-74.00	GRASSY PARAMO	1.42	4.91E-01	0.190444						
0	-38.49	1	17	-74.72	SLOPE	0.70	7.04E-01	0.273034						

DISCUSSION

Previously I reported a minimum count of five bears in the study area (Chapter 1). Although I did not estimate density, such a high minimum count (n=5) in such a small survey area (8 km^2) suggests these properties were suitable for bears at least in the short-term. Further study will be required to examine if these bears are resident or transient (see Chapter 1 for discussion of alternatives to camera traps).

The presence of bear sign was strongly, negatively associated with distance to the lower alpaca ranch (LA LIBERTAD) and positively associated with the presence of bamboo at the camera trap station (summed AIC_c weights = 76%). The model for the frequency of independent photo-captures of bears was less significant but included a positive association with distance to the road, a negative association with degree of slope and the interaction between the two (64%). Sites with the most wildlife species photo-captured had surrounding vegetation of grassy páramo (as opposed to scrub páramo) and a flatter slope (85%). Multivariate tests failed to resolve these associations. Given my small sample size (n=17) these predictors warrant caution. Below I discuss possible reasons for these results and the implications of roads on bear conservation.

My results suggest that bears and other wildlife used lesser slopes more often but the range of degree of slope at the camera trap stations was only 10° to 30° (mean = 19°). In northern Ecuador, Andean bears are known to use a wide range of slopes (Cuesta et al. 2003). Food sources may be more easily accessible or travel may be easier in flatter areas but I have no reason to think bears will not use steeper slopes. Except for polar bears (*Ursus* maritimus) and North American brown bears (*Ursus arctos*) all bear species climb trees (Garshelis 2004). Andean bears are among the most arboreal of the bear species (Garshelis 2004) so it is unlikely that the observed slopes would have a significant influence on their microsite use. Slope may be associated with unmeasured variables such as plant community structure (i.e., available food) or my placement of camera trap stations on lesser slopes.

The univariate tests showed the presence of bamboo was a significant predictor of bear presence and the presence of other wildlife. However, in the later stages of my analysis bamboo only appeared to be a significant predictor of bear sign, hinting perhaps that it was associated with another more important variable or that bamboo helped to protect sign. At sites with bamboo I found feeding remains, prints, and ground beds. Andean bears eat bamboo (Peyton 1980; Troya 2004) but I found no signs of bamboo feeding remains. Bamboo could also provide protection for these shy animals. Hunters are less likely to pursue wildlife in thick, dense understory so understory may be an important determinant of habitat use in areas of intense hunting (Naughton-Treves et al. 2003). Although bears have not recently been hunted on these two properties, frequent human presence may cause the same response from wildlife. The owner of the alpaca ranch hosts both students and researchers on his property and Colepato community members use the road to access a neighboring town. A more thorough survey of the location, abundance, and species of bamboo would be required to draw meaningful conclusions about bamboo as a predictor of bear sign.

The distance between a camera trap station and the lower alpaca ranch was a more interesting predictor of bear sign and was the strongest predictor overall. This could reflect the older age of the forest and more ground cover closer to the alpaca ranch, making sign easier to find (pers. obs.). However, the land-use practices on the alpaca ranch warrant consideration as well. The owner is conservation-minded and is the founder of Fundación Cordillera Tropical (FCT), a local environmental conservation organization (Appendix 2.3). His property is managed to conserve wildlife, allow the re-growth of native vegetation, and decrease soil erosion in the watershed. Only 31% of the total property is used for alpaca farming. The remaining 69% is left relatively undisturbed except for an old pine plantation scattered within natural vegetation. Only 15% of the alpacas are kept in the páramo (80% of the pasture land), which adheres to the idea that the páramo can sustain one alpaca per ha without being damaged (S. White, pers. comm.). Several years before this study, repeated puma (*Puma concolor*) attacks on alpacas prompted the landowner to install a puma-proof night corral, a non-lethal method of conflict mitigation. Puma attacks were almost completely eliminated but my study showed ≥1 pumas remain on his property (Chapter 1). Because of the success of the night corral, guards no longer need to sleep in pastures adjacent to the forest to protect the livestock, as they had previously when a puma was detected in the area (R. Buestán, pers. comm.). In addition, at the time of this study there were no dogs at La Libertad to scare off wildlife (Lacerda et al. 2009). Perhaps it is some combination of maintenance of native vegetation, low intensity land-use, no persecution of wildlife, little human presence in the forests near La Libertad, and the absence of dogs that have led to this strong, negative predictor for bear sign at stations closer the ranch. Lack of specific deterrents (e.g., dogs) combined with non-lethal conflict mitigation and high tolerance for wildlife could be a significant contributor to the successful conservation of Andean bears on private lands. A more intense study of the forests adjacent to Colepato pasture land and human settlements (as opposed to higher elevation forest and páramo) could provide an interesting comparison of more typical land management practices in Ecuador.

The distance to the road was the strongest (positive) predictor for how frequently a bear was photo-captured at a given station. It was not, however, a significant predictor of bear sign in the univariate tests. The raw data show that the camera trap station closest to the road, Ct15, photo-captured bears twice while the next closest trap, Ct06, did not photo-capture any bears. These data suggest there might be confounding factors that should be considered in our interpretations. The appearance of bears avoiding the road could reflect avoidance of any number of other variables associated with the road. For example, bears might have avoided encounters with people, or perhaps more importantly, their dogs. The road was a single-lane dirt road used 3-4 times per week. It is the most direct route between Colepato, the upper part of the alpaca ranch, and the neighboring community of Quesaries. The alpaca ranch owner will only occasionally (<1/year) drive on this road. No other vehicles use this road as it is private with locked gates and is often impassible by vehicle due to erosion caused by heavy rains. The Colepatans only ride horses on this road and it is not uncommon for dogs to follow behind. These dogs are known to follow the scent of wild animals for long distance through the páramo and forest, chasing off wildlife that might be in the area (pers. obs.; S. White, pers. comm.). Persecution of wildlife by free-roaming domestic dogs is not uncommon in areas where human-settled lands border wildlife habitat (Lacerda et al. 2009).

Anthropogenic land uses such as roads reduce the suitability of Andean bear habitat (Cuesta et al. 2003). Roads themselves can fragment bear habitat and displace bears that avoid roads (Kasworm & Manley 1998; Kattan et al. 2004; Mace et al. 1996). Roads provide hunters easier access to remote areas (Wilkie et al. 2000) which suggests that the hazard is not necessarily the road itself but the road as an index of human contact (Mace et al. 1996).

Alternatively, the bears might have preferentially used the roads and incidentally bypassed my cameras, which were not placed on the road. Ciarniello et al. (2007) found a higher probability of grizzly (brown) bear presence on infrequently used roads, where the possibility of human disturbance while foraging was low, than on roads used more frequently. Andean bears are known to use trails (Goldstein et al. 2008a; Goldstein & Marquez 2004) and a remote road with relatively low human presence that also cuts through forested areas could be used in the same manner.

There were a number of variables that failed to predict bear or other wildlife use of the study area. Distance to the Colepato alpaca house did not significantly predict the presence of bears or other wildlife. This small, one-story house was recently built to begin alpaca farming by the cooperative members. The house is located 0.05 km from the road and is one of the few structures the cooperative members have built in the páramo. At the time of the study the house was not permanently occupied and there were no alpaca present. The camera trap stations closest to the house (~0.6 km) and another camera trap 1.3 km away, did not photo-capture any bears or other wildlife. However, a bear destroyed a station 1.2 km away from the house. Sign was found at all stations on Colepato land, showing bears were present.

I had also expected distance between a camera trap station and the forest edge to predict bear presence. It is well known that Andean bears feed on terrestrial bromeliads (*Puya sp.*) found in the páramo (Goldstein 2004; Troya 2004). Patches of puya often bordered the forests along the study area and we frequently found fresh puya feeding remains. Because many of the traps were on the forest edge along wildlife trails bears could use to access the páramo, I expected distance to forest edge to have had some significance. In addition, one camera-trap (Ct04) was located in a small patch of forest, surrounded by páramo. Although I found bear sign in this forest patch, the camera trap did not photo-capture any bears. It only took one photo of any species (Andean fox) the entire 161 days it was in the field. Andean bear habitat is increasingly fragmented (Kattan et al. 2004) and these smaller forest fragments may play a role in providing cover for bears to pass between larger forested areas within human-dominated landscapes. As such, their use by bears warrants more study.

Predictive models of Andean bear microsite use could be improved by better resolution of the land cover class ‘forest.’ Distinguishing between primary and secondary might improve predictive accuracy. Ground-truthing satellite imagery would also be beneficial for landcover analysis. For example, Ct12 appeared to be in páramo by the satellite imagery but was actually located in a pine plantation (surrounded by native páramo species); it did not photo-capture any wildlife. There was bear sign in the area when the camera trap was set-up but very little new bear sign was found subsequently. Pine plantations have little food for Andean bears but are planted throughout the Ecuadorian Andes (Hofstede et al. 2002). Higher resolution imagery would help in discriminating pine plantations from other types of landcover. Similar to native forest fragments, further study of how bears use pine plantations would be necessary to find out if they provide any benefits (e.g., travel corridors) to bears.

Andean bear conservation on Colepato land

In Colepato, Andean bears are viewed both with fear and reverence. Andean bear-cattle conflicts occur when cattle is left unattended for long periods of time in pastures far from human settlements (Flores et al. 2005). People who have lost cattle to bear attacks generally fear the bears and believe a future attack is inevitable (Achig & Santillán 2009). The community believes there are two species of bears, distinguished by their diets. The vegetarian bear is called “aguaronguero” from the Kichwa word “aguarongo” for the puya plant (family: *Bromeliaceae*). The cattle-eating bear is “huagrero” from Kichwa word “huagra” for cattle (S. White, pers. comm.). The residents of Colepato have had their livestock attacked by wildlife (Achig & Santillán 2009) but despite their location within Sangay National Park boundaries the community does not receive any assistance from park officials when their livestock is attacked. The park itself is under-funded (annual budget of $4080 to manage the 110,000 ha southern sector, C. Schloegel, pers. comm.) and anecdotal evidence suggests park staff lacks the necessary training to address human-bear conflicts adequately. In a survey of Ecuadorian protected area management and legal enforcement activities, Naughton and Silva ranked the southern region of SNP among the lowest of the 14 parks surveyed (unpub. data). Despite its celebrated species richness, southern SNP is basically a park on paper. Lack of assistance from park officials makes the community feel that to protect the livestock they can either hunt bears (the species they tend to blame for all cattle attacks) or move their cattle out of unsupervised pastures in the páramo into crowded pastures close to their homes. The community claims it does not actively hunt or kill bears on their land (see Chapter 1) and the choice to move cattle closer to their homes may be unsustainable for some in the long-term (Achig & Santillán 2009). Like many rural communities in Ecuador, men from the Colepato community frequently immigrate to the United States (R. Buestán, pers. comm.). Women left to care for families on their own are not able to tend to cows in distant pastures (C. Schloegel, pers. comm.). This unintentional increase in cattle supervision could significantly decrease bear attacks but increases pressure on pasture land close to human settlements. It might also reduce the number of cattle each family can sustain. It is also unclear at this point how the group decision-making process of the cooperative will affect long-term bear conservation. Unlike on single-owner properties, dissenting members can stall initiatives regardless of the views of other members. Another consideration is the 30 non-voting families who also live on Colepato land.

If they are not involved in the decision-making process they may be less inclined to protect bears, habitat, or other wildlife.

The Colepato community is not unlike many rural communities in Andean Ecuador, whose tolerance of bear presence and involvement in non-lethal conflict mitigation and habitat conservation will be critical to the survival of Andean bears on private lands. The Colepato community continues to be involved in bear research and other conservation initiatives on their land. More community outreach on contiguous private lands that share bear habitat and have conservation-minded landowners is needed to illuminate the true potential of these areas for Andean bear conservation.

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APPENDIX 2.1 Variables used in univariate tests.

Predictor Variable
Elevation (masl)
Camera trap height (cm)
Bear sign present when station was set-up (Y/N)
Wildlife trail intersection at camera trap station (Y/N)
Wildlife trail definition (well, moderate)
Human use of area (Y/N):
road (Colepato-Quesaries)
well-defined trail
researchers
Aspect
Slope (moderate, severe)
Degree of slope (degree)
Distance to (m):
alpaca ranch (La Libertad)
alpaca ranch (Rumi Loma)
closest camera trap station
closest river point
closest town
Colepato alpaca house
Colepato cows
forest edge
road (Colepato-Quesaries)
Forest type at camera trap station:
primary, secondary (P/S)
bamboo at camera trap station (Y/N)
Surrounding vegetation (Y/N):
primary forest
secondary forest
grassy páramo
scrub páramo
bamboo
nacran
Percent landcover (by class):
% forest
% páramo

APPENDIX 2.2 Pearson's correlation matrix for continuous predictor variables.

	Total camera trap nights	Elevation (masl)	Height of camera trap	Aspect	Slope (ArcView)	% landcover in 100 m buffer: forest	% landcover in 100 m buffer: páramo	Distance from: forest edge	Distance to: closest town	Distance to: closest camera trap station	Distance to: road	Distance to: closest river point	Distance to: cows in Colepato pasture	Distance to: alpaca house	Distance to: Rumiloma	Distance to: La Libertad
Total camera trap nights																
Elevation (masl)	0.13															
Height of camera trap	-0.42	0.44														
Aspect	0.32	0.18	0.18													
Slope (ArcView)	0.42	0.26	-0.24	0.14												
% landcover in 100 m buffer: forest	0.15	-0.48	-0.61	0.04	0.03											
% landcover in 100 m buffer: páramo	-0.15	0.48	0.61	-0.04	-0.03	**-1.00**										
Distance from: forest edge	-0.18	-0.58	-0.41	-0.13	0.11	0.25	-0.25									
Distance to: closest town	-0.03	0.41	0.29	0.46	0.03	-0.53	0.53	-0.42								
Distance to: closest camera trap station	-0.15	0.06	0.06	0.29	0.18	0.08	-0.08	0.46	0.05							
Distance to: road	-0.22	-0.11	0.13	-0.21	0.01	-0.41	0.41	0.58	0.01	0.44						
Distance to: closest river point	0.37	0.58	0.03	-0.03	0.04	-0.10	0.10	-0.69	0.10	-0.26	-0.56					
Distance to: cows in Colepato pasture	-0.30	-0.03	0.23	0.05	0.04	-0.21	0.21	0.63	-0.05	**0.75**	**0.84**	-0.51				
Distance to: alpaca house	-0.29	0.04	0.28	0.08	0.06	-0.35	0.35	0.56	0.10	0.67	**0.89**	-0.56	**0.97**			
Distance to: Rumiloma	0.07	-0.36	-0.34	-0.52	-0.06	0.49	-0.49	0.14	**-0.80**	-0.17	-0.32	0.31	-0.27	-0.45		
Distance to: La Libertad	0.14	**0.80**	0.36	0.33	0.19	-0.56	0.56	-0.38	0.59	0.26	0.07	0.57	0.19	0.22	-0.43	

Predictors that exhibited high collinerarity (r>0.7) are in bold.

APPENDIX 2.3 Fundación Cordillera Tropical mission statement.

OUR MISSION
Fundación Cordillera Tropical's (FCT) mission is to conserve Ecuador's extraordinary biodiversity in the mountain complex of the Nudo del Azuay, within the southern tier of Sangay National Park.

OUR APPROACH
We concentrate our efforts in the Nudo del Azuay where the activities of legal in-holders threaten the integrity of Sangay National Park. These one hundred thousand hectares of montane cloud forest and high páramo grassland require management and protection.

Unless alternative livelihoods can be developed, farmers in Sangay National Park will convert native habitats to agricultural landscapes. Well-preserved montane cloud forests and páramos, designated internationally as a hot spot, could disappear within the next human generation. The presence of these legal in-holders requires that farmers be enlisted as conservation advocates.

In response to this challenge, Fundación Cordillera Tropical (FCT) aims to incorporate the imperatives of farmer livelihoods into its conservations strategies. To this end we are working to apply a system of Conservation Agreements, also known as payments for the protection of environmental services (PPES), in which downstream environmental service buyers compensate landowners for the protection of specific environmental services. FCT is convinced that concurrent investments in human capital will both increase conservation gains while simultaneously improving incomes for participants, and perhaps tend to equalize distribution of benefits within the community.

WHERE WE WORK
The Nudo del Azuay, at the heart of Ecuador's Cordillera Real Oriental, includes ecosystems spanning the high mountain páramo down to the Andean-Amazon piedmont. Singled out for its regional and global biodiversity importance, the Nudo del Azuay covers some 96,000 hectares, the majority of which are included within southern Sangay National Park.

www.cordilleratropical.org

RESEARCH & MANAGEMENT RECOMMENDATIONS

Researchers

This study only begins to outline the role of private lands in bear conservation in Ecuador. To get a broader picture, researchers should survey private lands where owners are less conservation-minded or have had higher rates of conflict with wildlife. Other properties in the Nudo del Azuay region adjacent to my study area might present interesting comparisons. Landowners have a very recent history of conflict with bears and have participated in retaliatory killing. In the 12 months following this study there were reports of three bears killed in nearby communities. Research into why these bears were killed (e.g., pre-emptive or retaliatory) will be a first step in developing non-lethal conflict mitigation methods and preventing private lands from acting as mortality sinks.

Microsite habitat analysis can help conservation managers better understand what attracts bears to certain sites and causes them to avoid others. This will be important when prioritizing areas for Andean bear conservation. More detailed information about specific types of forest (primary, secondary, etc.) and better resolution of important bear food sources would focus efforts at bear conservation.

Bear ranges tend to be related to food abundance and distribution, so private lands with abundant food sources may attract bears. If bears are then persecuted, attractive properties could act as sinks for the local bear population. This scenario would require different management schemes for each property. The first could bolster protection efforts for bears and the second could focus on habitat protection and protection for livestock. In addition, landowners who have had problems with bears in the past are less likely to be tolerant of bears on their property and less willing to become involved in conservation programs. They may need to be motivated through education or incentive programs.

The roles of bamboo, forest fragments, and pine plantations also warrant further research. Although my survey of bamboo was only cursory, it appeared several times as a predictor of bear presence. The forest fragment I surveyed contained bear sign but the camera trap station never photo-captured a bear. This fragment was surrounded by a wide expanse of páramo. Bears could be using forest fragments as stepping-stones to larger forest patches when they cross open areas, or they may largely ignore these fragments. Because forest fragments are increasingly common throughout bear range a better understanding of how bears are using them could be key to linking fragmented bear habitat. The same could be true for pine plantations. Largely devoid of Andean bear food, they could provide links to higher quality habitat and thus have conservation value.

The study area was relatively small and the time frame was relatively short. Accordingly the role of the road was ambiguous as an indicator of habitat suitability for bears. Also, seasonal variations and several habitat types were under-represented in my study. The properties I surveyed contain a variety of forests of varied density and distance to human activity. A larger study area with camera traps placed both closer to human activities (e.g., Colepato pasture land) and deeper in the forest (no station was set-up >700 m from páramo) may show results I missed. As with other bear species, seasonal change in food availability will impact habitat use.

Future studies at this site should focus on different seasons to investigate how food availability affects bears' use of páramo, road, and forest. Problems with camera trapping in the páramo may be insurmountable. Since the role of the páramo is understudied, other methods should be considered (Chapter 1).

On a technical level, researchers who plan to use camera traps to identify individual Andean bears should try to maximize the amount of indentifying characteristics collected during each hit to improve the overall rate of individual identification. Camera trap stations should consist of at least two opposing camera traps per station. Multiple camera traps will provide more information on individual patterning. The costs associated with purchasing large amounts of camera traps might be offset by a higher success rate for identifying individuals. More efficient identification could mean shorter deployment times for each trap. Two or more camera traps would also increase the probability of detecting bears (and other wildlife) present at a site. Camera traps could be moved more frequently and a larger area could be surveyed. In addition, I found that camera trap models with slow start-up and trigger speeds impede individual identification and as such should be avoided in studies aimed at individual identification. Researchers interested in individual identification may also want to consider combining or using alternative methods such as genetic analysis and GPS collars. I outline the potential benefits and drawbacks of alternative methods in Chapter 1.

I got better photos of bears when the understory was thin, allowing more time for the bear to approach the camera trap. When I placed camera traps in relatively dense vegetation I got more photos of unidentifiable body parts of bears rather than their faces. When identifying individuals is important, I recommend that camera traps be placed in areas with thin understory and far enough away from where bears might walk to allow the bear time to approach the camera trap. This would also allow the placement of height markers within the picture frame. Height markers could provide additional information on the individual bear and may provide information on gender (adult males can be significantly larger than females).

Throughout this study I worked closely with landowners and I believe it was key to the success of the project. Future studies on private lands should include local landowners and community members for the duration of the project and hire a field assistant from the community if possible. Initial planning should include time and budget for community meetings and presentation of final results. Researchers using camera traps for individual identification may also want to ask community members to help identify bears in the photos from their property. It not only allows the community to feel more invested in the outcome of the project but begins to build a foundation toward future conservation programs in the study area. Communities that feel alienated may become suspicious of both the researchers and the research results.

Wildlife managers & private landowners

Many of Ecuador's protected areas encompass or share boarders with private lands. If protected areas are to be more than "paper parks" (existing only on paper with no real enforcement or management), park officials will need to help landowners find, install, and maintain non-lethal solutions to their conflicts with wildlife, large carnivores in particular. My results show that landowners who tolerate the presence of one species of large carnivore (e.g., Andean bear) may inadvertently be tolerating the presence of other wildlife (e.g., puma). Not only might this provide buffer zones for protected areas (rather than sinks for wildlife mortality) they may also be important sources of new individuals to isolated populations in protected areas.

In addition, government officials and non-governmental organizations may want to consider rewarding communities for conserving their wildlife, rather than punishing them for harming it. Such approaches can make private landowners feel ownership over the wildlife and in turn, protect it. At the time of this report, the relationship between Colepato and CELEC-Hidropaute was an excellent example of private partnerships for conservation (Chapter 1).

Private landowners who want to reap government incentives for conservation should try to maintain large, contiguous areas of native vegetation (e.g., forests, páramo) as well as prevent hunting. They should take appropriate measures to protect their livestock and homes from damage by wildlife. Night corrals and other structures can be effective but expensive solutions to protect livestock. Moving cattle out of unwatched, far away pastures could be more cost effective solutions. Ideally, park officials and conservation organizations would work with landowners to find proven, appropriate, and effective solutions.

The properties in this study are excellent examples of landowners sharing conservation goals across property boundaries. While the two properties are managed differently and their owners have different motivations, by collectively prioritizing conservation goals their properties provide refuge for some of South America's largest carnivores. Landowners who want to serve as models for stewardship of nature must begin incorporating neighbors into their conservation initiatives.

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Contributed Paper

Participatory Planning of Interventions to Mitigate Human–Wildlife Conflicts

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Abstract: *Conservation of wildlife is especially challenging when the targeted species damage crops or livestock, attack humans, or take fish or game. Affected communities may retaliate and destroy wildlife or their habitats. We summarize recommendations from the literature for 13 distinct types of interventions to mitigate these human–wildlife conflicts. We classified eight types as direct (reducing the severity or frequency of encounters with wildlife) and five as indirect (raising human tolerance for encounters with wildlife) interventions. We analyzed general cause-and-effect relationships underlying human–wildlife conflicts to clarify the focal point of intervention for each type. To organize the recommendations on interventions we used three standard criteria for feasibility: cost-effective design, wildlife specificity and selectivity, and sociopolitical acceptability. The literature review and the feasibility criteria were integrated as decision support tools in three multistakeholder workshops. The workshops validated and refined our criteria and helped the participants select interventions. Our approach to planning interventions is systematic, uses standard criteria, and optimizes the participation of experts, policy makers, and affected communities. We argue that conservation action generally will be more effective if the relative merits of alternative interventions are evaluated in an explicit, systematic, and participatory manner.*

Keywords: animal damage, co-management, conservation actions, decision support, depredation, feasibility criteria, problematic animals, tolerance

Planificación Participativa de Intervenciones para Mitigar Conflictos entre Humanos y Vida Silvestre

Resumen: *La conservación de la vida silvestre es especialmente desafiante cuando las especies enfocadas dañan cultivos, atacan a humanos o afectan la caza y pesca. Las comunidades afectadas pueden tomar represalias y destruir a la vida silvestre o sus hábitats. Resumimos las recomendaciones de la literatura para 13 diferentes tipos de intervenciones para mitigar esos conflictos entre humanos y vida silvestre. Clasificamos ocho tipos como directos (reducen la severidad o frecuencia de encuentros con vida silvestre) y cinco como indirectos (incrementan la tolerancia a encuentros con vida silvestre). Analizamos las relaciones causa – efecto subyacentes en los conflictos para clarificar el punto focal de intervención para cada tipo. Para organizar las recomendaciones sobre intervenciones, utilizamos tres criterios estándar para la factibilidad: diseño costo-beneficio, especificidad y selectividad de vida silvestre y aceptabilidad sociopolítica. La revisión de literatura y los criterios de factibilidad fueron integrados como herramientas para el soporte de decisiones en tres talleres con múltiples actores. Los talleres validaron y refinaron nuestros criterios y ayudaron a que los participantes seleccionaran intervenciones. Nuestro método de planificación de intervenciones es sistemático, utiliza criterios estándar y optimiza la participación de expertos, políticos y comunidades afectadas. Argumentamos que la acción de conservación generalmente será más efectiva si los méritos relativos de las intervenciones alternativas son evaluados de manera explícita, sistemática y participativa.*

Palabras Clave: acciones de conservación, animales problema, criterios de factibilidad, daño por animales, depredación, manejo colaborativo, soporte de decisiones, tolerancia

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Introduction

Conserving wildlife that damage crops or livestock, attack humans, or take fish or game poses a special challenge for policy makers and managers (Thirgood et al. 2000; Karanth & Madhusudan 2002; Sillero-Zubiri et al. 2007). The traditional human response is to clear wildlife habitat or retaliate against wild animals for real or perceived threats (Marker et al. 2003; Treves & Naughton-Treves 2005; Woodroffe & Frank 2005). Such responses undermine broad conservation goals. For example, the removal of large-bodied predators has cascading effects on the populations of their prey and smaller predators (Estes et al. 1998; Terborgh et al. 2002; Ripple & Beschta 2004). Similarly the removal of elephants significantly alters vegetation cover and diversity (Wing & Buss 1970; Chapman et al. 1992; Kahumbu 2002). Yet efforts to protect problematic wildlife have turned affected communities against wildlife or against conservation efforts (reviewed in Treves 2009). Indeed many human societies attach strong positive and negative symbolism to large animals (Knight 2000, 2003; Nie 2002; Treves 2008). Thus policy and management of large animals are contentious topics.

Worldwide efforts to balance human needs with those of wildlife have fueled interest in the alternatives to retaliation. Among these are nonlethal management and ways to raise human tolerance for wildlife. Attention has also focused on the participation of affected households in planning responses to conflicts with wildlife and inclusion of a range of interest groups and values (Hill 2004; Raik et al. 2005; Treves et al. 2006). Striking an optimal balance requires solutions that are scientifically sound and politically acceptable.

We reviewed the literature and considered our experiences of working with affected communities to list and describe distinct types of methods used to mitigate human–wildlife conflicts (interventions). Then we classified these methods as *direct interventions* that aim to reduce the severity or frequency of encounters between wildlife and property or people or *indirect interventions* that aim to raise people's tolerances for such encounters. We summarized the recommendations about the interventions with three complementary criteria: cost-effective design, selectivity and specificity for the problematic wildlife, and sociopolitical acceptability. These three criteria are not prescriptions. Rather they capture experiences of strengths and weaknesses of each method under different conditions, so users can assess whether the interventions are feasible (i.e., "possible and practical to achieve easily or conveniently" [http://www.askoxford.com/concise_oed/feasible?view=uk]) in their particular sociopolitical and biophysical situations. Finally our framework dovetails with recent standards for conservation planning (Salafsky & Margoluis 1999; Salafsky et al. 2002; Groves 2003).

Methods

Literature Review

Since 2001 A.T. has compiled information on interventions intended to mitigate human–wildlife conflicts worldwide. These include peoples' preventive and reactive responses to wildlife damage as well as factors that exacerbate or lessen wildlife threats or people's perceptions of them. This literature search focused on terrestrial vertebrates >2 kg of body mass and on carnivores in particular. From >800 sources we cite 37 peer-reviewed articles that synthesized recommendations for numerous methods or provided detailed recommendations for a particular method.

Participatory intervention planning (PIP)

We held three workshops in which participants used a simple method for PIP to assess alternative types of interventions based on participants' evaluations of feasibility. The goals of our PIP workshops were to help participants consider all possible types of interventions and weigh the relative merits of the alternatives with standard criteria. Although it may appear as though we simply brainstormed various methods and the participants then made educated guesses about the relative feasibility, this brainstorming was structured and preceded by a critical first step that defined the cause-and-effect relationships underlying a given human–wildlife conflict (Fig. 1). This step exposed multiple possible focal points of intervention. The causal chains are analogous to those advocated for conservation planning (Salafsky et al. 2008).

After brainstorming the participants used three criteria—cost-effective design, wildlife specificity and selectivity, and sociopolitical acceptability—to evaluate candidate interventions. A cost-effective design, understood broadly, considers the resources, time, and expertise needed to install and maintain the intervention in its most effective form. Effectiveness must be evaluated against the goal, which is either to reduce the frequency or severity of encounters between wildlife and people or raise tolerance among people for wildlife encounters (Fig. 1). Wildlife specificity and selectivity are the effects of the intervention on targeted problematic wildlife and unintended targets. Sociopolitical acceptability is the tolerance for the installation, maintenance, and consequences of the intervention among affected individuals and households, more remote interest groups, and the broader populace.

We used the PIP method in three multistakeholder planning workshops to improve and refine our definitions, criteria, and procedures for eliciting stakeholder deliberations. Participatory intervention planning was first used by A.T. and R.W. as part of the Wildlife Conservation Society's program in La Paz, Bolivia, and A.T.

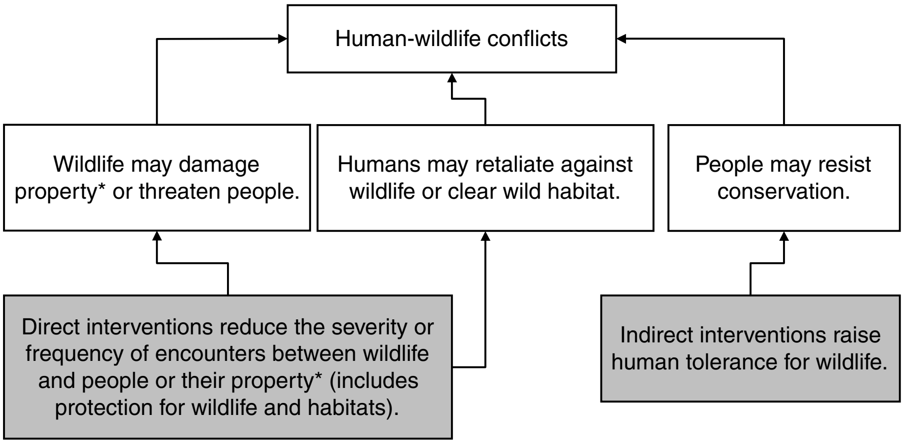

Figure 1. Cause-and-effect relationships underlying human–wildlife conflicts and their associated interventions. An asterisk indicates inclusion of claims to fish, game, and other natural resources.

and S.W. subsequently refined it for Fundación Cordillera Tropical, Cuenca, Ecuador. The workshops involved an array of stakeholders. The first pair of the 2-day workshops (January 2005 and May 2006) convened 40 Bolivian policy makers, managers, and wildlife researchers to guide nationwide policy recommendations. The third workshop (August 2007) in the village of Zhoray convened 57 Ecuadorian landowners to build consensus on coexistence with wildlife in and around Sangay National Park.

In each workshop the facilitators (the authors plus two to four staff assistants) listed all methods for intervention derived from the literature and asked the participants to identify additional methods—which added three to our list (see Results). We were wary of prejudicing later decision making and evaluation by providing definitive judgments on the effectiveness of any one method. Instead we briefly summarized the research on conditions under which each type or method of intervention was more or less effective. A thorough knowledge of intervention types and methods was a valuable prerequisite for effective PIP.

Participants working in groups or in plenary were asked to discuss the entire range of interventions and consider the cause-and-effect relationships underlying human–wildlife conflicts and their associated interventions (Fig. 1). As a first cut the participants discarded interventions that were unanimously seen as impossible. For example, S.W. ruled out lethal interventions against Andean bears (*Tremarctos ornatus*) because it is a legally protected species in Ecuador and is on the International Union for Conservation of Nature Red List (2008). Changing national laws and overcoming international pressure for the sake of a regional wildlife management plan would have been impossible. Thereafter the participants were asked to consider the feasibility criteria. Assessments of the criteria reflected the participants' knowledge of applicable law, national or local sociocultural norms, economic and material constraints, and biophysical conditions; hence, the assessments were subjective. Nevertheless, by designating subgroups randomly (Ecuador) or by species expertise (Bolivia), we anticipated complementarity within subgroups relating to formal and informal knowledge and experience. Such complementarity was expected to promote a more thorough and objective assessment.

Once the list of feasible interventions was compiled the participants were asked to consider the potential compatibility of combined interventions. The interventions were considered functionally incompatible if the same individuals, time, materials, or funds would be needed for both interventions but could not be divided adequately between the two. The interventions were considered logically incompatible if one proposed intervention would produce a change that excluded the other (e.g., hunting wildlife is often incompatible with wildlife viewing at the same or nearby sites). The participants could have been asked to rank or rate the alternatives, but we did not take this step because the Bolivian workshops were aimed at national policy rather than at a specified site and many of the Ecuadorians made independent land management decisions.

Results

We identified eight distinct types of direct interventions to reduce the severity or frequency of encounters between wildlife and people or their property and five distinct types of indirect interventions intended to raise people's tolerance for wildlife encounters (Table 1). Within each type there were one to seven methods (i.e., subtypes). Four methods were a combination of the direct and indirect interventions: hunting of problematic wildlife may reduce property damage and raise tolerance for wildlife among hunters and affected communities; wildlife laws or policies that give affected communities ownership or authority of wildlife may raise tolerance and prevent retaliation against the wildlife seen as "property"; incentive schemes that combine payments for surviving wildlife with changes in husbandry or management of

Table 1. Direct and indirect interventions for mitigating human–wildlife conflicts characterized by three criteria for feasibility.

		Design criterion			
Intervention type	*Examples of methods*	*cost-effective design*	*wildlife selectivity/specificity*	*sociopolitical acceptability*	*Source**
Direct interventions reduce severity or frequency of encounters between wildlife and property/people.					
Barriers	buffer zones, fences, moats, nets, trenches, and walls	consider placement, size, permeability, and materials/labor/maintenance costs; can include escape paths, alarms, and deterrents (e.g., electric, thorns and nonpalatable crops)	with time intelligent, motivated animals may penetrate; consider impact on migration/dispersal movements	generally familiar and popular among those who feel threatened; consider impact on local people's access to resources; metal fence wires have been used as snares; livestock may injure themselves on barriers; 3 wide barriers (e.g., buffers) must be profitable if land is scarce	1–5
Guards	supervision by dogs, humans, or other animals	consider timing relative to wildlife activities; guards may be exposed to disease, attack, or weather; consider behavior of guards: feeding, health, ranging, social system, vigilance, and vocal	consider risk of disease transmission between guard and wildlife; consider whether guard competes with or preys on wildlife; human guards may fail to deter habituated wildlife; hence, more effective in areas with hunting	generally familiar but time required may limit acceptance; risk to guards and indirect costs (stay home from school) or unintended effects (barking dogs or wandering dogs) may reduce acceptance; consider opportunity costs carefully	4–7
Repellents	acoustic: sirens, explosions, and predator sounds; chemical: odor/taste repellents and conditioned taste aversion (CTA); visual: colors, lights, and predator mimicry	from most to least effective: behavior-contingent, motion-activated, unpredictably mobile, or stationary; chemical, consider persistence in various climates; CTA, determine whether predatory response is inhibited or simply feeding	consider chemical toxicity; consider circadian behavior, intelligence, and the visual and acoustic acuity of target, non-target wildlife, people, and domestic animals	generally familiar, but acceptance of loud sounds, lights at night, noxious odors, toxic chemicals, and attraction of predators vary	2, 4, 8–10
Manipulate problematic animals (lethal/permanent)	culling, eradication, hunting, relocate to captivity, selective removal, or sterilization	selective removal of culprits difficult; goals of hunters (e.g., food and sport) may not match those of complainants (e.g., safety and income) or managers (e.g., conservation and revenue); complex methods of capture and animal handling demand professional supervision and are costly; public collaboration (e.g., hunting) demands professional communications, monitoring, and enforcement	risky for endangered species; generally possible to target problematic species, but varies by method (shooting vs. traps, explosives, or poison); selection of individual culprits is difficult; if released, consider disease transmission and capture-related injury	generally familiar, but certain methods (e.g., poison and traps), certain sites (private lands and densely settled areas), and certain targets (social, intelligent, and charismatic species) provoke opposition by common interest groups	2, 3, 11–16

continued

Table 1. (continued)

Intervention type	Examples of methods	Design criterion: cost-effective design	Design criterion: wildlife selectivity/specificity	Design criterion: sociopolitical acceptability	Source*
Manipulate problematic animals (nonlethal/ temporary)	capture followed by deterrence (e.g., punish or affix electric shock collar), release, or relocate	selective removal of culprits difficult; released animals often return or cause problems at new site; complex methods of capture and animal handling demand professional supervision and are costly	risky for endangered species. Generally possible to target problematic species, but varies by method; selection of individual culprits is difficult; if released, consider disease transmission and capture-related injury	capture of problematic animals familiar, but subsequent handling may not be; generally more acceptable to urban, wealthy populations; affected communities may distrust release	9, 17, 18, 19
Manipulate habitat or other wildlife	alter resources required by problematic wildlife (food, shelter, breeding sites, etc.) to discourage use of human areas	demands information on behavioral ecology of problematic wildlife or comparisons of affected and unaffected properties/people; improvement of habitat through remediation and restoration activities may discourage wildlife damage to property or degradation of habitat may diminish wildlife abundance	suitable for endangered wildlife if habitat is improved (e.g., restoring wild prey); unpredictable consequences for wider ecosystem	improvement may be unfamiliar; degradation of habitat is generally familiar; little data on acceptability; biodiversity interests may oppose degradation	20–22
Protect wildlife or habitats	prevent retaliation against wildlife or habitat destruction via law enforcement, interdiction, or physical barriers to access	depends on frequent and sensitive monitoring or surveillance at local scales; clear rules that govern access and the use of natural resources; physical barriers and obvious delimiters; trained staff to communicate, enforce, and prosecute	far-ranging animals that cross jurisdictions elude protection; if retaliation and habitat destruction are inconspicuous activities, interdiction and enforcement will be difficult	generally familiar but opposed when traditions or broader policies allow access to and the use of natural resources; enforcement may generate political clashes and local ill will	3, 11, 21, 23
Reduce attractiveness of property/ people	remove attractants (e.g., food and garbage), relocate property or activities, or switch contested resource to less desirable varieties	reduce attractiveness of property/people; demands information on behavioral ecology of problematic wildlife and comparisons of affected and unaffected properties/people; change in locations, timing, or attributes or vulnerable property/people	suitable for endangered wildlife if the habitat is improved (e.g., removing human influences); difficult for damage patterns that are uniform, extremely variable in space or time, or difficult to ascribe to target wildlife	few people like to change their livelihood practices or living conditions; cost–benefit analyses and opportunity costs are key; high potential risk for vulnerable people	2, 4, 19, 20, 23, 24
Indirect interventions raise tolerance for wildlife encounters.					
Co-management (collaboration in planning, intervention, or monitoring)	involve interest groups or stakeholders in planning, implementation, or monitoring	should include affected households, consensus, social learning, long-term investment in relationships, fair representation of affected households, technical experts, and legal "owners" of wildlife	most effective for wildlife with value (material or nonmaterial); less effective for inconspicuous wildlife or those with little value to any interest group	generally familiar, but acceptance depends on whether participants and processes are seen as legitimate, representative, and fair; majority views may dominate and mislead planners	4, 11, 21, 22, 25–30

continued

Table 1. (continued)

		Design criterion			
Intervention type	*Examples of methods*	*cost-effective design*	*wildlife selectivity/specificity*	*sociopolitical acceptability*	*Source**
Compensation/ insurance reimbursements	payments for damaged property or injury to people (cash or equivalent)	vulnerable to fraud, corruption, inefficiencies, and moral hazards; difficult to phase out; administration may demand training	most effective for rare wildlife or small populations or costs rise; demands generous donor base so most effective for charismatic wildlife	generally familiar, but acceptance varies with political clashes between donors, payers, and recipients; acceptance may decline as costs rise; payments do not turn recipients into prowildlife advocates; some recipients may reject payments in favor of wildlife control	31–33
Incentives/ performance payments	add value to live wildlife as a commodity or through direct payments for live wildlife	see recommendations for compensation/reimbursements; link to wildlife survival is key; tourism can have negative impacts on wildlife if not designed with the behavioral ecology of wildlife in mind	demands a market or donors, so most effective for valued wildlife	unfamiliar to most except for tourism revenue sharing; some recipients may reject payments in favor of wildlife control; markets volatile and complex	4, 21, 34
Information sharing	communication of information generated by research via environmental education, consulting, media, training, and writings	salience to target audience, clarity, novelty, and communication medium are the key; broadcast may reach many but persuade few; interpersonal communication may reach few but persuade effectively; goal is often to change behavior among receivers	works for any wildlife, but dissemination/persuasion for noncharismatic species difficult	generally familiar, but acceptance improves with trusted messengers; unfamiliar advocates may engender skepticism; deeply held values and beliefs change slowly	35, 36
Policy/legal reform or devolution of authority	changing legal relationships to wildlife or habitats (tenure and rights of property, use, access, etc.)	ownership may enhance perceived control over wildlife and their damages; use rights may enhance the perceived value of wildlife and habitats; policy and legal reforms must be communicated to stakeholders effectively and clearly; misincentives for overharvesting or misuse common; regulation of use/access may still be needed; vulnerable to fraud, corruption, inefficiencies, and moral hazards	most effective for wildlife with value (material or nonmaterial); less effective for inconspicuous wildlife or those with no traditional value to affected households	generally familiar, but acceptance varies with the rules of use and ownership; political clashes between past and current owners likely	22, 28–30

**Sources: 1, Angst 2001; 2, Hoare 2001; 3, Karanth & Madhusudan 2002; 4, Osborn & Parker 2003; 5. Ogada et al. 2003; 6, Smith et al. 2000a; 7, Andelt 2001; 8, Smith et al. 2000b; 9, Shivik 2006; 10, Mason et al. 2001; 11, Noss & Cuellar 2001; 12, Burns et al. 1991; 13, Ratnaswamy et al. 1997; 14, Treves & Naughton-Treves 2005; 15, A.T. unpublished; 16, Woodroffe & Frank 2005; 17, Linnell et al. 1997; 18, Schultz et al. 2005; 19, Wydeven et al. 2004; 20, Meriggi & Lovari 1996; 21, Mishra et al. 2003; 22, Naughton-Treves & Treves 2005; 23, Mech et al. 2000; 24, Shaw et al. 1988; 25, Carr & Halvorsen 2001; 26, Treves et al. 2006; 27, Raik et al. 2005; 28, Murombedzi 1992; 29, Du Toit 2002; 30, Virtainen 2003; 31, Montag 2003; 32, Bulte & Rondeau 2005; 33, A.T. unpublished; 34, Zabel & Holm-Muller 2008; 35, Dunwoody 2007; 36, Jacobson & McDuff 2009.*

wild habitat may combine direct and indirect intervention steps; and voluntary, negotiated household relocation or resettlement projects may reduce threats from wildlife. If outcomes include improved human safety or livelihoods, one may also see higher tolerance for wildlife. Several methods of mitigating human–wildlife conflicts were unknown to the authors before the PIP workshops. The participants in Bolivia introduced us to *chaku* (wildlife drives) (Table 1)—a multimodal repellent procedure in which large numbers of community members move through grazing areas making noise, holding lit firecrackers, and generally clearing the way of predators and grazing competitors. The same participants introduced us to *captura y castigo*, wherein a problematic wild animal is live trapped, punished in a cage, and then released in hopes that it will not dare to approach humans or their property again. Ecuadorian participants introduced us to planting tree or brush cover near poultry coops so that poultry can find safety from aerial attack in its dense branches or hop and climb onto low branches to avoid some ground predators.

The participants readily narrowed the 13 types of interventions to four to six that seemed possible. This winnowing was rapid: approximately 2 h in the Ecuador workshop and 4–8 h in the two Bolivia workshops, longer in the latter probably because of larger area of land and greater number of wildlife species considered. The participants reported no problems in conceptualizing the feasibility criteria. Nonetheless, cost-effective design seemed to require the most time and produced the greatest uncertainty. The participants were unanimous that sociopolitical acceptance had to be considered carefully. We included a fourth criterion—monitoring demands or constraints—but we found no evidence that the participants thought it was important (A.T., personal observation).

Although direct interventions at first glance may seem the most straightforward and effective way to prevent wildlife damage or avert retaliation, in practice, the participants commonly cited three reasons to prefer indirect interventions. Illicit killing of wildlife and private landowners' conversion of wild habitat were often deemed impossible to prohibit or enforce, so methods to change motivations underlying these behaviors were sought instead. Direct interventions often require the legal authority to interdict, relocate, or confiscate, which few participants imagined themselves holding. Many participants understood that retaliation or opposition to conservation stemmed from common, contributing factors or indirect threats (e.g., lack of education, poverty, unwise legislation, or lack of management capacity). Therefore, the direct threats or proximate contributing factors might respond efficiently to a cascade of "upstream" changes triggered by one indirect intervention (e.g., education, policy reform, or training). For example, training farmers to detect and deter transgressing wildlife seemed more efficient than inviting central authorities or an outside team to do so. Likewise changing policy sometimes seemed more feasible than trying to stop every infringement of existing rules.

Discussion

Our literature review and PIP workshops revealed 13 types of interventions and several dozen subtypes intended to mitigate human–wildlife conflicts in one situation or another (Table 1). Although we believe that our types are exhaustive, we also expect that additional methods will be added as researchers and practitioners around the world report on their observations and experiments. Several types ("reduce attractiveness of property/people..." and "policy/legal reform/devolution") will likely benefit from greater resolution and further analysis. For example, the former could encompass changes as diverse as livestock owners switching breeds, vaccinating herds, removing carcasses, and improving pastures and farmers switching crops, rotating fields, and clearing brush (Mech et al. 2000; Osborn 2002; Wydeven et al. 2004). Addition of other methods to this catch-all category might materially change our recommendations.

Although our classification of the interventions into direct and indirect types is a useful heuristic device and helps clarify the cause and effect, it fails to capture the manifold actions of at least four complex interventions. (1) Hunting problematic wildlife may reduce property damage and raise tolerance for wildlife among hunters and affected communities (Linnell et al. 2001; Mincher 2002). Its effectiveness at both these goals needs systematic study. (2) Similarly wildlife laws or policies that give affected communities ownership of or authority over wildlife may raise tolerance and prevent retaliation against wildlife because they are valued as "property" (Du Toit 2002; Virtanen 2003). (3) Incentive schemes that combine payments for surviving wildlife with changes in husbandry or management of land engage both direct and indirect interventions (Mishra et al. 2003). This too needs study to formulate general recommendations (Zabel & Holm-Muller 2008). (4) Similarly interventions involving voluntary, negotiated property relocation or resettlement may reduce threats from wildlife. If human safety and livelihoods improve as well, this intervention may also raise tolerance for wildlife. The feasibility and effectiveness of such schemes still need to be verified independently and generalized to other settings (Karanth & Madhusudan 2002; Karanth 2005).

These dual-purpose interventions represent complex, manifold collaborations between users, managers, and policy makers. This underscores the importance of integrating social science with ecological science to understand human–wildlife conflicts and the importance of conducting research to test hypothesized cause-and-effect relationships between threats and interventions.

Conservation Planning

Standard definitions and practices of conservation are gaining wide acceptance. Salafsky et al. (2008) call for systematic classifications of conservation actions to permit comparison across projects and better information sharing. Although we prefer the term *intervention* as more explicit and more generally understandable than *conservation action*, we offer just such a detailed classification scheme as it pertains to human–wildlife conflicts.

Another goal of our paper was to address three common problems in planning interventions. The first is the assumption that only one or a few solutions exist for a given threat. Our results challenge this assumption. First we showed that several paths to intervention exist if one explicitly identifies the causal chains underlying a conservation problem (Fig. 1). Second, our thorough review of the literature demonstrated how many alternative methods exist for the same general set of threats (Table 1). Admittedly human–wildlife conflicts have been studied for decades and solutions attempted for millennia (Smith et al. 2000*a*, 2000*b*), but we maintain that finding several alternative interventions (direct and indirect) is not unique to our topic. Acknowledging multiple paths to intervention and listing alternative methods for intervention spurred our participants to suggest varied solutions. Furthermore our PIP method separated the identification of solutions from the assessments of relative feasibility among the alternatives—a step toward more explicit, systematic planning.

The second, related problem is the selection of the first solution that comes to mind to the exclusion of others. For example, ecotourism is often proposed as a way to make conservation pay for itself, and other forms of incentives (e.g., conservation performance payments and sustainable use) are not explored fully. Any proposed intervention should be weighed against alternatives with explicit criteria, lest conservation be more art than science.

We do not propose that threats can be equally well abated by multiple, alternative interventions. Instead two or more candidates always exist because direct and indirect pathways to intervention are universal—and the pathways and methods should be weighed explicitly by their relative merits. Nor do we argue that the instincts and experiences of experts are a poor guide to planning because experts will be needed to evaluate alternatives, in addition to other key roles. Rather we believe that a systematic, explicit examination of alternative interventions for a given threat will improve the design and success of interventions. Such deliberation and discussion likely will stimulate creative thinking that can result in new solutions or catalyze the integration of different ideas. Furthermore we believe that conservation expertise is not the sole province of formally trained scientists or field-tested conservation practitioners, but it should also engage civilians, policy makers, and other organizations (Treves et al. 2006; Danielsen et al. 2007). This is particularly true when planners strive to balance human and biodiversity needs so that the eventual intervention (or lack of action) reflects sociopolitical acceptance.

Third we argue that the selection of interventions in any field should be based on feasibility, not just effectiveness, which includes cost-effective design, wildlife specificity and selectivity, and sociopolitical acceptability. Our participants supported this idea to the extent that they estimated feasibility from pragmatic estimates of constraints on resources and effort, effectiveness, target wildlife, and sociopolitical acceptability. To wit affected households may reject the intervention that prevents wildlife damages if it fails their evaluations of local practicality or impinges on the other realms of life. For example, Indian communities undermined effective barriers to wildlife because they sought resources on the other side (Karanth & Madhusudan 2002; Gubbi 2007). Likewise the most popular intervention may not be cost-effective. For example, many surveys show public preference for capture and relocation of problematic carnivores (Manfredo et al. 1998; Naughton-Treves et al. 2003), yet wildlife authorities balk at the costs of such interventions and research shows that they rarely reduce damages in the long run (Linnell et al. 1997). Similarly the effects of interventions on target wildlife and unintended consequences for non-target wildlife may lower the relative feasibility of any given intervention, especially when managing valued or protected species (e.g., Burns et al. 1991). Our PIP workshop participants grasped these ideas readily. They did not embrace a fourth criterion that we tried to introduce: monitoring demands. This supports one expert's assertion that "...you want to pick the best strategy for the job and then figure out how to monitor it as best you can" (N. Salafsky, personal communication). Weighing one criterion over another is likely to be a subjective decision and one well suited to participation and consensus building through debate and discussion.

Optimal Participation

Participation in conservation planning should be optimized. Participation has costs and benefits that are well known from democratic theory and natural resource participation theory (Gillingham 2001; Halvorsen 2003; Raik et al. 2005). For PIP methods potential costs of participation include the transaction costs of meeting, communicating, and building a shared vision; the risk that opponents consolidate to disrupt planning or implementation; and the risk that participants are unrepresentative of interest groups that then undermine their decisions. Potential benefits include the generation of diverse ideas: participation in decision making may raise tolerance for wildlife or management even in the absence of measurable reductions in threats; participants may offer help to implement or monitor interventions; and participants may gain skills in negotiation, democracy, and coalition building. Ideally planners will consider optimal participation. For example, our method for strategic choice of interventions based on feasibility requires local knowledge, scientific judgments, and broader sociopolitical experiences. Thus we caution against centralized, rigid, technocratic scoring systems that replace intuition and informal knowledge.

Planners may not be so free, however, because some threats or interventions engender strong emotions or economic self-interest. Hence individuals and organizations may demand to be involved in planning interventions, regardless of their capacity to contribute. Excluding influential or interested stakeholders from planning can itself trigger opposition, regardless of any good intentions. Indeed some interventions become saddled with broader sociopolitical issues that interest many stakeholder groups. For example, wolf reintroduction in the United States was slowed by long-standing debates about public use of federal lands for grazing and mining (Bangs et al. 1998; Nie 2002).

Disagreements and intractable conflicts of interest can bog down participatory processes. For example, Raik et al. (2005) described PIP-like procedures to resolve human–deer (*Odocoileus virginianus*) conflicts in suburban and rural U.S. communities. Some of the dozen communities considered in the study took years to decide on interventions, most often because the participants disagreed about killing deer. We believe that deadlocked meetings can be avoided if facilitators articulate goals clearly (top down) or build a shared vision among participants (bottom up) at the outset. For example, the goal of balancing deer needs and human needs will generate different sets of interventions than the goal of reducing deer damage to property. The latter would more likely promote lethal control. The appropriate choice of top-down or bottom-up planning of interventions depends in part on whether participants are formulating policy recommendations (cf. our Bolivian workshops) or implementing interventions. Then implementers who act independently may opt for different goal statements than would communal implementers. In the former case the goal statement may be general because each participant takes away her or his preferred method (cf. our Ecuadorian workshop), whereas in the latter case, facilitators should relinquish control and allow consensus goals to surface.

We expect intervention planning will stand on a firmer footing when the choice of conservation interventions is systematized and made explicit. One step in that direction is to be clear about cause and effect of direct and indirect interventions. We also advocate the use and refinement of the criteria for evaluating alternative interventions, while optimizing the level of participation in planning.

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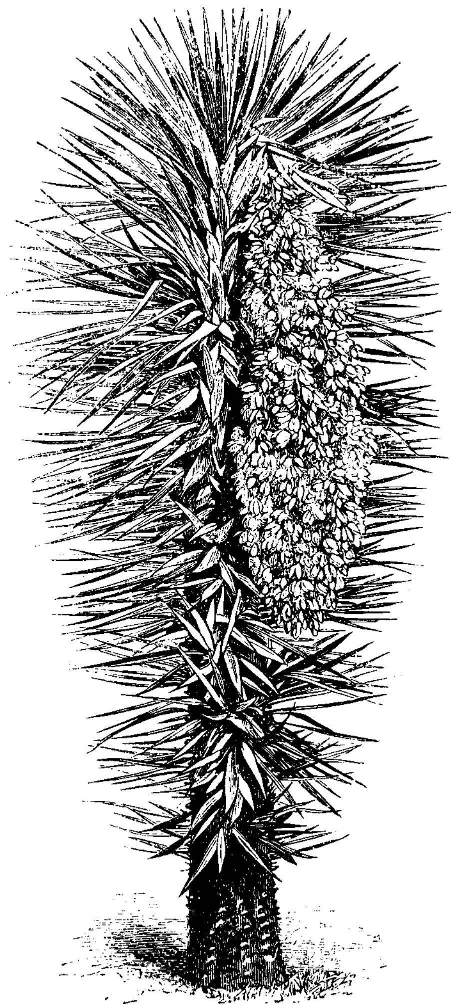

Frontiers in Ecology and the Environment

Strategic tradeoffs for wildlife-friendly eco-labels

Adrian Treves and Stephanie Michelle Jones

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Strategic tradeoffs for wildlife-friendly eco-labels

Adrian Treves[1*] and Stephanie Michelle Jones[1,2]

Labels on products are meant to influence consumer behavior. Consumers buying products labeled as eco-friendly may hope to help conserve the environment, but eco-labels vary in their claims and credibility. We define three types of wildlife-friendly eco-labels, according to their potential to conserve wildlife, and describe barriers to convincing consumers of their claims. Eco-labels we term "Supportive" donate revenues to conservation organizations and are, at best, indirect interventions, opaque to consumer scrutiny. "Persuasive" eco-labels certify manufacturing/collection practices, under the assumption that wildlife will benefit as a result. "Protective" eco-labels certify wildlife conservation, which can gain the highest level of credibility, but require the greatest verification effort. Proving that producers conserved wildlife is costly, time-consuming, and technically challenging, because wild animals ignore property boundaries and experience mortality and dispersal irrespective of people, but their population dynamics often obscure the role of human activities and economic practices. Nevertheless, wild animals are among the most inspiring and marketable components of the environment.

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Environmental conservation organizations have long sought the "holy grail" of market-based financing for the protection of nature. Ecotourism, hunting fees, and conservation banking are among the many examples of market-driven efforts to conserve wildlife and protect wildlands from destructive activities (Ferraro and Kiss 2002). More recently, the biodiversity conservation sector has sought consumer financing for conservation incentives. Among these efforts are various product-labeling and certification schemes (eco-labels), meant to offer a price premium or enhanced market access to producers who support wildlife conservation (van Amstel *et al.* 2007a,b). Given the growing interest in eco-labels for biodiversity conservation, here we focus on the reliability of claims that products are wildlife friendly. Because this paper specifically looks at wild animal conservation, our use of the term "wildlife" refers to animal life, unless otherwise noted.

In a nutshell:

- Eco-labels claim that purchases contribute to environmental protection; wildlife-friendly eco-labels claim to conserve wildlife
- We distinguish three types of wildlife-friendly eco-labels by how they certify products and what steps are taken to verify that wild animals were conserved
- The most credible but costly are "Protective" labels that must verify wildlife conservation in the vicinity of certified businesses
- Wildlife conservation poses special challenges for certifiers, because wild animal populations fluctuate naturally, and field verification of producers' impacts is slow, complex, and costly

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Connecting conservation-minded consumers with wildlife-conserving producers

Uniting consumers and producers in attempts to conserve wildlife depends on two things: (1) a direct incentive for producers to conserve wild animals that have meaning to consumers; and (2) an explicit and common-sense link between a preferred system of production (manufacture or collection) and the conservation of specific wildlife, either on land or in the oceans (Searle *et al.* 2004; Fischer *et al.* 2008). These requirements may rule out several conservation approaches that could effectively conserve wildlife, but do not meet the expectations of consumers or producers; for instance, reimbursing producers for the costs of coexistence with wildlife (eg compensation for wildlife damage to property) can generate perverse incentives, such as negligent defense of property by producers or retaliation against individuals of the species that caused the damage (Naughton-Treves *et al.* 2003; Bulte and Rondeau 2005). By contrast, linking revenues directly to successful reproduction or survival of wildlife is thought to foster pro-wildlife attitudes among commercial producers (Mishra *et al.* 2003; Schwerdtner and Gruber 2007; Zabel and Holm-Muller 2008). "Pay for living wildlife rather than dead livestock" is one common way of articulating the latter strategy and its link to conservation. Recruiting consumers to a particular wildlife conservation strategy demands different approaches from those used with producers. For example, sustainable harvest of wildlife has long been a tool in conserving certain species (Jackson 1996; Loveridge *et al.* 2007), but many consumers in wealthy nations view hunting as inhumane or anti-conservation (Holsman 2000; Peterson 2004). Thus, market approaches to wildlife conservation such as eco-labels will be most effective when they can be understood as wildlife-friendly by the widest possible set of consumers. The communication role of eco-labels is therefore critical to consumer recruitment.

Eco-labels are intended to signal to consumers that purchases help nature. Signal theory suggests that senders will try to manipulate receiver behavior (Alcock 1999), in the same way that product labels attempt to influence purchasing behavior (Ottman *et al.* 2006). The theory also tells us that receivers will discriminate against unreliable, inaccurate signals because poor choices have negative consequences for receivers. Although human communication is more complex, choosy consumers in a crowded marketplace do confront an array of different signals, with varying information content and reliability (van Amstel *et al.* 2007a). When the interests of both signaler and receiver align – as with conservation-minded producers and consumers – a reliable message can more effectively change receiver behavior (Dunwoody 2007). Many eco-label schemes embrace transparency, explicit standards, and third-party verification to convey their reliability and the accuracy of their information content (van Amstel *et al.* 2007a). These steps may build a bond with some consumers, but do not ensure market success.

Eco-labels face three challenges that are common to many environmentally preferable, product-marketing efforts (Ottman *et al.* 2006). Following Ottman and colleagues (2006), we call these the three C's: consumer value, credibility of claims, and calibration of marketing messages to reduce confusion.

(1) Consumer value

Most people buy products based on perceived quality or convenience, not the nebulous benefits of positive environmental outcomes (Oosterhouis *et al.* 2005). Environmentally preferable products must therefore also surpass the competition in one or more other dimensions. Eco-labels may enjoy an advantage, if they can credibly certify producers or clearly show evidence of wildlife conservation. This advantage might give producers access to dedicated markets and insulate them from competition with more mainstream producers.

(2) Credibility of claims

Creators and users of eco-labels may be the subject of consumer skepticism as well as environmental watchdogs, consumer interest groups, competitors, and a free press investigating the veracity of their claims. This scrutiny has led to the disappearance of eco-labeled products when producers were unable to prove their claims (Ottman *et al.* 2006). Agrobiodiversity conservation claims associated with sustainable agriculture are beginning to face such scrutiny in Europe (Oosterhouis *et al.* 2005; van Amstel *et al.* 2007a).

(3) Calibration of marketing messages to reduce confusion

Consumers face dozens of competing claims about products, but without the time or ability to evaluate the labels. Producers and distributors must therefore communicate the benefits of their goods quickly and easily to their target consumers. In the following section, we explore reliability, consumer confidence, and producer incentives as they relate to the wildlife conservation claims made on eco-labels.

Framework for understanding wildlife conservation claims of eco-labels

Wildlife creates particular challenges for producers who wish to use eco-labels, because verifying conservation successes and failures is complex, technical, and costly (van Amstel *et al.* 2007b; Salafsky *et al.* 2008). First, verifying whether a business has been instrumental in conserving wildlife is particularly challenging, because wildlife ignore jurisdictional property boundaries (Naughton and Sanderson 1996; Woodroffe and Ginsburg 1998). Second, wild animal populations experience complex, stochastic, long-term demographic changes that obscure the putative influences of humans (Adams *et al.* 2008; Robinson *et al.* 2008; Vucetich and Peterson 2009). Third, many species of conservation concern are wary of humans, due to past persecution (van Schaik and Griffiths 1996), which makes monitoring them expensive and difficult. Fourth, a number of wildlife species do damage property or threaten people, so incentives must at least offset losses, to prevent retaliatory killing (Woodroffe and Frank 2005; Long *et al.* 2007; Treves 2008; Zabel and Holm-Muller 2008). Finally, wild animals share complex ecosystems with other, interdependent organisms that may be adversely affected by human activities, making efforts for one focal species dependent on the conservation of others as well (Estes *et al.* 1998; Terborgh *et al.* 2002; Rooney and Anderson 2009). Credibly linking one producer to the success or failure of particular wild animals may therefore not always be possible. Nevertheless, many charismatic species are iconic in wealthy countries and may act as attractive marketing emblems.

Given the variables summarized above, it is not surprising that wildlife conservation eco-labels vary widely in their claims and their certification standards. In this paper, we use the term "verification" to mean gathering information specific to a product or business for systematic comparison with explicit standards, and we use the term "certification" to mean the decision by an authorized body to permit or prohibit use of an eco-label, based on

Figure 1. *Examples of the three types of eco-labels: (a) Supportive; (b) Persuasive; and (c) Protective.*

comparison of data collected during verification against a consistent set of pre-existing criteria (ie standards).

The various claims made on labels have different implications for wildlife conservation. Our review of company websites, as well as the academic and gray literature, suggested three functional types of eco-label: *Supportive*, *Persuasive*, and *Protective* (Figure 1). Each functional type has a different relationship to wildlife, threats, and the indirect factors contributing to those threats (sensu Salafsky *et al.* 2008; Treves *et al.* 2009). Products that claim to donate money to conservation organizations (Supportive eco-labels) ostensibly provide funds to remote actors who may be conserving wildlife. However, the verification process is complicated by the transfer of funds to a third-party recipient, who is usually not accountable to consumers. As a result, verification cannot go far beyond financial audits of the intermediary donor. Persuasive eco-labels claim to change manufacture, collection, or producer behavior in some way. These certify improved methods of production, but not actual wildlife conservation. Verification can vary from affidavits to third-party inspection of the production sites. Finally, Protective eco-labels claim to help conserve particular species or the ecosystems on which they depend. Verification rests on evidence that wildlife survived or reproduced successfully in and around the certified businesses and could range from producer reports of wildlife sightings to systematic, third-party monitoring of survival or reproduction among focal wildlife. Some eco-labels bridge the Persuasive and Protective categories by requiring that producers protect habitat and verifying such habitat conservation through site inspections (Table 1). We discuss the use of habitat as a proxy for wildlife conservation below. In sum, eco-labels can be viewed as interventions that affect conservation groups (Supportive), producers (Persuasive), or wildlife (Protective).

The functional differences between these three categories of eco-labels have important implications for consumer confidence and producer recruitment. By "consumer", we mean both the end-user of a product and consumer advocates. By "producer", we mean the manufacturer(s) or collector(s) responsible for assembly or production of an eco-labeled product.

Consumer confidence may not align or rise in parallel with producer incentives because of a fundamental trade-off in verification effort (Figure 2). The short-term effort needed to satisfy certifiers and verify applicants' claims will reduce producer participation and recruitment, despite the resulting potential long-term increase in con-

Table 1. Eco-labels evaluated and classified

Label	*Type*	*Products*	*Habitat protection**	*Website*
Marine Stewardship Council	Protective	Fish	Mandatory	www.msc.org
Tiger Friendly	Protective	Herbs	Mandatory	www.tigerfriendly.org
Certified Wildlife Friendly	Persuasive/ Protective	Food, apparel, toys	Mandatory	www.wildlifefriendly.org
FairWild	Persuasive/ Protective	Wild plants	Mandatory	www.fairwild.org
Snow Leopard Enterprises	Persuasive/ Protective	Wool products	Voluntary	www.snowleopard.org
Rainforest Alliance Certified	Persuasive/ Protective	Food products	Mandatory	www.rainforest-alliance.org
FishWise	Persuasive/ Protective	Fish	Ambiguous	www.fishwise.org
Aurora Certified Organic	Persuasive	Food products	Mandatory	http://demeter-usa.org/get-certified
Baystate Certified Organic	Persuasive	Food products	Voluntary	www.baystateorganic.org
Bird-Friendly Coffee	Persuasive	Coffee	Mandatory	http://nationalzoo.si.edu/ConservationAndScience/MigratoryBirds/Coffee/roaster.cfm
Various Certified Organic: CCOF, COFA, and CO State Department of Agriculture	Persuasive	Food products	Voluntary	www.ccof.org, www.cofa.net, www.certifiedorginc.org, and www.colorado.gov/cs/Satellite/Agriculture-Main/CDAG/1167928162828
Demeter Certified Biodynamic	Persuasive	Food products	Mandatory	www.demeter-usa.org
Dolphin Safe	Persuasive	Tuna	Ambiguous	www.earthisland.org/dolphinSafeTuna
Fair Trade Certified	Persuasive	Food products	Voluntary	www.transfairusa.org
Food Alliance Certified	Persuasive	Food products	Mandatory	www.foodalliance.org
Forest Stewardship Council	Persuasive	Wood products	Mandatory	www.fsc.org
Global GAP	Persuasive	Food products	Mandatory	www.globalgap.org
Green Seal	Persuasive	Manufactured goods, hotels, lodging	Voluntary	www.greenseal.org
Predator Friendly	Persuasive	Honey, wool products, meat, and eggs	Voluntary	www.predatorfriendly.org
Protected Harvest	Persuasive	Food products	Mandatory	www.protectedharvest.org
Salmon Safe	Persuasive	Food products; also urban areas, parks, natural areas	Voluntary	www.salmonsafe.org
Veriflora	Persuasive	Cut flowers, potted plants	Mandatory	www.veriflora.com
Organic Bouquet Wildlife Conservation Roses	Persuasive/ Supportive	Cut flowers	–	www.organicbouquet.com
Endangered Species Chocolate	Supportive	Candy	–	www.chocolatebar.com
MyLipStuff Charitabalms	Supportive	Lip balm	–	www.mylipstuff.com/charitabalms.html

Notes: *Mandatory = habitat protection required for certification; Voluntary = habitat protection recommended.

sumer confidence. If the certifier and producer attempt to defray the costs of certification and verification, consumers may have to pay higher prices for the labeled products. In short, increasing the verification effort will cut into profits, but raise consumer confidence, creating a conflict of interest between producers and consumers (Figure 2). The certifier is caught in the middle and will be under pressure to dilute standards or cultivate a niche market of dedicated consumers willing to pay premium prices.

Consumer confidence depends in part on how claims are verified and in part on who is communicating with the consumer. Recent research suggests consumers do not generally make extensive efforts to compare eco-labels before purchasing (Oosterhouis *et al.* 2005). Third-party informants – such as retailers, brands, and consumer advocates – may enjoy more consumer trust than the producers themselves, unknown brands, or unfamiliar messengers (Dunwoody 2007). Communication with consumers is beyond the scope of this work. Instead, we examine how the different conservation claims of eco-labels may be verified and the implications for consumer confidence.

Verification of eco-labels

The effort invested in verification should be optimized to match the standards for certification and the target level of consumer confidence. Certification standards range from trust in producer testimonials (affidavits from certified businesses) through independent (third-party) field verification, using approved scientific methods. We apply our three eco-label categories – Supportive, Persuasive, and Protective – to examine these different methods of verification and the meaning of certification. Indeed, Supportive, Persuasive, and Protective eco-labels experience different functional limits to credibility, because of inherent constraints on the verification methods they can apply (Figure 2).

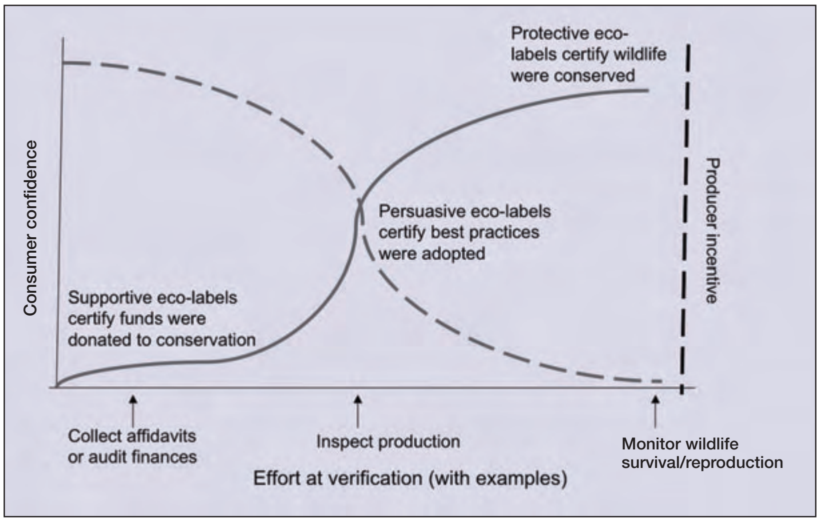

Figure 2. *The theoretical relationship between effort at verification (horizontal axis), consumer confidence in eco-label claims (solid vertical axis at left), and producer incentives to participate (dashed vertical axis at right). Examples of verification procedures are arrayed under the horizontal axis and line up with our three types of eco-labels within the graph. The pair of curves depict hypothetical producer incentives (dashed gray) and consumer confidence (solid gray).*

The funds generated by Supportive eco-labels can be audited, but it is practically impossible to go beyond this, because there is no legal obligation for the recipient to report precisely how it used funds. For example, Endangered Species Chocolate is a Supportive eco-label because it claims that "10% of net profits [are] donated to help support species, habitat, and humanity" (Endangered Species Chocolate 2009). Their website indicates that the company donates to various causes, including wildlife conservation. Organizations seeking support from Endangered Species Chocolate must apply for funds, and the website refers interested readers to recipients' websites for more information. The consumer must therefore be satisfied with the reputations and philanthropic messages of recipient organizations. Although an auditor can account for use of the funds, the skeptic will wonder if they are being well spent.

Persuasive eco-labels address production and its possible impacts on wildlife and habitats (Table 1). As a result, these tend to enjoy more credibility than Supportive eco-labels. Some Persuasive eco-labels rely on producers' affidavits to demonstrate adherence to conservation practices (eg Predator Friendly 2009). Other Persuasive eco-labels use site inspections to verify producer behavior (Searle *et al.* 2004; van Amstel *et al.* 2007a). For example, Salmon Safe is a Persuasive eco-label because it certifies various businesses, based on their pollution, land use, and other practices that may affect salmon watersheds. Use of the label is not contingent on verification of salmon survival or reproduction within the sphere of influence of each business (Salmon Safe 2009). Similarly, Dolphin Safe tuna certifies fishers who adopt practices that reduce bycatch of dolphins during tuna fishing (eg no encirclement of dolphins during a fishing trip or use of drift gill nets; Dolphin Safe 2009). Dolphin Safe is verging on being included in the Protective category, because its monitoring collaborator collects and publishes statistics on reduced dolphin bycatch worldwide (International Marine Mammal Project 2009), as evidence of wildlife conservation. However, the consumer may retain some doubt that a given shipment of tuna entailed no harm to dolphins. The doubt persists because the Persuasive eco-label depends on aggregate data from vast areas, and not on verification of the individual tuna fisher's impact on dolphins or the tuna industry's indirect impact on dolphin prey and ecosystems.

Protective eco-labels certify that wildlife survived or reproduced in and around the participating producers' properties. Most wildlife conservation eco-labels aspire to reach this level of certainty (eg Certified Wildlife Friendly 2009; Figure 3). Verification of improved survival of individuals of key wildlife species or upward trends in threatened species' population indices could earn higher credibility than other types of eco-labels. However, verification will involve time-consuming site visits to monitor wildlife, which may require trained staff and sophisticated methods. As a result, thorough verification of Protective eco-labels may be prohibitively expensive. The producer's incentive to participate is therefore likely to drop more quickly (Figure 2).

Relating credibility to consumer confidence and producer incentives

If one assumes that the profit curve in Figure 2 correlates strongly and positively with the incentive for producers to undergo certification, and that the confidence curve correlates well with the number of conservation-minded consumers who purchase the eco-labeled products, then it is possible to see two distinct strategies. To the left of the intersection of the two curves (Figure 2) are inexpensive products with eco-labels whose claims are opaque or unverifiable (low consumer confidence), but are produced in high volumes at low prices (many producers on-board). By contrast, to the right of the cross-over point there are lower volume, more costly products with verifiable claims that garner high consumer confidence and demand pre-

Figure 3. *Domestic alpaca from All Things Alpaca Ecuador – a Certified Wildlife-Friendly business.*

al. 2008). Several conclusions have emerged. When attempting to protect most or all of the biodiversity on a business property, the use of a single surrogate as an index of condition is unlikely to succeed. Current recommendations are to use multiple surrogates with diverse environmental tolerances and different sensitivities to human activities. By choosing the set of indicators carefully, the odds of an unmeasured species vanishing are expected to diminish. For Persuasive eco-labels that focus on one species (eg Dolphin Safe 2009), the indicator must be the most severe and urgent threat to that species. Indirect measures of the threat are unlikely to serve as good proxies. For example, measuring dolphin bycatch back in harbor may not be sensitive enough to detect if fishers dump bycatch out at sea. For Protective eco-labels – particularly those with a single focal species of concern (eg Tiger Friendly 2009) – one needs to focus on the key indicators of reproductive performance or survival to be confident that the population is being protected. There is no acceptable surrogate species, and thus the measures of condition must be chosen well to confirm conservation success.

mium pricing to offset the costs of field verification. A number of industry-specific and local variables will determine the precise shape of the curvilinear relationships and the optimal point for verification effort; for example, new monitoring or production technologies (Figure 4) may enhance consumer confidence without costing producers more.

The effort invested in verification to assess compliance with certification standards depends critically on what is measured, and by whom. Verification by a third party offers consumers the most confidence, but incurs the highest costs. The scientific fields of conservation biology and biodiversity science have debated indicators of successful conservation for years (Groves 2003; Salafsky and Margoluis 2003; Roberge and Angelstam 2004; Salafsky *et*

The diversity of products under an eco-label will also affect the methods of verification. Many – if not most – eco-labels are tied to one or a few products or commodities (Table 1). Such "narrow scope" eco-labels include sustainably harvested fish (Fishwise 2009) and sustainably grown nursery plants (eg VeriFlora 2009). In contrast, some certification standards apply to a wide variety of commodities, connected by a desired environmental outcome. Among the "broad scope" eco-labels, we find Salmon Safe and Certified Wildlife Friendly, because very different businesses (foods, urban and natural areas, and foods, apparel, and toys, respectively) are being certified. The breadth of products covered by an eco-label will also determine how many producers will seek, or qualify for, certification.

Regarding producers, analysts debate how to balance the stringency of standards against recruitment of many producers. Some argue that expanding the producer pool dilutes environmental standards and serves bigger business interests rather than small producers (Guthman 1998). In an assessment of Marine Stewardship Council-certified fisheries, Searle *et al.* (2004) advocated low initial standards to recruit more producers, while attaching requirements that such producers continually improve their production processes. Properly executed, such compromises may allow fledgling certification efforts to survive and recruit many producers, as

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Figure 4. *A wild Andean (or spectacled) bear (*Tremarctos ornatus*) photographed by a motion-activated camera on the property of All Things Alpaca Ecuador.*

well as helping to spread more sustainable practices throughout an industry. Indeed, several environmental certification efforts are credited with raising consumer awareness of threats to the environment and of promoting less-damaging manufacturing practices (Bartley 2003; Oosterhouis *et al.* 2005; Ottman *et al.* 2006).

Novel alliances for certification

Eco-labeled products must compete in a crowded market with hundreds of brands and labels touting any number of benefits to the consumer. The obstacles to success in the marketplace go beyond branding and include trade regulations, quality and volume demands of retailers, and many other impediments to swift sales (Aquino and Falk 2001). Wildlife conservation organizations tend to be unprepared for this arena. Those attempting eco-labeling would do well to collaborate with business experts to design effective marketing campaigns and organize collectively, so expertise in verifying wildlife conservation is connected to expertise in reaching retail and wholesale outlets and persuading consumers. Wildlife conservation organizations and new graduates with expertise in environmental monitoring may find new niches as verifiers of eco-friendly manufacturing.

Conclusions

There is a fundamental, strategic tradeoff in the design and marketing of eco-labels, which is epitomized by wildlife-friendly eco-labels: transparent and effective verification increases consumer confidence, but lowers the incentive for producers to change practices and apply for certification. This conflict between producer and consumer puts pressure on certifiers to relax standards or cut the costs of verification, or alternatively to raise the costs of eco-labeled products. The former dilutes the meaning and value of the label, but expands market access, whereas the latter creates a niche market populated by only a few, dedicated consumers.

Supportive eco-labels – those donating profits to conservation – will never attain the highest level of credibility, because improvements in the environment are indirect and opaque to consumers. By contrast, eco-labels that encourage businesses to change production processes (Persuasive eco-labels) and those that demonstrably conserve the environment (Protective eco-labels) can gain higher credibility. However, they face obstacles to success because of the costs of field verification. Indeed, widespread profitability for Persuasive and Protective certification schemes may not be a realistic goal (Searle *et al.* 2004). Successful wildlife conservation through eco-labeling schemes demands the careful planning of wildlife-friendly production – balancing producers' needs, wildlife needs (Fischer *et al.* 2008), and consumer needs (Ottman *et al.* 2006).

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Camera-trapping forest–woodland wildlife of western Uganda reveals how gregariousness biases estimates of relative abundance and distribution

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ABSTRACT

Camera traps are increasingly used to estimate relative abundance and distribution of wildlife. These methods are powerful and efficient ways to inventory multiple species simultaneously and count rare, secretive individuals across landscapes. However the estimation methods demand assumptions about relative capture probability that may not hold well for gregarious animals. We present results from the first systematic, camera-trap study in forest–woodland, western Uganda. Within a landscape of seven protected areas with globally important biodiversity, we detected >36 species of large mammals and birds in 8841 camera-trap days. Species photographed in groups of two or more individuals produced higher estimates of relative abundance and wider distribution than species photographed as single individuals. We propose these findings reflect higher detectability for animals that forage or travel in groups. We discuss how capture–recapture theory should be adapted to account for both non-independence among individuals in groups and for the interaction between individual and temporal variation in capture probability. We also identify several species that deserve greater conservation attention in Uganda and beyond. Among them, leopards were unexpectedly rare, especially when compared to the sympatric African golden cat. We recommend against a recent policy on leopard trophy hunting, at least in western Uganda.

1. Introduction

Monitoring multiple wildlife species across a wide area can be prohibitively costly in time, personnel, and resources (Field et al., 2005; Gompper et al., 2006; Long et al., 2007; Manley et al., 2004). Thus automatic cameras triggered by motion or body heat are increasingly being applied to species inventories, abundance estimation, and evaluation of conservation efforts (Balme et al., 2009; Mccarthy et al., 2008). Such "camera traps" may also reveal humans or associated threats to habitats and wildlife (O'Brien et al., 2003; van Schaik and Griffiths, 1996). Therefore the data from camera traps can help conservation planners to assess progress toward conservation goals and to target and design interventions (O'Brien et al., 2010; Wegge et al., 2004).

Camera traps are especially useful if conditions preclude direct observation or efficient indirect surveys. Wild animals using rugged topography, dense vegetation, or nocturnal conditions and those wary of humans have all been successfully photographed using camera traps (Larrucea et al., 2007; Maffei et al., 2004; Mccarthy et al., 2008; Silver et al., 2004). Camera traps provide precise estimates of the number of species of large (>1 kg), terrestrial mammals and birds (O'Brien et al., 2003; Tobler et al., 2008) and allow estimation of abundances based on individual identification for some species (Henschel and Ray, 2003; Karanth et al., 2004; Silver et al., 2004; Wegge et al., 2004). Abundance estimates from camera-trap surveys have also been validated by calibration with other methods with some caveats (Balme et al., 2009; O'Brien, 2008; O'Brien et al., 2003; Wegge et al., 2004). However, estimates of abundance and distribution from camera-trap studies must be treated with caution given the major potential bias arising from differential detectability of individuals or species.

Relative detectability is expected to correlate positively with time spent near camera sensors. The duration and also the frequency of visits may increase under several common conditions. If animals are large-bodied, slow-moving, or if wildlife is attracted to the cameras by novelty, lure or bait, then they may linger and produce numerous photos in one visit (Larrucea et al., 2007; Tobler et al., 2008; Zug, 2009). Commonly researchers avoid this by discarding photos of the same species within a set time interval such as 0.5 h (O'Brien et al., 2003). Similarly, the frequency of visits to camera-trap stations may increase if animals prefer microsites selected and accessible by researchers using camera traps (e.g., terrestrial vs. arboreal), if the animals have small home ranges, or if

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the wildlife habituate to signs of people (Larrucea et al., 2007; O'Brien et al., 2003). By the same logic, we predict that detectability may also increase with gregariousness and site fidelity as follows. Gregariousness may increase detectability in a number of ways. For a single source with descriptions of how diverse animals move in groups (see Boinski and Garber, 2000). Social facilitation occurs if one group-member draws the attention of others to an object; it has been demonstrated in studies of visual attention to associates and studies of foraging behavior in gregarious primates and birds (Treves, 2000; Vickery et al., 1991). Social facilitation could increase the number of different individuals photo-captured in the same group and thereby elevate the probability of recapturing a particular, marked individual. Furthermore, repeat visits over intervals of minutes to hours might occur if groups meander back and forth during foraging more than singletons. Gregarious animals that forage on small arthropods and concentrated fruits are noted for such meandering and return visits over various intervals (Robinson, 1986; Waser, 1981). Site fidelity such as territoriality or central place foraging (Larrucea et al., 2007; Waser and Wiley, 1979) would also tend to increase the frequency of revisits to a few camera stations. Differences between species in the duration of visits to foraging patches and the frequency of their revisits have been documented for many species (Boinski and Garber, 2000). In addition to increasing photo-captures at one or a few stations, gregariousness could increase the apparent spatial distribution of a species. Large groups tend to travel further than small groups within many species (Wrangham et al., 1993), hence larger groups may cross a greater number of different camera stations. Finally, species with nomadic movements or large numbers of dispersers might produce many scattered photos of the same individuals especially if cameras are distributed along habitual travel routes such as human-made paths (Maffei et al., 2004; Wegge et al., 2004). Social organization and individual differences in the costs and benefits of gregariousness underlie many of these predictions as short-term associations (e.g., mating associations), seasonal fluctuations in grouping, and behavior within groups produce differential patterns of association among individuals and among species. In short, complex, temporal and spatial variations in social behavior may affect the number of photos collected in a camera-trap survey and the temporal and spatial distribution of such photos.

Here we present results of the first camera-trap study of the forests and woodlands of western Uganda (Fig. 1). We present species inventories from 8841 camera trap-days at 192 separate stations in seven protected areas (Table 1). We present measures of species richness for a landscape pool of 36 taxa and estimates of spatial distribution at three scales. We explore relative detectability as a function of two estimates of gregariousness taken from our own study, as well as female body mass, female home range size, and microsite use, all estimated from the literature. We end by calling attention to several species needing conservation attention including information for an ongoing debate about hunting leopards (*Panthera pardus*) in Uganda.

2. Methods

We placed camera traps in seven protected areas (PAs, Fig. 1). Three were national parks (NPs) and four were Forest or Wildlife Reserves (Reserves) but average size of NPs and Reserves was the same (Table 1: median test $X^2 = 1.0$, $df = 1$, $P = 0.31$). The two categories experienced different levels of protection and management attention in Uganda (Howard, 1991; Uganda Wildlife Authority, 2000). All camera-trap (CT) stations were in the northern Albertine Rift, which stretches from the northern tip of Lake Albert to Lake Tanganyika, Tanzania. The Albertine Rift is one of the most species-rich regions on earth (Plumptre et al., 2007a). Four of the PAs in this landscape have been noted for species richness or high numbers of endemic vertebrates and threatened species: Kibale NP, Bwindi NP, Rwenzori NP, and Kasyoha–Kitomi Reserve (Plumptre et al., 2007a). All the protected areas are ascribed to the Greater Virunga Landscape and adjoin densely settled areas or Virunga National Park, across the frontier of the Democratic Republic of Congo (Plumptre et al., 2007b; Treves et al., 2009).

We positioned CT stations (film Camtrakkers) in one of two ways. Where access was difficult (Kasyoha–Kitomi $n = 49$ CT stations, Maramagambo $n = 25$, and Kalinzu Reserves $n = 23$), we mapped transects by Systematic Segmented Trackline Sampling using DISTANCE software (Thomas et al., 2006). We then walked these transects, cut occasionally for access, and placed CT stations only where wildlife trails or sign crossed transects. In all other PAs, CT stations were placed along wildlife trails or within 6 m of a trail used by people or wildlife but no transects were cut because access was easier. No two CT stations were placed within 200 m of each other and most were 0.5–1 km apart, clustered in localities within PAs. The locations of individual CT stations are not necessarily discernible in our map due to scale but localities can be seen as clusters of CT station points (Table 1; Fig. 1). GPS locations of CT stations are available from the authors. Localities were distinguishable to the field teams by obvious habitat or topographical differences. Thus we adopted a stratified approach within each PA but the placement of CT stations was somewhat haphazard within the constraints of the criteria mentioned above. Indeed this study spanning a long period with two field team leaders (SI and PM) working at different PAs may include interobserver differences that add to or confound intersite and interannual variations. This raises the possibility that we under- or over-represented species that preferred the habitats accessible to us. This is a common bias in camera-trap studies – one alternative would have been to cut vegetation around camera traps to improve human access but that approach carries with it different biases.

We identified most wildlife photos to species (Appendix 1 for scientific names). However a few were difficult to distinguish or taxonomically unresolved so we pooled them at the level of genus or family (genets, mongooses, squirrels) but for simplicity we refer to them as species.

We followed common recommendations on sampling a wide area to capture far-ranging species and using many CT stations for long periods (O'Brien et al., 2010; Tobler et al., 2008). However, our mixed design for CT station placement over several years demands caution in interpreting differences in species richness between PAs. Differential use of wildlife trails could bias for and against some species and individuals (Harmsen et al., 2009; Larrucea et al., 2007; Maffei et al., 2004). Also the multi-year span of the study could confound temporal changes in species richness (turnover, colonization, local extinction, etc.) with differences between PAs.

Because we did not resample the same CT stations at successive seasons and within-seasons, we have no objective way to define resampling intervals. Hence our design did not meet the demands of occupancy analysis for two key reasons. First, robust and precise estimation of occupancy demands an appropriate model of detection probability as a prerequisite (Bailey et al., 2007). Our "model of detection probability" (which we call detectability) is based on rank correlations (i.e., relative between species) not an absolute probability of detection. Furthermore our data contain neither temporal replication between-seasons nor objective criteria for within-season replication, yet "occupancy estimators were generally less biased under designs that include temporal survey replication both within *and* among seasons..." (emphasis added, p. 289 Bailey et al., 2007). Although we might adopt an arbitrary interval to designate a temporal replicate, that could be biased by variable likelihood of photo-capture over time, e.g., trap shyness (Wegge et al., 2004). Our results on detectability can guide future efforts

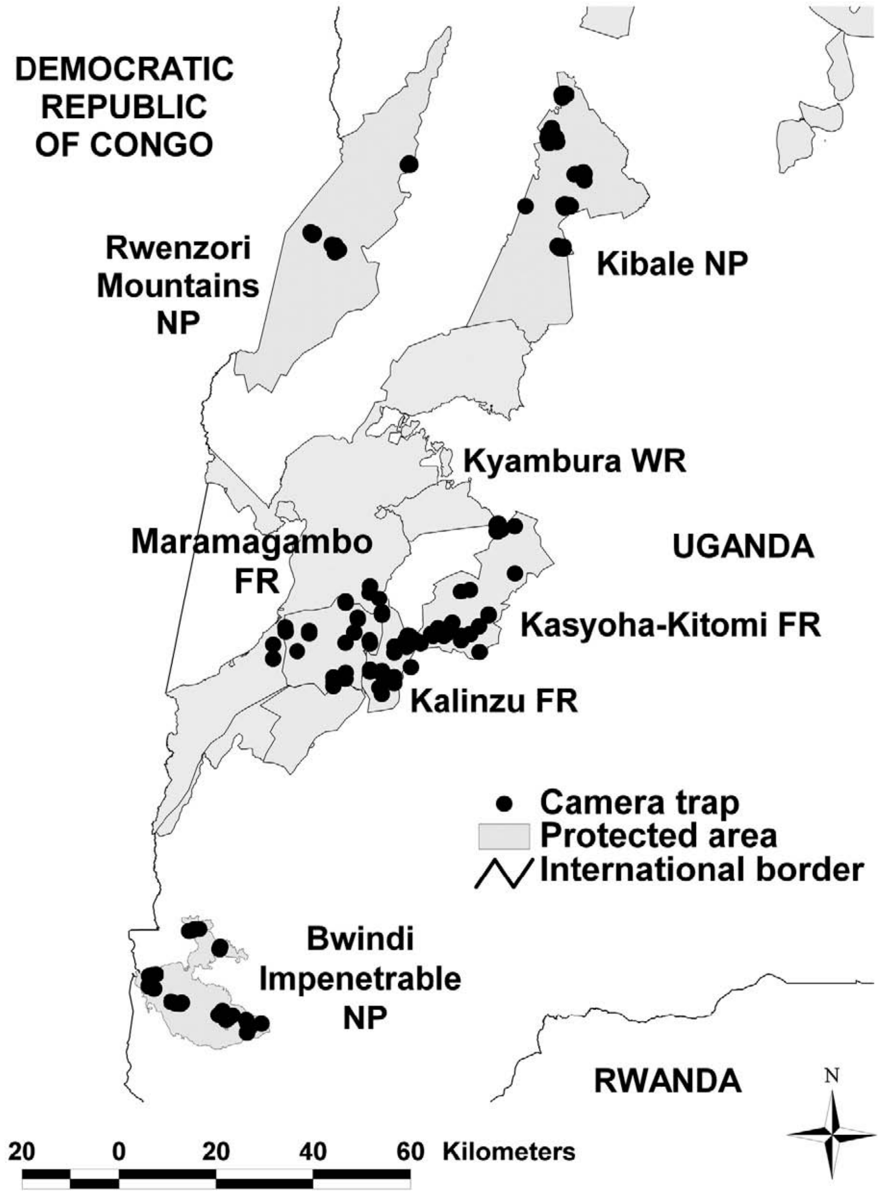

Fig. 1. Western Ugandan protected areas sampled with camera traps (dark circles).

Table 1
Wildlife photo-captured in seven protected areas of western Uganda 2004–2008.

Protected area (km^2)[a]	*N* of independent				Species richness		Abundance indices		
	Trap-days	Localities	CT stations	Photo-captures (wildlife)	Observed	As % of total	Humans/100 trap-days[b]	Species/100 trap-days	Photo-captures/ 100 trap-days
Bwindi NP (321)	864	5	28	225	18	50	46.875	2.083	26.042
Kalinzu FR (137)	1498	1	23	101	7	19	0.334	0.467	6.742
Kasyoha–Kitomi FR (399)	2345	6	49	141	20	56	2.4733	0.853	6.013
Kibale NP (764)	1318	5	45	313	19	53	5.083	1.442	23.748
Kyambura WR (157)	602	2	12	39	10	28	1.163	1.661	6.478
Maramagambo FR (580)	893	1	25	92	17	47	1.904	1.904	10.302
Rwenzori NP (996)	1321	3	10	37	5	14	1.363	0.379	2.801
Total	8841	23	192	948	36	100			

[a] NP = National Park, WR = Wildlife Reserve, FR = Forest Reserve.
[b] Includes domestic animals with or without humans and sums individuals in all photos.

to estimate detection probabilities but that will require resampling our sites. Therefore we limit ourselves to two sets of analyses relating to photo-capture rates and interspecific variation in detectability.

2.1. Photo-capture rates

We report estimates of observed species richness and proportional species richness as a percentage of the total species inventory for the study. We also report the number of CT stations, localities, and PAs at which a species was photographed as indices of relative distribution over the landscape. To index relative abundance, we follow (O'Brien et al., 2003) and calculate independent photos per 100 CT station-days (RAI_2) with one difference. We do not have records of time (only date) on our photos, so we defined photos to be independent when taken of the same species in the same CT station on different days. Thus any large group passing a CT station multiple times in 1 day would still be recorded as one independent photo no matter how many other species were interspersed or how many animals were photographed. This is more conservative than the latter authors' criterion of 0.5 h between successive photos of the same species or interspersion of different species. It should be noted that mixed-species associations including terrestrial forms such as baboons, L'hoest's monkeys, duikers, bushpigs, and guinea fowl are not uncommon in these forests (Struhsaker, 1997; Treves, 1997; Waser, 1987). Therefore we explored detectability by analyzing the associations between species characteristics on the one hand and RAI_2 and the indices of spatial distribution on the other hand.

2.2. Detectability

We collated species data on MASS (natural log of female body mass), RANGE (natural log of female home range size), and categorized species' habitat specialization HABITATS as *t*, *f*, or *t* + *f*, where *t* = primarily terrestrial travelers vs. arboreal, volant, or semi-aquatic travelers, and *f* = species found at higher densities in forests or woodlands than more open habitats, all from (Dorst and Dandelot, 1993; Estes, 1991) and personal observations of the authors. We also used the mean and maximum observed group sizes from our photos (GROUPMEAN and GROUPMAX respectively). Note that large-bodied animals might have had smaller average values when calculated this way because fewer can fit in one photographic frame but we found no such correlation in our dataset (our measures of gregariousness vs. female mass: $r_s < 0.05$, $P > 0.80$ in both tests).

For the categorical predictor of habitat specializations (HABITATS) we employed the non-parametric median test with chi-squared approximation and $df = 2$. For the four continuous predictors (MASS, RANGE, GROUPMEAN, and GROUPMAX) we employed the Spearman rank correlation coefficient. The indices of abundance and the count data of number of photos violated the assumption of constant variance for linear correlations so we ran non-parametric statistics in JMP 8 (SAS Institute 2009). We accepted $\alpha \leqslant 0.04$ to correct for the 25 tests we ran.

3. Results

3.1. Species richness, abundance, and inventories

In 8841 CT station-days we collected 1750 useful photographs. Setting aside 335 photos of humans or domestic animals, the remaining 1415 contained 948 (67%) independent photos of 36 wildlife species. Cameras detected 5–20 species per PA or 14–56% of the total pool (Table 1). NPs and Reserves did not differ in total number of humans photo-captured, number of wildlife species photo-captured, or independent photos, all divided by CT-days ($df = 1$, $X^2 < 1.1$, $P > 0.30$ for all tests).

We photo-captured the greatest number of species at Kasyoha–Kitomi, but Kibale, Bwindi, and Maramagambo yielded almost as many with less effort (Table 1). RAI_2 of all wildlife at PAs varied from 2.8–26.0 (Table 1), with Kibale and Bwindi NPs having 2–3 times the relative abundances of the Reserves. Rwenzori NP approximated one-third of the abundances of the Reserves (Table 1). We fitted an exponential curve to the number of species photo-captured at a PA against the number of CT-days and found that after about 1000 CT-days and 18 species, the detection of new species approached an asymptote. Therefore we probably under-estimated species richness at Kyambura with only 12 species, and possibly Bwindi and Maramagambo with 18 and 17 species respectively (for a warning against asymptote-fitting, see O'Brien, 2008).

The most diverse groups photo-captured were the eight genera of carnivores, five genera of non-human primates, and eight genera of ungulates or megaherbivores, which included 6–7 species of duikers (Table 2, Appendix 1). The most commonly photo-captured species in the NPs were all duikers: yellow-backed (Bwindi), red (Kibale, species indeterminate), and black-fronted (Rwenzori). The single photo of a red-flanked duiker may have been an old individual of black-fronted duiker (Plumptre, unpublished data), so we omit further discussion of it. By contrast, olive baboons were the most commonly photo-captured species at all four Reserves. Cameras in the NPs detected eight species not detected at the Reserves (great blue turaco, helmeted guineafowl, handsome francolin, African white-bellied pangolin, red duiker, redtail monkey, Rwenzori duiker, and African wild cat), whereas cameras in Reserves detected seven species not detected in the NPs (black-and-white colobus, giant forest hog, hippopotamus, leopard, spotted hyaena, squirrels, and waterbuck; Table 2).

Species varied in spatial distribution. They were detected at 1–58 CT stations, 1–23 localities, and 1–6 PAs. Baboons and L'hoest's monkeys were the most widespread. Different species were photo-captured 1–230 times (mean 39, sd 56) with 1–119 independent photos per species (mean 27, sd 37). RAI_2 values for species varied from 0.05 to 6.22 (mean 0.72, sd 1.15) independent photos per 100 CT-days.

Species varied in gregariousness. The largest groups photo-captured were helmeted guineafowl (up to nine) and olive baboons (up to six). Fifteen other species were photographed in pairs or trios (Table 2).

3.2. Detectability

The total number of photos we obtained of a species was highly correlated to the indices of abundance and spatial distribution: RAI_2, and the numbers of CT sites, localities, and PAs at which that species was detected ($r_s = 0.87$, 0.96, 0.91, and 0.71 respectively; $P < 0.0001$ in every case). GROUPMAX was significantly, positively correlated with all the photo-capture measures whereas GROUPMEAN was associated with RAI_2 only (Table 3). Species with GROUPMAX > 1 had significantly higher RAI_2 than those with GROUPMAX of 1 ($df = 1$, $X^2 = 13.1$, $P = 0.0003$). HABITATS predicted RAI_2, and the numbers of CT stations and localities at which a species was photo-captured. All the significant relationships were in the predicted direction.

An anonymous reviewer suggested our method may under-estimate the abundance of territorial, solitary species with our conservative criterion for independence between photos. For example if we unwittingly placed cameras near the boundaries of small territories (e.g., paths), we might have discarded numerous photos of different individuals visiting an area of overlap between their ranges, on the same day. We tested this prediction *post hoc* by calculating the number of photos discarded (total photos – independent photos) and testing if that number differed between species photo-captured in groups or solitary. The result was significant ($df = 1$, $X^2 = 6.9$, $P = 0.009$) but in the direction opposite to that predicted; namely we discarded more photos of gregarious species (22 sd 31 vs. 4 sd 8 photos discarded on average)–suggesting a less conservative approach would have further inflated the photo records of gregarious species.

Table 2
Wildlife species photo-captures and characteristics.

Wildlife[a]	Protected areas[b]	CT stations (localities)	Total photos	Independent photos	RAI_2[c]	Group size mean (range)	MASS (kg)	RANGE (km^2)	HABITATS[f]
Baboon, olive	Bw, Ka[b], Kk[b], Ki, Ky[b], Ma[b]	58 (23)	230	119	1.58	1.5 (1–6)	11.5	22.0	t, f
Black-and-white colobus	Kk, Ky	4 (3)	6	4	0.14	1.2 (1–2)	8.3	0.2	f
Black-fronted duiker	Bw, Kk, Rw[b]	30 (6)	118	101	1.73	1 (1–2)	13.9	na	t, f
Blue duiker	Ka, Kk, Ki, Ma	41 (17)	140	111	1.83	1 (1–3)	4.9	0.1	t, f
Blue monkey	Ka, Kk, Ki, Rw	4 (4)	6	4	0.05	1 (1)	4.0	0.2	f
Buffalo, cape	Ki, Ma	2 (2)	3	2	0.09	1 (1)	576.0	10.5	t
Bushbuck	Ka, Kk, Ki, Ma	24 (15)	72	50	0.83	1.1 (1–2)	42.5	0.0	t, f
Bushpig	Bw, Ka, Kk, Ki, Ma	24 (11)	44	30	0.43	1.2 (1–3)	70.0	5.1	t, f
Chimpanzee	Bw, Ka, Kk, Ki, Ky, Ma	45 (15)	104	76	1.01	1.2 (1–3)	38.0	3.0	t, f
Civet, African	Bw, Ki, Ma	10 (6)	18	15	0.49	1 (1)	13.5	na	t, f
Elephant	Bw, Kk, Ki, Ky, Ma	22 (13)	129	45	0.75	1.1 (1–3)	3250	1757	t
Gambian rat	Ka, Kk, Ki, Ky	8 (6)	12	9	0.16	1 (1)	1.0	na	t, f
Genets	Kk, Ki, Ky, Ma	9 (7)	14	11	0.21	1 (1)	1.8	2.6	
Giant forest hog	Ma	2 (1)	4	3	0.34	1.3 (1–2)	180.0	na	t, f
Golden cat, African	Bw, Kk, Ki, Ma	11 (6)	13	12	0.22	1 (1)	6.2	na	t, f
Great blue turaco	Ki	1 (1)	3	2	0.15	1.3 (1–2)	1.0	na	f
Guinea fowl, helmeted	Bw, Ki	19 (11)	42	28	1.28	2.4 (1–9)	1.1	na	t, f
Handsome francolin	Bw	4 (3)	16	13	1.51	1.3 (1–3)	1.0	na	t, f
Hippopotamus	Kk, Ky, Ma	7 (5)	26	20	0.52	1.1 (1–2)	1400	na	t
L'hoest's monkey	Bw, Kk, Ki, Ma, Rw	55 (17)	127	91	1.13	1.1 (1–3)	3.5	na	t, f
Leopard	Ma	2 (1)	2	2	0.22	1 (1)	43.0	17.5	t, f
Mongooses[d]	Bw, Kk, Ki, Ky, Rw	7 (7)	11	9	0.12	1 (1)	2.7	3.4	t, f
Mountain gorilla	Bw	4 (2)	8	4	0.46	1.5 (1–3)	85.0	6.0	t, f
Pangolin, African white-bellied	Bw	1 (1)	1	1	0.12	1 (1)	2.5	na	t, f
Red duiker	Ki[b]	26 (13)	109	82	6.22	1 (1)	13.6	0.1	t, f
Red-flanked duiker[e]	Bw	1 (1)	1	1	0.12	1 (1)	12.5	na	t, f
Redtail monkey	Ki	1 (1)	1	1	0.08	1 (1)	2.0	0.2	f
Rwenzori duiker	Rw	1 (1)	2	2	0.08	1 (1)	15.0	na	t, f
Serval	Kk, Ki	2 (2)	3	2	0.06	1 (1)	11.0	15.5	t, f
Side-striped jackal	Bw, Kk, Ky	8 (5)	9	9	0.24	1 (1)	8.3	2.5	t
Spotted hyena	Ma	1 (1)	1	1	0.11	1 (1)	71.0	30.0	t
Squirrel spp.	Kk	3 (2)	4	4	0.17	1.3 (1–2)	1.0	na	f
Waterbuck	Ma	1 (1)	1	1	0.11	1 (1)	186.0	6.0	t
Weyn's duiker	Bw, Kk, Ky, Ma	15 (8)	17	16	0.34	1.1 (1–2)	15.0	na	t, f
Wild cat, African	Bw	1 (1)	1	1	0.12	1 (1)	4.0	0.8	t
Yellow-backed duiker	Kk, Bw[b]	25 (8)	116	92	2.87	1 (1)	68.0	na	t, f

[a] One unknown species (blurry photo) excluded; Scientific names in Appendix 1.
[b] Bw = Bwindi, Ka = Kalinzu, Kk = Kasyoha–Kitomi, Ki = Kibale, Ky = Kyambura, Ma = Maramagambo, Rw = Rwenzori, identifies the species-PA pairs that were most common (most independent photos).
[c] Independent photos per 100 CT-days.
[d] Two species identified plus one unidentified.
[e] Possibly an old black-fronted duiker.
[f] Mainly terrestrial = t, higher densities in forest or wooldands = f, see Methods for criteria.

HABITATS did not show constant variance against RAI_2 ($F = 5.8$, $df = 2, 13.7$, $P < 0.015$) and the residual plots for GROUPMAX and GROUPMEAN appeared heteroschedastic, so we did not attempt multivariate linear analysis. When we set aside the non-terrestrial (semi-aquatic, volant, and arboreal) travelers, GROUPMAX and GROUPMEAN were still strongly correlated to RAI_2 ($n = 28$, $r_s = 0.61$ and 0.51, $P < 0.0031$ in both cases) suggesting microsite preferences did not confound the association with gregariousness.

Finally, to assess rarity in the landscape we used our most conservative measure of spatial distribution (number of PAs in which a species was photo-captured), discarded non-terrestrial travelers and used RAI_2 to index abundance (Table 4). We also omitted species groups (mongooses, genets) because we felt conclusions about their rarity were premature without specific resolution. Six species were localized in 1–2 PAs and in the lowest quartile for RAI_2, and another three had intermediate abundances but were localized in 1–2 PAs (Table 4).

4. Discussion

We found several species-specific characteristics associated with the number of photos and the number of sites at which a species was detected. Thus we are building upon prior work that showed detectability varying with species traits and behavioral ecology (Larrucea et al., 2007; Long et al., 2007; O'Brien et al., 2003; Tobler et al., 2008). Prior work showed how detection probability can confound estimates of abundance and spatial distribution made from camera-trap photos. For example, non-breeding, younger coyotes, *Canis latrans*, were more detectable than others and detectability of the same age–sex classes even varied by season and microsite (Larrucea et al., 2007). Between species, detectability was higher for habitat generalists, terrestrial forms, and large-bodied species (O'Brien et al., 2003; Tobler et al., 2008). Microsite use was only weakly associated with relative abundance between species in our study, probably because few non-terrestrial species appeared in our pool. We did not find female body mass or female range size associated with abundance or distribution but these variables taken from the literature were crude and may not have adequately differentiated the populations within our landscape. By contrast, gregariousness indexed as the mean or maximum group size in our photos was strongly correlated with relative abundance and the indices of distribution.

There are two possible interpretations of the latter finding. First, species observed in groups of two or more might be found at higher densities than ones photographed singly across most of our sites. Consistent with this, all carnivores from genets to hyaenas were photo-captured alone (Table 2) and carnivores generally occur at low densities because of their diet. But gregarious species

Table 3
Univariate tests of detectability.

Wildlife characteristics[a]	Test[b]	RAI_2	CT stations[c]	Localities[c]	PAs[c]
HABITATS	X^2	8.2	7.3	8.6	1.7
	P	**0.017**	**0.026**	**0.013**	0.428
GROUPMAX	r_s	0.62	0.53	0.51	0.35
	P	**<0.0001**	**0.0009**	**0.0013**	**0.038**
GROUPMEAN	r_s	0.49	0.33	0.30	0.15
	P	**0.0023**	0.053	0.076	0.395
MASS	r_s	0.11	0.07	0.00	0.03
	P	0.521	0.708	0.991	0.877
RANGE	r_s	−0.10	−0.16	−0.18	0.09
	P	0.664	0.495	0.458	0.704

[a] Definitions in Methods and Table 2.
[b] Median test ($df = 2$) or Spearman rank correlation ($n = 36$ except for RANGE $n = 20$ and HABITATS n=35).
[c] Definitions in Methods and Table 1.

widely considered rare or in low-density populations (chimpanzee, elephant, giant forest hog, hippopotamus, L'hoest's monkey, mountain gorilla) produced estimates of relative abundances above the observed median of 0.23. A more likely explanation is that the index of relative abundance was inflated for gregarious species. This inflation could arise from repeated photo-capture at the same camera-trap stations. Indeed we found more photos of gregarious species in the same day (discarded from analyses) and across multiple days at the same camera-trap stations or different ones (Table 3). In sum, gregarious species appeared to revisit camera traps more than species photographed as singletons and gregarious species also appeared more widespread or having larger ranges. We recommend further research into detection probabilities of gregarious animals, using marked or known individuals to estimate the functional relationship between different group sizes, ranging patterns, and independence of recapture intervals. We also recommend adoption of a more conservative interval than 30 min between photos of the same species at a given camera-trap station.

Because we found significant differences in relative abundance for species with maximum group sizes of two or more, we believe this potential bias is widespread. Interindividual proximity and even overlap in range use will vary by species, season, site, and individual even among "solitary" species (Harmsen et al., 2009). Because gregariousness varies by numbers and proximity of kin, mates, and other associates, we encourage additional study of gregariousness and range overlap before estimating abundance of wild animals without individual identification. For capture-recapture theory, the predominant software (CAPTURE) assumes individual variation and temporal variation have independent effects on capture probabilities (Otis et al., 1978). We predict several common features of groups as small as two animals violate that assumption. If the probability that an individual joins a group varies among groups (by size, location, season, etc.) and among individuals (by rank, sex, dominance, etc.) then individual and temporal variation in capture probabilities will not be independent but rather strongly interacting. A number of primate, carnivore, and ungulate groups fuse, split, and change as individuals come and go in relation to changing costs and benefits of association and resource availability (Chapman et al., 1995; Larrucea et al., 2007; Waser and Wiley, 1979; Wrangham et al., 1993). Males and females, adults and young, or dominants and subordinates often differ in their propensity to associate and travel in groups. Hence the probability of capture at a given camera is a function of group size and composition, individual traits, and time, all interacting in a complex manner. Chimpanzees epitomize this variability but baboons, elephants, and pigs may also. Studies of highly solitary animals, such as jaguars and tigers, may not be as strongly affected by this bias (Harmsen et al., 2009; Karanth and Nichols, 1998; Maffei et al., 2004; Mccarthy et al., 2008), except when traveling with mates or dependent young. But other species such as pack-living predators and the gregarious prey of solitary carnivores may be acutely affected by the bias. Further empirical and modeling studies will be needed to quantify the effect.

Our finding of higher detectability among gregarious species has theoretical implications for predator–prey ecology as well. Larger groups should not be assumed safer *a priori* (Bednekoff and Lima, 1998; Treves, 2000). Gregarious species may be detected more often by sit-and-wait predators, just as they were detected more often by our camera traps. If larger groups can also be followed more easily than singletons, a stalking predator would benefit from waiting for prey stimuli and following them until an unwary group member can be approached.

4.1. Species richness and conservation status

The western Ugandan national parks, Bwindi and Kibale, contained higher abundances of forest–woodland wildlife captured in fewer camera-trap days than did the four Reserves (Table 1). This suggests better habitats, better protections, or larger areas. However Bwindi was smaller than three of the four reserves, hence area seems inadequate to explain the abundances seen in the two national parks. Examining protection, the frequency of photo-captures of humans was not different between the national parks and the reserves but high rates of photo-capture of tourists and researchers in the former may obscure the disparate threats posed by different groups of people. We could not assess habitat quality. Differential gregariousness did not create the apparent differences between national parks and reserves either, because the most common species in the former were the mostly solitary duikers whereas the most commonly photo-captured species in the Reserves were the gregarious baboons.

Table 4
Relative abundance and distribution of forest–woodland wildlife in protected areas of western Uganda.

Relative abundance RAI_2[a]	Spatial distribution	
	Localized: 1–2 PAs	Widespread: 3–6 PAs
Abundant (top quartile)	Red duiker, yellow-backed duiker, handsome francolin[c], helmeted guineafowl[c]	Blue duiker[c], black-fronted duiker[c], olive baboon[c]
Intermediate (interquartile range)	Mountain gorilla [b,c], giant forest hog[c], leopard	l'hoest's monkey[b,c], chimpanzee[b,c], bushbuck[c], elephant[c], African civet, bushpig[c], Weyn's duiker[c], side-striped jackal, African golden cat, gambian rat
Rare (lowest quartile)	African wild cat, spotted hyena, waterbuck, cape buffalo, Rwenzori duiker, serval	–

[a] Non-terrestrial travelers, genets, mongooses, and red-flanked duiker were omitted (see Results).
[b] Vulnerable by IUCN (2008).
[c] GROUPMAX > 1.

The national parks lacked a few species that were present in one or more reserves and vice versa (Table 2). This leads us to two conclusions regarding protected area conservation in this landscape. First, national parks and reserves are not interchangeable; both types are needed for conservation of large mammal and terrestrial bird diversity. Second, cameras in the woodland reserves may have captured species that rarely use the more densely forested sites such as Bwindi and Kibale (e.g., hippopotamus, serval, side-striped jackal, spotted hyaena, waterbuck). We return to the carnivores below but buffaloes and waterbucks are found in great numbers in savanna parks (Rwetsiba, 2005; Treves et al., 2009), so their rarity in our study does not demand conservation action. Preference for less forested habitats does not explain why we did not detect black-and-white colobus or squirrels in the national parks, as these are present and seemingly abundant (personal observations; Struhsaker, 1997). Most likely their arboreality reduced their detectability.

Incorporating gregariousness into our assessments of rarity of different species (Table 4), we found cause for concern about the conservation status of several species. Six species were least abundant and narrowly localized in the landscape (African wild cat, spotted hyaena, waterbuck, Cape buffalo, Rwenzori duiker, and serval). As noted above, waterbuck and Cape buffalo are more abundant in nearby savanna parks (Rwetsiba, 2005). The same may be true for servals, side-striped jackals, and African wild cats (all listed as "Least concern" (IUCN, 2008), but we recommend Ugandan wildlife authorities support surveys for them to assess whether savanna parks protect adequate populations of these carnivores.

On the other hand, the Rwenzori duiker is recognized by some as a distinct species allied to *Cephalophus nigrifrons* and found only in the Rwenzori Mountains above 2500 m altitude (IUCN, 2008; Plumptre et al., 2009). It may therefore be an endemic with a very restricted range, deserving national and global conservation attention.

Finally, three species showed intermediate abundances but were found in only 1–2 PAs (Table 4): leopards, giant forest hogs, and mountain gorillas. The mountain gorilla is listed as "Critically Endangered" (IUCN, 2008) and already receiving focused conservation attention. The giant forest hog uses forested habitats as its name would imply as well as more open savanna–woodland and is gregarious (Estes, 1991). Therefore we recommend Ugandan wildlife officials support a focused survey that includes savanna areas to determine if the rarity we observed is real or biased by low detectability.

Our data also suggest large carnivores need more conservation attention. Leopards and spotted hyaenas were almost eradicated from Uganda in the 20th century (Treves and Naughton-Treves, 1999), and appear not to have recovered strongly. Spotted hyaenas have been reduced in number in the savanna parks because of poisoning by cattle keepers who use the parks illegally. We recommend a survey to assess their status throughout western Uganda. The leopard demands more urgent conservation action. Leopards were recently reclassified from "Least Concern" to "Near Threatened" globally, with a decreasing population trend (IUCN, 2008). Across Africa, leopards occur in all habitats except desert (Bailey, 1993; Estes, 1991; Henschel and Ray, 2003), but we detected 1–2 in Maramagambo Forest Reserve only. One has been seen recently crossing a road in Kibale NP (C. Chapman, personal communication 2009), yet we did not detect them in woodland or forested areas of national parks at all. It seems unlikely our cameras simply missed leopards given the intensity of effort (Balme et al., 2009; Henschel and Ray, 2003). Comparison with its smaller relative, the African golden cat, corroborates that view. One would expect the golden cat to be as difficult to detect by camera trapping as the leopard or more difficult because of its rarity in other places, solitary habits, and higher arboreality (Boy, 2003; Henschel and Ray, 2003; IUCN, 2008; Ray et al., 2005). Yet we photo-captured golden cats 13 times in four PAs (Table 2). Thus, the scarcity of leopards in the Greater Virunga landscape seems to be a robust result, which emphasizes the need for leopard conservation in western Uganda. Large carnivores often suffer higher mortality near the edges of protected areas, leading to local extinction from small ones (Balme et al., in press; Loveridge et al., 2007; Woodroffe and Ginsberg, 1998). Therefore recent policies allowing trophy hunting of leopards in Uganda (www.cites.org/common/cop/14/inf/E14i-22.pdf) seem imprudent in our study area (see also Balme et al., 2009, 2010).

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Appendix A

See Table A1.

Table A1
Scientific names of wildlife species from IUCN 2008.

Common name	Scientific name
Baboon	*Papio anubis*
Black-and-white colobus	*Colobus guereza*
Black-fronted duiker	*Cephalophus nigrifrons*
Blue duiker	*Philantomba monticola*
Blue monkey	*Cercopithecus mitis*
Buffalo	*Syncerus caffer*
Bushbuck	*Tragelaphus scriptus*
Bushpig	*Potamochoerus larvatus*
Chimpanzee	*Pan troglodytes*
African civet	*Civettictis civetta*
Elephant	*Loxodonta africana*
Gambian rat (Northern giant pouched rat)	*Cricatomys gambianus*
Genets	*Viverridae* spp.
Giant forest hog	*Hylochoerus meinertzhageni*
Golden cat	*Caracal aurata*
Great blue turaco	*Corythaeola cristata*
Helmeted guineafowl	*Numida meleagris*
Handsome francolin	*Francolinus nobilis*
Hippopotamus	*Hippopotamus amphibius*
L'hoest's monkey	*Cercopithecus lhoesti*
Leopard	*Panthera pardus*
Mongooses[a]	*Herpestidae* spp.
Mountain gorilla	*Gorilla beringei*
African white-bellied pangolin	*Phataginus tricuspis*
Red duiker	*Cephalophus spp? or Sylvicapra grimmia*
Red-flanked duiker	*Cephalophus rufilatus*
Redtail monkey	*Cercopithecus ascanius*
Rwenzori duiker	*Cephalophus rubidus*
Serval	*Leptailurus serval*
Side-striped jackal	*Canis adustus*
Spotted hyaena	*Crocuta crocuta*
Squirrel spp.	*Sciuridae*
Waterbuck	*Kobus ellipsiprymnus*
Weyn's duiker	*Cephalophus weynsi*
Wild cat	*Felis silvestris*
Yellow-backed duiker	*Cephalophus silvicultor*

[a] Two identified but one unidentified.

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MANTENIMIENTO DEL EQUILIBRIO ENTRE LA FAUNA Y LAS NECESIDADES DE LA GENTE:

CUANDO LA FAUNA PERJUDICA LOS CULTIVOS Y SE ALIMENTA DEL GANADO

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Este informe LTC se basa en la experiencia en tres continentes para describir progresos recientes en la comprensión y administración de conflictos entre el hombre y la fauna, con objetivos paralelos de conservación de biodiversidad y mitigación de la pobreza.

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YA SEA LEONES, TIGRES Y OSOS devorando ganado, o elefantes, loros y venados alimentándose de cultivos, los conflictos surgen cuando las actividades de animales silvestres coinciden con las de la gente. A pesar de que los daños atribuidos a la fauna silvestre no tienen el impacto que implican las enfermedades y la sequía, son de importancia crítica a nivel político y ambiental para la conservación de la biodiversidad. Pueden también presentar consecuencias económicas catastróficas para hogares vulnerables.

Las fronteras entre áreas protegidas y paisajes con una mezcla de desarrollo antrópico y áreas silvestres son testigos de la mayoría de conflictos hombre-fauna silvestre (HWC). A escala mundial, cada año mueren miles de personas y se pierden miles de millones de dólares en propiedades debido a HWC. Tradicionalmente, la gente ha respondido a las amenazas de la fauna matando animales “problemáticos” y eliminando hábitats silvestres para prevenir futuras pérdidas. Es difícil estimar la magnitud de costos económicos y de biodiversidad para países en desarrollo, pero los datos de países desarrollados son indicativos. El gobierno de estados unidos responde a casi $1.000 millones en daños a la agricultura a lo largo de la nación mediante el sacrificio de aproximadamente 2,5 millones de animales silvestres anualmente. En el 2004, esto incluyó 107.044 carnívoros silvestres, de los cuales cerca de 3% eran especies amenazadas o en peligro, o a las que involuntariamente se les dio muerte cuando otras especies eran el objetivo.

No existe evidencia de que los daños a la agricultura ocasionados por la fauna silvestre estén disminuyendo en Estados Unidos, pero en los países en desarrollo las condiciones son más volátiles. Por un lado, la pérdida severa de hábitats ha disminuido las poblaciones silvestres, reduciendo el número de hogares afectados por los HWC, *con un gran costo para la biodiversidad*. Por otro lado, donde la protección de la naturaleza ha sido exitosa, la vida silvestre amenazada podría recuperarse y causar daños a propiedades o cobrar vidas en hogares a cierta distancia de áreas silvestres, *con un gran costo para las economías rurales*. Avances recientes en la investigación y administración de HWC prometen romper la espiral de pérdidas en cualquiera de las dos direcciones y simultáneamente promover la conservación de la biodiversidad y la mitigación de la pobreza.

Durante las últimas dos décadas, la investigación científica ha identificado un puñado de principios de HWC y ha generado un buen número de recomendaciones para su administración. Este trabajo destaca las dimensiones de los HWC relacionadas con la vida silvestre, evalúa nuestro conocimiento de las percepciones de riesgo y decisión de la gente afectada, traza senderos hacia una intervención exitosa a través de planificación participativa y co-administración, y examina el rol clave de la investigación en la resolución de HWC.

Dimensiones de la fauna: el comportamiento de individuos problemáticos

El destino de la fauna depende de la tolerancia humana. Así, los HWC son ahora vistos como un serio reto para la conservación, particularmente para animales de gran tamaño que requieren de áreas de distribución extensas y con frecuencia explotan los mismos recursos que las personas. En el caso de grandes carnívoros, pocas áreas protegidas son suficientemente extensas para mantener una población viable y las causas predominantes de mortalidad en todas las poblaciones de

Definiciones

Co-administración: Administración compartida entre las comunidades afectadas y organismos gubernamentales u ONG.

Mecanismos para hacer frente a las situaciones: Medidas para reducir la vulnerabilidad individual u hogareña, que abarca desde defensa personal individualizada hasta seguridad colectiva basada en reciprocidad social. Lo primero depende en gran medida del acceso individual a la tierra, trabajo, y recursos económicos, que dependen a su vez del patrimonio e influencia política. En contraste, los mecanismos comunales para hacer frente a situaciones dependen de redes de parentesco, tradiciones de intercambio, reciprocidad, y administración conjunta de la tierra.

Personas locales involucradas: Las comunidades afectadas y las autoridades designadas nacionalmente encargadas de la administración de la vida silvestre en un lugar. Aunque puede ser un reto identificar la unidad apropiada de organización social que será involucrada en la administración, la unidad natural y obvia está compuesta de individuos y hogares afectados por conflictos hombre-fauna silvestre en una localidad determinada.

Administración: Planificación, intervención, y monitoreo (incluyendo investigación fundamental aplicada).

Riesgo: La probabilidad de pérdidas para una localidad determinada. (Comparar con “vulnerabilidad.”)

Vulnerabilidad: Capacidad de los individuos u hogares de lidiar con el riesgo.

Fauna: Este informe está enfocado en vertebrados terrestres (mayores a un kilogramo) en vez de organismos más pequeños que típicamente producen mayores pérdidas económicas, porque los organismos más grandes presentan un mayor riesgo físico inmediato y provocan más conflictos políticos entre los intereses ambientales y otros grupos involucrados.

carnívoros estudiadas hasta ahora se deben a los seres humanos.

En todo el mundo, análisis espaciales enfatizan el carácter irregular de los conflictos con la fauna silvestre. Algunas localidades sufrirán fuertes pérdidas mientras que otras permanecerán ilesas. En efecto, una minoría de los grandes mamíferos individuales representa una amenaza para los cultivos, el ganado o la gente, así como sólo una minoría de los hogares sufre la mayoría de las pérdidas. La distribución irregular de los HWC reduce la relación costo-beneficio de los esfuerzos no selectivos y a gran escala de control de la fauna. Por ejemplo, el control letal selectivo ha fallado repetidamente puesto que la fauna problemática no es erradicada y animales no involucrados son eliminados. Sin embargo, las personas con frecuencia perciben los métodos letales como una solución "final," por lo que otras estrategias podrían requerir persuasión, un tema abordado en detalle en la próxima sección.

Además, los animales "problema" alteran su comportamiento cuando residen en y alrededor de propiedades humanas. Se han reportado alteraciones en el tiempo de actividad, modificaciones en el comportamiento vocal y preferencia por lugares pequeños para evadir la detección y represalias por parte de la gente. El carácter esquivo y cauteloso de carnívoros problema es legendario. Por ejemplo, en Ecuador nueve osos andinos fueron exterminados por granjeros locales antes de que se sintieran confiados de haber eliminado el único oso que, según pensaban, estaba atacando al ganado. En definitiva, identificar a los posibles culpables en los HWC es un paso crítico para proteger una población silvestre de represalias humanas desproporcionadas. A su vez es un paso que típicamente requiere investigación.

Incluso el control letal selectivo de la fauna podría no ser rentable si nuevos animales reemplazan a los removidos, y si la distinción entre los culpables y los animales no involucrados es errada, como usualmente sucede. Así, la disuasión no letal podría ser más rentable y normalmente es preferible desde un punto de vista de conservación de biodiversidad.

La fauna silvestre es usualmente neofóbica, esto es, cautelosa ante nuevos estímulos. Por lo tanto, las intervenciones no letales más exitosas son variadas y flexibles, utilizando distintos elementos disuasorios en combinación o en serie para evitar que la fauna se acostumbre. Debido a que los animales repelidos de una propiedad podrían moverse a otra, los elementos disuasorios deberían ser aplicados normalmente en propiedades múltiples y vecinas. Sin embargo, la extensión total de dicha instalación (cercado, por ejemplo) debería reflejar el comportamiento de distribución del animal problemático, no alguna unidad sociopolítica. Esto podría requerir trabajar a través de jurisdicciones, lo que enfatiza los beneficios potenciales de la participación de grupos involucrados en la planificación.

Dimensiones humanas: Vulnerabilidad y percepciones

Los HWC pueden poner a las comunidades afectadas en contra de las iniciativas de conservación de vida silvestre y, en algunos casos, provocan que los gobiernos locales dejen de crear áreas protegidas. El resentimiento local ante daños por la fauna puede impedir la discusión de otros temas ambientales, como erosión del suelo, contaminación y administración del agua. Minimizar o ignorar el problema puede generar resentimiento adicional.

Las percepciones de los HWC influyen en los reclamos, tolerancia por la vida silvestre, aprobación de iniciativas de administración y cooperación en soluciones propuestas. Las percepciones locales de los HWC son complementarias a las medidas sistemáticas y científicas de pérdida e igualmente importantes en la administración del problema. A continuación, tres razones para esto.

Pérdidas catastróficas versus el promedio. Las percepciones están modeladas por eventos catastróficos más que por pérdidas frecuentes a pequeña escala, a pesar del mayor costo económico y acumulativo de las últimas. En contraste, la mayoría de los estudios científicos de HWC enfatizan el promedio, no los extremos. Los promedios regionales pueden enmascarar a los pocos individuos u hogares que sufren pérdidas devastadoras. Por ejemplo, los elefantes pueden causar daños catastróficos a una granja pero pocas son afectadas y solo raras veces. Sin embargo, muchos granjeros se quejan con amargura de los elefantes, mientras que pocos mencionan las crónicas y ampliamente distribuidas pérdidas causadas por monos.

Magnitud temporal y magnitud espacial. Las percepciones humanas se pueden extraer de viejos recuerdos e historias de personas distantes. Esta amplitud y profundidad es raramente capturada en estudios científicos, que usualmente muestrean un área menor durante un periodo más breve.

Audiencias. Las comunidades afectadas y las personas comunes y corrientes con frecuencia consideran que las historias personales son más convincentes o comprensibles que los datos científicos. En contraste, las medidas sistemáticas pueden ser más convincentes para las autoridades, científicos y extranjeros, quienes podrían querer ver evidencia cuantitativa antes de invertir tiempo y esfuerzo.

Las percepciones son una realidad de la administración. Las percepciones de los HWC podrían moldear las expectativas acerca de intervenciones propuestas. En Japón, la mayor parte de los granjeros encuestados se oponían al control letal de monos sospechosos de asaltar cultivos porque los monos eran percibidos como físicamente similares a los humanos. Además, debido a que las percepciones están moldeadas por eventos raros y catastróficos, más que por eventos más frecuentes a pequeña escala, las intervenciones exitosas contra estos últimos podrían no reducir las quejas acerca de los HWC, incluso si las pérdidas económicas son reducidas significativamente. De manera similar, algunas intervenciones altamente efectivas podrían chocar con normas sociopolíticas de comportamiento o tradiciones culturales.

Las intervenciones contra los HWC no deberían ser unilaterales enfrentando sólo el comportamiento humano; esto podría ser visto como “culpar a la víctima.” Cambios simultáneos en el comportamiento agrícola o humano junto a intervenciones contra el comportamiento de la fauna podría igualar la carga del cambio. Con frecuencia esto requiere implementar dos o más intervenciones, lo que también se ajusta a las recomendaciones de estudios recientes que demuestran que las intervenciones únicas rara vez funcionan por mucho tiempo. Las percepciones de los HWC no solo están moldeadas por la severidad y frecuencia de las pérdidas sino por muchos factores sociales y biofísicos relacionados con la vulnerabilidad y riesgo individual. Definimos “riesgo” como la probabilidad de pérdida en una localidad determinada. En contraste, “vulnerabilidad” se refiere a la capacidad de un hogar o individuo de lidiar con ese riesgo. Vecinos que enfrentan un riesgo idéntico de daño a plantaciones de maíz por el oso frontino podrían tener vulnerabilidades muy distintas basadas en sus recursos y en las medidas de protección en que han invertido. Si uno de los vecinos tiene un segundo trabajo que le impide vigilar su granja, entonces su propiedad podría sufrir más daños, pero su segundo ingreso podría compensar las pérdidas. Las ventajas y desventajas entre los métodos alternativos para enfrentar situaciones y sus consecuencias para la vulnerabilidad enfatizan que los métodos para enfrentar situaciones son experimentos.

Las condiciones cambiantes alteran esta interrelación, así que debemos monitorear los resultados de distintos métodos para enfrentar situaciones, causas y consecuencias de vulnerabilidad diferencial entre hogares, y factores fluctuantes de riesgo externo, especialmente si aplicamos herramientas e intervenciones técnicas en regiones de productividad marginal. Por ejemplo, el multi-millonario India Eco-Development Project (IEDP), de cinco años de duración, intentó proteger un parque nacional que albergaba tigres, mientras protegía también a los cultivos contra la fauna e incrementaba los ingresos locales. Incentivos económicos de muchos tipos fueron proporcionados en consulta con las comunidades beneficiarias. Pero el monitoreo de biodiversidad fue recortado del presupuesto y el monitoreo a largo plazo de intervenciones económicas no fue incluido en el plan del proyecto. Un estudio independiente realizado cinco años después de que el IEDP terminara, descubrió que la mayoría (66%) de las contribuciones materiales—para medios de subsistencia alternativos y para defensa de cultivos—no fueron usados o mantenidos (Gubbi 2007). Además, el mismo estudio no reveló diferencias en las actitudes de conservación entre los beneficiarios y no beneficiarios del IEDP en el mismo parque. Este es un recordatorio aleccionador de que los incentivos para la conservación deberían ser complementados con sanciones, de lo contrario los aportes se convierten en privilegios y las actitudes o comportamientos no cambiarán. Además, los esfuerzos para proteger hogares afectados contra los HWC deberían tomar en cuenta los métodos de mediación tradicionales y la sustentabilidad a largo plazo de cualquier intervención que se intente.

La gente de la localidad con frecuencia tiene miedo de, o no le gusta la fauna silvestre porque la ve como un símbolo de propiedad gubernamental. (Foto de Leela Hazzah)

Mecanismos para hacer frente a HWC

Los mecanismos para hacer frente a estas situaciones abarcan desde defensa individual hasta seguridad colectiva basada en reciprocidad social. Lo primero depende en gran medida del acceso individual a la tierra, trabajo, y recursos económicos, que dependen a su vez del patrimonio e influencia política. En contraste, los mecanismos comunales para hacer frente a situaciones dependen de redes de parentesco, tradiciones de intercambio, reciprocidad, y administración conjunta de la tierra. Los hogares migrantes y más pobres enfrentan una vulnerabilidad agravante. Sin grandes tenencias de tierra o redes de parentesco no pueden defenderse de los conflictos con la fauna, ni pueden contratar mano de obra adicional.

Ciertos escenarios limitan el uso de los mecanismos sociales de mediación (por ejemplo, migración reciente de nuevos grupos étnicos, o incentivos para la tenencia individual de la tierra). Por supuesto, existe una escala variable desde los mecanismos individuales hasta los completamente comunales y sociales, y los hogares afectados podrían participar en ambos.

Debido a que los HWC con frecuencia conllevan a la destrucción de áreas y fauna silvestre o a conflictos políticos sobre protección de biodiversidad, grupos foráneos a menudo se ven involucrados. En este punto se multiplican las soluciones propuestas y los métodos de mediación tradicionales podrían ser olvidados. El riesgo en dichos casos consiste en que los métodos tradicionales para hacer frente a estas situaciones son con frecuencia más comprensibles, sustentables y costo-efectivos para los hogares afectados que las soluciones novedosas recomendadas por los involucrados que no están directamente afectados por los HWC. Además, las comunidades afectadas son a veces privadas completamente de su derecho a intervenir si extranjeros y autoridades encargadas de la vida silvestre intervienen para controlar los HWC.

Para evitar los extremos—ya sean los tradicionales controles de fauna no regulados, que usualmente derivan en matanzas insustentables, o novedosas soluciones técnicas impuestas sobre las personas afectadas—este informe se enfoca en la co-administración, incluyendo la participación de hogares afectados en la toma de decisiones, implementando intervenciones experimentales, e incluso monitoreando HWC.

Participación y co-administración

Nuestra suposición de partida es que la participación debería ser *optimizada*. Es decir, la participación en la planificación, implementación y monitoreo tienen potenciales ventajas y desventajas. Las desventajas reflejan los costos transaccionales de cumplir y construir acuerdos mutuos y organizar actores en roles coordinados, al igual que potenciales enfrentamientos políticos que surgen de diferencias de opinión o conflictos de interés. Las ventajas incluyen reclutar a potenciales personas involucradas como socios, generar ideas adicionales para la implementación que otro subgrupo pudo haber descuidado, combinar recursos y personal para alcanzar un objetivo común, y proporcionar un modelo para una toma de decisiones más transparente y democrática. El nivel óptimo de participación maximiza la relación costo-beneficio en una localidad determinada y en cada paso del ciclo de un proyecto. En resumidas cuentas, la participación debería ser adaptada a las condiciones locales, y no ser considerada como una meta en sí misma sino como un medio estratégico para lograr un objetivo final.

Idealmente, los individuos y los hogares afectados administrarían independientemente los HWC sin perjudicar permanentemente a la biodiversidad. Sin embargo, varias condiciones demandan colaboración entre hogares afectados y otras personas involucradas. Por un lado, muchos conflictos ocurren en límites de áreas protegidas o involucran especies amenazadas, que podrían ser parte de la jurisdicción de los administradores de la vida silvestre. Podrían necesitarse terceros (una ONG o un investigador extranjero, por ejemplo) si existe una historia de desconfianza entre las personas involucradas localmente. Sin embargo, los extranjeros deberían evitar ser vistos como más aliados a las autoridades centrales que a las comunidades locales.

La planificación participativa de proyectos relacionados con HWC requiere que se definan objetivos comunes, que se identifiquen obstáculos (o amenazas indirectas) y oportunidades (un ambiente favorable que mejorará la probabilidad de intervención exitosa), seguido por discursos sobre la selección y diseño de métodos de monitoreo e intervención. Los objetivos comunes deberían incluir tanto el bienestar humano como reducir las amenazas contra la fauna. Si estos dos objetivos no reciben la misma atención ni la misma inversión—como en el ejemplo del IEDP citado anteriormente—es muy probable que el proyecto fracase. Los proyectos de administración de HWC seguramente fracasarán en la conservación de vida silvestre si los distintos grupos de interés están insuficientemente representados o en desventaja en el proceso de decisión. Es más fácil ponderar los votos de los hogares afectados que los votos de la fauna y es también más fácil enfocarse en los costos y beneficios económicos que en los costos no materiales y los beneficios de las situaciones de HWC. Al mantener ambos objetivos en primer plano y en mente al diseñar los proyectos con una participación óptima, estas trampas pueden ser evitadas.

Entre los beneficios de la planificación participativa para proyectos de HWC se encuentran los siguientes.

1. Debido a que las intervenciones, la investigación y el monitoreo con frecuencia requieren acceso a propiedades privadas y posiblemente otras intromisiones en la vida de la gente, los esfuerzos para construir entendimiento comunitario, participación y pertenencia a un proyecto de HWC usualmente facilitan la implementación.

2. De manera similar, muchas intervenciones requieren un cambio en el comportamiento humano. A nadie le gusta que le digan lo que tiene que hacer, especialmente si creencias o tradiciones mantenidas por mucho tiempo son amenazadas; por lo tanto, los individuos u hogares afectados son más propensos a aceptar cambios si han definido la necesidad de cambiar e identificado el cambio que desean realizar, o si al menos han escogido entre opciones que se les han ofrecido.

3. Las sanciones contra la destrucción de la vida silvestre son esenciales en el balance de los objetivos de administración de HWC, a fin de que el interés en la conservación de vida silvestre no sea subordinado completamente a actividades de desarrollo, cuya aceptación es más fácil de inducir entre los involucrados. Las estructuras de co-administración, siempre y cuando estén diseñadas adecuadamente, permiten a las comunidades supervisarse. Por ejemplo, grupos de conservación que trabajan en Mongolia y Nepal han estado usando por muchos años contratos de negociación bilateral con ganaderos dentro del área del leopardo de las nieves. Los hogares de las comunidades locales hacen productos con lana de ovejas domesticadas, los grupos de conservación venden los productos en naciones desarrolladas a un alto precio, y una porción pre-negociada de las ganancias se le paga a cada productor. También, la comunidad como un todo recibe un bono sustancial distribuido de manera equitativa entre sus miembros si el monitoreo de leopardos de las nieves y su presa demuestran que los objetivos de conservación fueron alcanzados ese año. Los miembros de las comunidades han entregado cazadores furtivos forasteros en las tierras de su comunidad para evitar perder la bonificación.

Claramente, los beneficios de la participación requieren representantes legítimos de personas involucradas localmente, incluyendo atención justa a la distribución diferencial de vulnerabilidad debido a género, etnicidad, riqueza, etc. En vista de que aquellos que reclaman más fuertemente podrían no ser los más vulnerables, permitir que los hogares afectados discutan la distribución de costos y beneficios abierta y transparentemente podría promover equidad en las intervenciones.

Intervenciones

La aceptación sociopolítica de las intervenciones puede ser tan importante como la relación costo-beneficio. Las intervenciones familiares y económicas—aquellas que requieren poca tecnología nueva y cambio mínimo en el comportamiento existente—tienen más probabilidad de éxito. Por ejemplo, uno de los grupos del leopardo de las nieves mencionado anteriormente proporcionó un modesto apoyo financiero y técnico para la construcción de un cerramiento comunal luego de que los aldeanos identificaran esta como la intervención más apropiada. En este caso, los cerramientos eran ampliamente usados pero la administración comunal de rebaños no era tradicional.

Desde el principio, es importante disipar las esperanzas de intervenciones monetarias o soluciones milagrosas. Naturalmente, mucha gente que sufre pérdidas por la fauna silvestre quiere compensación y soluciones definitivas. Dichas soluciones son raras o ilusorias. Sin embargo, un análisis cuidadoso de los factores que hacen a los hogares vulnerables y los factores que elevan el riesgo, en conjunción con información sobre ecología de comportamiento de vida silvestre, usualmente nos hará recordar una variedad de intervenciones directas e indirectas. La combinación de intervenciones directas e indirectas promete equilibrar más efectivamente las necesidades de la fauna y de los humanos.

Intervenciones directas. La mayoría de las situaciones de HWC involucran a fauna silvestre que encuentra propiedades desatendidas o desprotegidas o es atraída a fuentes de alimento más apetecibles o nutritivas que las encontradas en la naturaleza. Consecuentemente, la mayoría de intervenciones directas intentan defender la propiedad (vigilantes, barreras, remoción de fauna) o hacerla menos atractiva (repelentes) o alguna combinación de los dos (cambiando el tipo, el tiempo o la ubicación de las actividades humanas). Pocos han intentado incrementar el atractivo relativo o la disponibilidad de alimentos silvestres, que podría ser clasificado como la segunda forma de intervención mencionada. La mayoría de intervenciones directas han sido probadas experimentalmente o han sido sometidas a generaciones de ensayos por productores bajo condiciones operativas. Esto no es cierto para las intervenciones indirectas que maduraron a partir del movimiento conservacionista de la vida silvestre.

Intervenciones indirectas. Debido a que los HWC tan solo requieren de intervención si los hogares afectados no pueden tolerar los conflictos, algunos administradores de HWC son partidarios de incrementar la tolerancia de la gente como un medio indirecto de reducir conflictos. La forma más común es la compensación: pagos después de que las pérdidas han ocurrido. La compensación ha sido criticada desde toda perspectiva concebible usando tanto evidencia teórica como empírica. Es particularmente propensa al fraude, a la corrupción y la inequidad; disuade la inversión en defensa de propiedad y puede frustrar la inversión en soluciones más permanentes; una vez iniciada, sus costos inevitablemente aumentan y es muy difícil de terminar; y le da más peso a las opiniones de adinerados donantes extranjeros en la toma de decisiones de HWC. Por otro lado, la compensación sí distribuye los costos de la conservación de vida silvestre más equitativamente entre la sociedad; también puede atraer a la discusión a personas involucradas hostiles y dar una voz más fuerte a los intereses de protección de la vida silvestre.

Clasificación de los métodos para mitigar los HWC

Los métodos directos reducen la severidad o frecuencia del daño a la vida silvestre:

- Barreras (cercas, zanjas, muros, zonas de amortiguamiento, etc.)
- Guardianes (humanos o animales)
- Cambiar el tipo, momento o ubicación de las actividades humanas
- Repelentes (químicos, auditivos o estímulos visuales repulsivos)
- Remoción de la vida silvestre (captura, eliminación y esterilización)

Los métodos indirectos aumentan la tolerancia de la gente ante los conflictos con la fauna silvestre:

- Compensación e incentivos
- Participación
- Investigación y educación ambiental

El suministro de incentivos en la forma de aportes materiales o técnicos antes de que ocurran pérdidas para prevenir represalias contra la vida silvestre debería ser superior a la compensación para equilibrar las necesidades de la gente y la vida silvestre, debido a que los incentivos apoyan la prevención mientras que la compensación promueve reacción y dependencia de un contribuyente. La precaución que acompaña el enunciado anterior es que la conservación basada en incentivos es una idea no comprobada, a pesar de su popularidad reciente.

Como mencionamos antes, la participación de hogares afectados podría incrementar su tolerancia por un proyecto de mitigación de HWC. También podría mejorar su tolerancia por los daños atribuidos a la fauna. Esto es un tanto especulativo, pero anécdotas preliminares sugieren que los reclamos de la gente se suavizan cuando algo se hace con respecto a los HWC. Es de suponer que la planificación no es suficiente pero las intervenciones tal vez lo son, incluso si la efectividad todavía no ha sido demostrada.

Finalmente, la investigación y la diseminación resultante, con frecuencia llamada educación ambiental, recibe a veces el crédito por mejorar la tolerancia de la gente ante la fauna amenazante. A partir de estudios sobre actitudes humanas tenemos abundante evidencia de que la gente con mejor formación académica es más tolerante a los grandes carnívoros. Sin embargo, los individuos que específicamente tienen más conocimiento sobre la vida silvestre, incluyendo carnívoros, no son siempre más tolerantes. Por lo tanto, necesitamos una prueba experimental rigurosa porque la necesidad de educación ambiental es una suposición de muchos proyectos ambientales.

El rol de la investigación

Recopilar información base es un primer paso vital en la administración de HWC debido a que la comprensión del momento y ubicación de los conflictos, los comportamientos de los individuos involucrados (personas y vida silvestre), y las percepciones de los afectados son esenciales para la planificación de intervenciones. Grandes vacíos en el conocimiento hacen que cualquier esfuerzo para seleccionar y diseñar intervenciones o monitorear el éxito de dichas intervenciones no sea eficiente o efectivo. Con frecuencia, la investigación disfruta de cierto grado de tolerancia debido a que generalmente invade muy poco la vida de la gente y su producto (el conocimiento) es a menudo claro. Sin embargo, este escenario positivo no está garantizado. A menudo, los campesinos desean compensación o intervenciones contra los HWC, no investigación. Un granjero que enfrenta daños a cultivos a causa de elefantes quería “comida, no números.” Las comunidades marginalizadas por condiciones políticas podrían rechazar y desconfiar de la investigación si ha sido usada para su perjuicio en el pasado. La investigación en sí puede ser politizada porque las cosas que uno cuantifica, la manera en que uno estructura las preguntas, y cómo uno interpreta los resultados, podrían favorecer a un lado o al otro. Se debe tener cuidado para mantenerse imparcial como un honesto intermediario de información; esto es, el investigador debe renunciar al control sobre el resultado de las negociaciones entre involucrados.

Dimensiones humanas. Los medios para estudiar y cuantificar las percepciones, vulnerabilidad y métodos para hacer frente a estas situaciones varían, y varían en efectividad. Las reuniones de grupo son fuentes valiosas de comprensión de las percepciones, pero con frecuencia sólo ponen de manifiesto vistas públicamente avaladas o la experiencia mayoritaria. Captar más opiniones representativas debería mejorar el entendimiento de los HWC y puede crear confianza entre los involucrados. Las desigualdades económicas, políticas y de género podrían requerir comunicaciones confidenciales. Cuando uno entrevista a personas similares a uno mismo, uno podría captar mayor sutileza y perspectiva en las percepciones. Los ciudadanos de países anfitriones probablemente deberían dirigir los equipos de monitoreo, y es incluso mejor si miembros de la comunidad local lo hacen. Aún así, las entrevistas con mujeres podrían no ser posibles si los hombres interrumpen el acceso. Al llevar a cabo entrevistas en los ámbitos de la mujer, uno podría descubrir que las mujeres perciben y reportan amenazas de fauna diferentes que las percibidas y reportadas por hombres. Los ejercicios participativos de cartografía son usualmente útiles porque los HWC se encuentran distribuidos de forma desigual en el espacio y mucha gente codifica la información de recursos naturales de manera espacial en mapas mentales. También se puede traer un mapa impreso a las entrevistas individuales para obtener visiones más variadas de la distribución social y espacial de los conflictos. Sin embargo, las representaciones bidimensionales del espacio no son explícitas para todos los individuos o culturas.

Dimensiones de la fauna. Uno debería tener mediciones básicas de la ubicación, del tiempo y la severidad del daño, y cuáles especies se vieron involucradas para seleccionar las intervenciones apropiadas o instalarlas efectivamente. Si es posible, recopilar datos ecológicos y de comportamiento de la fauna silvestre alrededor y en las áreas de uso humano en vez de depender de estudios en áreas silvestres. No existe ningún sustituto para un entendimiento cuidadoso de la biología conductual de las especies causantes de conflicto, especialmente si está relacionado a sus interacciones con la gente.

Poniendo a prueba posibles intervenciones. Los descubrimientos de la investigación podrían también ser útiles para catalizar el diálogo acerca de las intervenciones, especialmente cuando la investigación ha sido invitada y co-diseñada por personas involucradas locales. Se debe evitar escoger la primera solución que se viene a la mente. Cualquier solución propuesta es una prueba y debe ser tratada como tal.

Monitoreo de intervenciones

El monitoreo es esencial para juzgar la efectividad de las intervenciones, que son, por su naturaleza, experimentos. El monitoreo debería incluir tres medidas jerárquicas de desempeño:

- ¿Se implantaron las intervenciones de acuerdo a lo planificado?
- ¿Disminuyó el nivel de HWC?
- ¿Se mantuvo o se restauró la biodiversidad? ¿Se mejoró el bienestar humano?

Como mínimo, el monitoreo debería distinguir las fluctuaciones secundarias en los HWC, poblaciones de vida silvestre e indicadores de bienestar humano, de los efectos de las intervenciones. Al haber diseñado protocolos de monitoreo a largo plazo, los planificadores del proyecto estarían bien preparados para diseñar alternativas que son menos intrusivas para los hogares afectados. Tener dos o más opciones le da a los sujetos una opción en cuanto al nivel de intromisión en sus asuntos. Las dos alternativas deberían ser casi idénticas en información obtenida, pero diferentes en características logísticas que afectan la participación comunitaria o interrumpen horarios comunitarios. Por ejemplo, un equipo abordó dos planes para estudiar y mejorar la situación de pérdidas de ganado en Bolivia. La primera fue sencilla para los administradores de vida silvestre (pedirle a los dueños de ganado que agrupen sus rebaños pequeños en un valle con un sistema comunal de rotación entre valles), pero el equipo anticipaba una tolerancia baja ante dicho plan debido a la reputación individualista de la comunidad. Entonces idearon un segunda propuesta que parecía más simple para los dueños del ganado (los guardaparques ubicados en el pueblo examinarían cadáveres de ganado en cada valle). En ambos casos, la mayoría de incidentes de mortalidad de ganado serían detectados e investigados (de manera menos rápida y fiable en el segundo plan), a pesar de eso el primer plan implicaba un cambio mayor en las actividades tradicionales.

Conclusiones

Este informe destaca la dimensión que para la fauna tienen los conflictos con personas, revisa avances recientes en el entendimiento de las percepciones de riesgo y decisión de las personas afectadas, traza caminos hacia una intervención exitosa a través de la co-administración, y finalmente examina el rol clave de la investigación en la resolución de conflictos entre personas y fauna. Nuestra metodología enfatiza la contribución de las ciencias sociales debido a que los HWC son un desafío tanto social como técnico. A pesar de que los pasos son simples y directos, los detalles específicos del lugar pueden ser extremadamente complejos.

La capacidad de administrar efectivamente las amenazas de la fauna contra la propiedad y seguridad humana—sin comprometer la viabilidad de las poblaciones de animales silvestres o la vida y el sustento humanos—está a nuestro alcance. Para hacerlo, creemos que los co-administradores deberían combinar la experiencia técnica con el conocimiento local y adoptar procesos de planificación participativa transparentes y democráticos, con los sacrificios que esto conlleva.

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FINANCIAMIENTO DE MERCADO PARA LA CONSERVACIÓN DE BIODIVERSIDAD Y VENTAJAS Y DESVENTAJAS ESTRATÉGICAS DE LAS ECO-ETIQUETAS AMIGABLES CON LA VIDA SILVESTRE

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Los consumidores que compran productos “eco-etiquetados” podrían tener la esperanza de ayudar a conservar el medio ambiente, sin embargo, la credibilidad de las eco-etiquetas varía. La conservación de vida silvestre plantea serios retos para las declaraciones de las eco-etiquetas debido a que las poblaciones de animales silvestres fluctúan de manera natural y la verificación de impactos en el campo puede ser lenta, compleja y costosa. Este informe define tres tipos de eco-etiquetas de acuerdo a su capacidad potencial de conservar la vida silvestre, y examina los obstáculos para convencer a los consumidores de las declaraciones de las eco-etiquetas.

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Las organizaciones DE CONSERVACIÓN DEL MEDIO AMBIENTE han deseado por mucho tiempo usar financiamiento basado en el mercado para proteger la naturaleza. El ecoturismo, los impuestos sobre la cacería y los bancos de conservación son algunos de los múltiples esfuerzos impulsados por el mercado para conservar la fauna y proteger tierras silvestres contra actividades destructivas. Más recientemente, el sector de biodiversidad ha buscado el financiamiento del consumidor para los incentivos de conservación. Entre estos esfuerzos se encuentran varias estrategias de certificación y etiquetación de productos—eco-etiquetas—diseñadas para ofrecer precios ventajosos o un mejor acceso al mercado para los consumidores que apoyan la conservación de la vida silvestre (Amstel et al. 2007). En vista del creciente interés en las eco-etiquetas, este informe examina la confiabilidad de las declaraciones de que los productos no amigables con la vida silvestre.

Conexión entre los consumidores interesados en la conservación y los productores que conservan la vida silvestre

Para unificar a consumidores y productores como afiliados en la conservación de vida silvestre se necesitan dos condiciones: (1) un incentivo directo para que los productores conserven animales silvestres que son importantes para los consumidores, y (2) un enlace explícito y con sentido común entre un sistema preferido de producción (manufactura o recolección) y la conservación de animales representativos (Searle, Colby y Milway 2004; Fischer et al. 2008). La búsqueda de actividades económicas amigables con la vida silvestre podría pasar por alto los métodos que podrían conservar este recurso pero no se integran con las expectativas o el comportamiento de los consumidores o productores. Por ejemplo, retribuir económicamente a los productores por el costo de la coexistencia con la fauna (por ejemplo, proporcionando compensación por daños de la fauna contra la propiedad) puede generar incentivos perversos, como defensa negligente de la propiedad o represalias contra los animales que causaron el daño (Naughton-Treves, Grossberg, y Treves 2003; Bulte y Rondeau 2005). En contraste con estos métodos, enlazar directamente las utilidades con la sobrevivencia o reproducción exitosa de fauna podría fomentar actitudes pro-fauna entre los productores (Mishra et al. 2003; Schwerdtner y Gruber 2007; Zabel y Holm-Muller 2008). "El pago por fauna viva en vez de ganado muerto" es una forma común de articular la estrategia anterior y su enlace con la conservación.

La necesidad de atraer consumidores hacia una estrategia particular de conservación de vida silvestre requiere diferentes métodos a los usados con los productores. Por ejemplo, la recolección sustentable de fauna ha sido usada por mucho tiempo como una herramienta en la conservación de ciertas especies (Loveridge, Reynolds, y Milner-Gulland 2007), pero muchos consumidores en naciones desarrolladas consideran a la cacería como inhumana o anti-conservación (Peterson 2004). Esto sugiere que los métodos de mercado para la conservación de fauna serán más efectivos cuando puedan ser entendidos como ecológicos por el más amplio grupo posible de consumidores. El rol de comunicación de las eco-etiquetas es, por lo tanto, crítico para atraer consumidores.

Las eco-etiquetas están concebidas para indicar a los consumidores que las compras contribuyen con resultados ambientales positivos. Los consumidores exigentes en un mercado muy concurrido confrontan un conjunto de señales con distinto contenido de información y confiabilidad (Amstel et al. 2007). Cuando el interés de tanto los productores interesados en la conservación como el de los consumidores se alinea, entonces un mensaje confiable de los

Retos para verificar si una empresa conserva la vida silvestre

- la vida silvestre ignora las fronteras jurisdiccionales y de propiedad
- las poblaciones de animales silvestres experimentan cambios demográficos complejos, fortuitos y a largo plazo que obscurecen la presunta influencia de los humanos
- muchas especies de interés para la conservación son cautelosos a causa de pasadas persecuciones humanas, lo que dificulta y encarece los costos del monitoreo.
- una buena parte de la fauna mayor causa daño a propiedades o amenaza a la gente, de tal manera que los incentivos deben compensar las pérdidas para evitar matanzas en represalia
- los animales silvestres comparten ecosistemas complejos con otros organismos interdependientes que podrían verse negativamente afectados por las actividades humanas, de manera que los esfuerzos para conservar una especie focal se hacen dependientes de la conservación de otras

productores puede cambiar efectivamente los hábitos de compra de los consumidores (Dunwoody 2007). Por lo tanto, muchos esquemas de eco-etiquetación adoptan un modelo transparente, estándares explícitos y verificación por terceros para transmitir su confiabilidad y la precisión de su contenido de información (Amstel et al. 2007). Estos pasos podrían construir un enlace con algunos consumidores, pero no aseguran el éxito de mercado.

Las eco-etiquetas enfrentan tres dificultades comunes a muchos esfuerzos de venta de productos preferibles para el medio ambiente. Imitando a Ottman, Stafford y Hartman (2006), llamamos a estas dificultades las tres Cs.

Costo para el consumidor. La mayor parte de la gente compra productos en base a conveniencia o calidad percibida, no en base a beneficios difusos de resultados ambientales positivos (Oosterhouis, Rubik, y Scholl 2005). Por lo tanto, los productos preferibles para el medio ambiente deben también superar a la competencia en una o más magnitudes notables. Las eco-etiquetas amigables con la vida silvestre podrían disfrutar el acceso a mercados especializados, que los aíslan de la competencia con productores más convencionales.

Credibilidad de las declaraciones. Las eco-etiquetas enfrentan el escepticismo de los consumidores, pero también a organismos ambientales de control, grupos de interés entre los consumidores, competidores, y a una prensa libre que podría investigar la veracidad de las declaraciones. Este escrutinio ha hundido a productos eco-etiquetados que no son capaces de comprobar sus declaraciones (Ottman, Stafford y Hartman 2006).

Calibración de los mensajes de venta para reducir confusión. Los consumidores enfrentan docenas de declaraciones rivalizantes sobre productos sin el tiempo o los recursos para evaluar las declaraciones. Los productores deben comunicar los beneficios de sus artículos rápida y fácilmente a sus consumidores objetivo.

En la siguiente sección, exploramos la confiabilidad, verificación, confianza del consumidor e incentivos para el productor según se relacionan con las declaraciones de las eco-etiquetas acerca de la conservación de vida silvestre.

Esquema para entender las declaraciones de conservación de vida silvestre

Muchas especies carismáticas son representativas en países desarrollados y podrían ser atractivos emblemas de mercadeo, sin embargo, la verificación de éxitos y fracasos en la conservación de vida silvestre puede ser compleja, técnica y costosa. Por eso, las eco-etiquetas de conservación de vida silvestre varían ampliamente en sus declaraciones y estándares de certificación. Empleamos el término “verificación” para referirnos a la acumulación de información específica para un producto o empresa para compararlo de manera sistemática con estándares explícitos, y usamos el término “certificación” para referirnos a la decisión por parte de un cuerpo autorizado de permitir o prohibir el uso de una eco-etiqueta, en base a una comparación explícita de los datos colectados durante la verificación contra un set consistente de criterios preexistentes (en otras palabras, estándares).

Varias declaraciones planteadas por las etiquetas tienen diferentes implicaciones en la conservación de la fauna. Nuestra revisión de tanto las páginas web de compañías, como de literatura gris y académica, sugiere tres tipos funcionales de eco-etiquetas: *De apoyo, de persuasión,* y *de protección* (Figura 1). Cada tipo se relaciona de manera diferente con la fauna, las amenazas y los factores indirectos que contribuyen con dichas amenazas.

Los productos que afirman donar a las organizaciones conservacionistas (eco-etiquetas de apoyo) aparentemente proporcionan fondos a participantes remotos que podrían conservar la biodiversidad. Sin embargo, la verificación se ve dificultada por la transferencia de fondos a un destinatario externo, que usualmente no tiene que rendirle cuentas a los consumidores. Por lo tanto, los métodos de verificación no pueden ir más allá de las auditorías.

Las eco-etiquetas de persuasión afirman cambiar de cierta manera el método de manufactura, colección, o el comportamiento del productor. Estas etiquetas certifican mejores métodos de producción, pero no la conservación de fauna en sí. La verificación varía desde testimonios a inspecciones por terceros de los sitios de producción.

de terceros de la sobrevivencia o reproducción de la fauna enfocada.

Algunas eco-etiquetas integran la persuasión con la protección al requerir que los productores protejan el hábitat y al verificar dicha conservación a través de inspecciones del sitio (Tabla 1). (Discutimos el uso de hábitats como representante de la conservación de vida silvestre a continuación.) Las diferencias funcionales entre estos tres tipos de eco-etiquetas tienen implicaciones importantes para

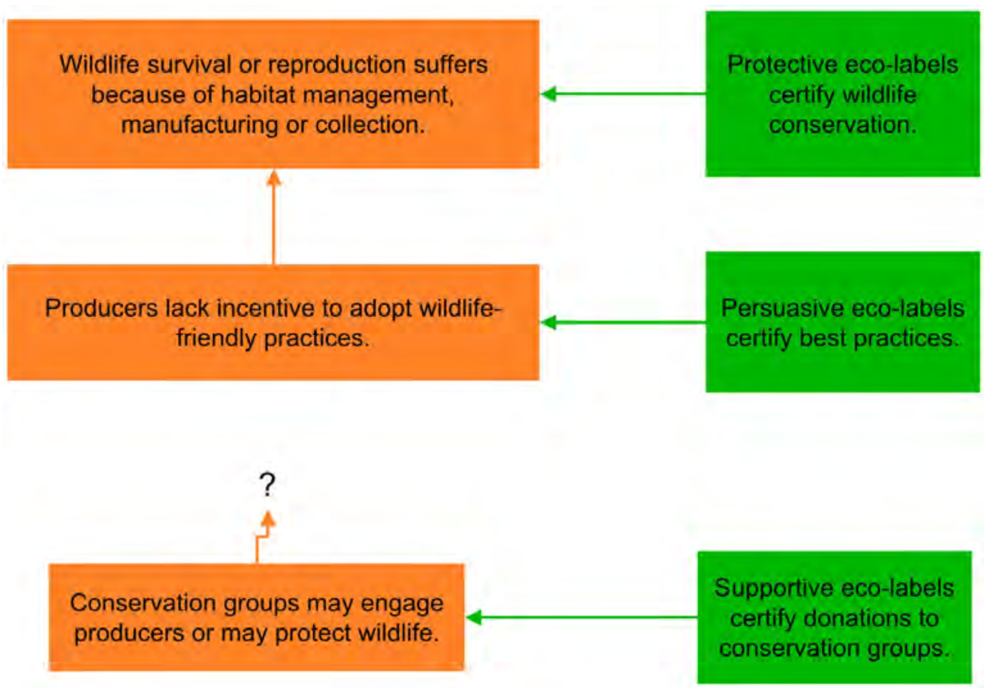

Figura 1. Puntos de enfoque de tres tipos de eco-etiquetas que actúan sobre grupos de conservación, productores, o sobre la fauna.

Las eco-etiquetas de protección afirman ayudar a conservar determinados animales silvestres o a los ecosistemas de los que dependen. La verificación se apoya en evidencia de que los animales sobrevivieron o se reprodujeron en y alrededor de la empresa certificada, y puede abarcar desde reportes de avistamientos de fauna por parte de los productores hasta el monitoreo sistemático a cargo

la confianza de los consumidores y para la captación de productores. Por “consumidor” nos referimos tanto a los usuarios finales del producto como a los defensores del consumidor. Por “productor” nos referimos al fabricante(es) o cobrador(es) responsable(s) del ensamblaje o producción de un producto eco-etiquetado.

Tabla 1. Eco-etiquetas evaluadas y clasificadas

Etiqueta	*Nuestra clasificación*	*Productos*	*Protección del hábitat*	*Página web*
Marine Stewardship Council	**Protección**	Pescado	Obligatoria	www.msc.org
Tiger Friendly	**Protección**	Hierbas	Obligatoria	www.tigerfriendly.ru
Certified Wildlife Friendly	**Persuasión/ Protección**	Alimentos, ropa, juguetes	Obligatoria	www.wildlifefriendly.org
FairWild	**Persuasión/ Protección**	Plantas silvestres	Obligatoria	www.fairwild.org
Snow Leopard Enterprises	**Persuasión/ Protección**	Productos de lana	Voluntaria	www.snowleopard.org
Rainforest Alliance Certified	**Persuasión/ Protección**	Productos alimenticios	Obligatoria	www.rainforest-alliance.org
FishWise	**Persuasión/ Protección**	Pescado	Ambigua	www.fishwise.org
Aurora Certified Organic	**Persuasión**	Productos alimenticios	Obligatoria	www.demeter.net
Baystate Certified Organic	**Persuasión**	Productos alimenticios	Voluntaria	www.baystateorganic.org
Bird-Friendly Coffee	**Persuasión**	Café	Obligatoria	nationalzoo.si.edu/ConservationAndScience/ MigratoryBirds/Coffee/roaster.cfm
Various Certified Organic: CCOF, COFA, and CO State Dept. Ag	**Persuasión**	Productos alimenticios	Voluntaria	www.ccof.org, www.cofa.net, www.certifiedorginc.org, y www.colorado.gov/cs/Satellite/Agriculture-Main/CDAG/1167928162828
Demeter Certified Biodynamic	**Persuasión**	Productos alimenticios	Obligatoria	www.demeter-usa.org
Dolphin Safe	**Persuasión**	Atún	Ambigua	www.earthisland.org/dolphinSafeTuna
Fair Trade Certified	**Persuasión**	Productos alimenticios	Voluntaria	www.transfairusa.org
Food Alliance Certified	**Persuasión**	Productos alimenticios	Obligatoria	www.foodalliance.org
Forest Stewardship Council	**Persuasión**	Productos de madera	Obligatoria	www.fsc.org
Global GAP	**Persuasión**	Productos alimenticios	Obligatoria	www.globalgap.org
Green Seal	**Persuasión**	Productos manufacturados, hoteles, alojamiento	Voluntaria	www.greenseal.org
Predator Friendly	**Persuasión**	Miel, productos de lana, carne y huevos	Voluntaria	www.predatorfriendly.org
Protected Harvest	**Persuasión**	Productos alimenticios	Obligatoria	www.protectedharvest.org
Salmon Safe	**Persuasión**	Productos alimenticios; áreas urbanas, parques, áreas naturales	Voluntaria	www.salmonsafe.org
Veriflora	**Persuasión**	Flores de regalo, plantas de vivero	Obligatoria	www.veriflora.com
Organic Bouquet Wildlife Conservation Roses	**Persuasión/ Apoyo**	Flores de regalo	–	www.organicbouquet.com
Endangered Species Chocolate	**Apoyo**	Caramelos	–	www.chocolatebar.com
MyLipStuff Charitabalms	**Apoyo**	Bálsamo labial	–	www.mylipstuff.com/charitabalms.html

* Obligatoria: protección del hábitat necesaria para la certificación. Voluntaria: se recomienda la protección del hábitat.

La confianza del consumidor podría oponerse a los incentivos de los productores con respecto a las ventajas y desventajas fundamentales en los esfuerzos de verificación (Figura 2). El esfuerzo a corto plazo necesario para satisfacer a los certificadores y para verificar las declaraciones de los candidatos reducirá la captación y participación de productores a pesar del incremento potencial a largo plazo que resulta en la confianza de los consumidores. Si el certificador y los productores intentan costear la certificación y verificación, los consumidores podrían tener que pagar precios más altos por los productos etiquetados. En resumen, el aumento del esfuerzo de verificación podría afectar las ganancias pero aumentar la confianza del consumidor, creando un conflicto de intereses entre los productores y consumidores. El certificador se encuentra atrapado en el medio y experimentará presión para diluir los estándares o para cultivar un mercado específico de fieles consumidores dispuestos a pagar precios más altos.

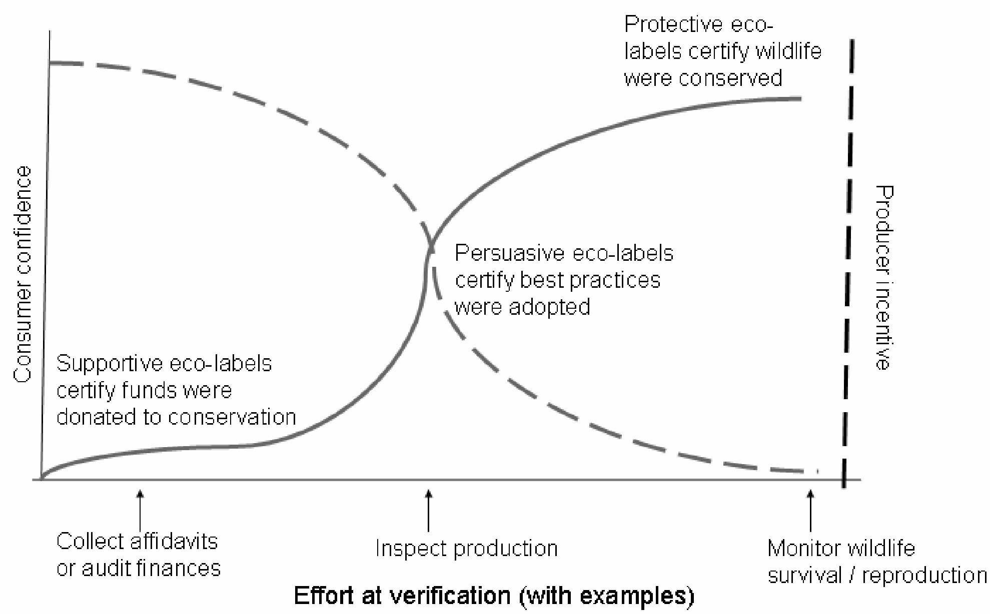

Figura 2. Relación teórica entre el esfuerzo de verificación (eje horizontal), confianza de los consumidores en las declaraciones de las eco-etiquetas (eje vertical continuo, izquierda), y los incentivos de los productores para participar (eje vertical punteado, derecha). Ejemplos de procedimientos de verificación se encuentran ordenados bajo el eje horizontal y están alineados en el gráfico con tres tipos distintos de eco-etiquetas. Un par de curvas representa los hipotéticos incentivos de los productores (punteado gris) y la confianza de los consumidores (negro continuo).

La confianza de los consumidores depende en parte de cómo son verificadas las declaraciones y de quién se comunica con el consumidor. Investigación reciente sugiere que los consumidores generalmente no hacen esfuerzos significativos por comparar entre eco-etiquetas antes de comprar (Oosterhouis, Rubik, y Scholl 2005). Los informantes externos—como minoristas, marcas, defensores del consumidor— podrían disfrutar de mayor confianza del consumidor que los mismos productores, o que marcas o mensajeros desconocidos, etc. (Dunwoody 2007). La comunicación con el consumidor está fuera del ámbito de este informe. En cambio, examinamos las implicaciones para la confianza del consumidor y cómo las diferentes declaraciones conservacionistas de las eco-etiquetas pueden ser verificadas.

Verificación de las eco-etiquetas

El esfuerzo invertido en la verificación debería ser mejorado para adaptarse a los estándares de certificación y al nivel objetivo de confianza del consumidor. Los estándares de certificación abarcan desde confianza en los testimonios de productores (declaraciones por parte de empresas certificadas) hasta verificación de campo independiente (por terceros) utilizando métodos científicos aprobados. Los tres tipos de eco-etiquetas que categorizamos antes —de apoyo, persuasión y protección— experimentan diferentes límites funcionales para la credibilidad debido a restricciones intrínsecas en los métodos de verificación que cada tipo puede aplicar.

Los fondos generados por las eco-etiquetas de apoyo pueden ser verificados, pero ir más allá de esto es prácticamente imposible porque el destinatario no tiene ninguna obligación legal de reportar precisamente cómo utilizó los fondos. Por ejemplo, Endangered Species Chocolate es una eco-etiqueta de apoyo debido a que afirma donar "10% de la ganancia neta para apoyar a las especies, hábitats y a la humanidad" (www.chocolatebar.com). Su página web indica que la compañía dona a varias causas, entre ellas, la conservación de la fauna. Por lo tanto, el consumidor debe conformarse con las reputaciones y los mensajes filantrópicos de las organizaciones destinatarias. A pesar de que un auditor puede contabilizar el uso de los fondos, el escéptico se preguntará si los fondos están bien empleados.

Las eco-etiquetas de persuasión se encargan de la producción y su supuesto impacto en la fauna y los hábitats. Con frecuencia, éstas disfrutan de mayor credibilidad que las eco-etiquetas de apoyo. Algunas eco-etiquetas de persuasión cuentan con las declaraciones de los productores para demostrar adherencia a las prácticas de conservación. Otras eco-etiquetas de persuasión usan inspecciones de sitio para verificar el comportamiento de los productores. Por ejemplo, Salmon Safe es una eco-etiqueta de persuasión porque certifica a varias empresas en base a su contaminación, uso del suelo, y otras prácticas que podrían afectar a las cuencas hidrográficas del salmón. El uso de la etiqueta no depende de la verificación de la reproducción o sobrevivencia del salmón dentro del área de influencia de cada empresa. Igualmente, el atún de Dolphin Safe Tuna certifica a pescadores que adoptan prácticas que reducen la captura accidental de delfines durante la pesca de atún. Dolphin Safe se encuentra cerca de ser una eco-etiqueta de protección porque su colaborador de monitoreo, International Marine Mammal Project, reúne y publica estadísticas sobre la reducción de capturas accidentales de delfines en todo el mundo como evidencia de la conservación de la fauna. Sin embargo, el consumidor podría dudar que comprar atún conserva los delfines; las eco-etiquetas de persuasión dependen de datos acumulativos de áreas extensas, no de la verificación del impacto individual del pescador de atún sobre los delfines, ni del impacto indirecto de la industria pesquera del atún sobre las presas de los delfines y los ecosistemas.

Las eco-etiquetas de protección certifican que la fauna sobrevivió y se reprodujo en y alrededor de las áreas de los productores participantes. La mayoría de las eco-etiquetas de conservación de vida silvestre aspiran alcanzar este nivel de certeza. La verificación de una mejor sobrevivencia de individuos de especies silvestres clave o de tendencias ascendientes en los índices poblacionales de especies amenazadas podría recibir mayor credibilidad que otros tipos de eco-etiquetas. Sin embargo, la verificación involucra el monitoreo de fauna, que consume mucho tiempo y que podría necesitar personal calificado y métodos sofisticados. Como resultado, la verificación ideal podría ser prohibitivamente costosa. Es probable que el incentivo de los productores por participar se desplome más rápidamente.

Relacionando la credibilidad con la confianza de los consumidores y los incentivos de los productores

Si se asume que la curva de ganancias en la Figura 2 se relaciona fuerte y positivamente con el incentivo de los productores de someterse a certificación, y se asume que la curva de confianza se relaciona con el número de consumidores interesados en la conservación que compran los productos eco-etiquetados, entonces se pueden observar dos estrategias diferentes. A la izquierda de la intersección de las dos curvas se encuentran productos baratos con eco-etiquetas cuyas declaraciones son sombrías o inverificables (baja confianza del consumidor) pero tienen altos volúmenes y bajos precios (muchos productores a cargo). En contraste, el lado derecho de la intersección muestra menor volumen, productos más costosos con declaraciones verificables que reciben alta confianza de los consumidores y demandan precios más altos para contrarrestar los costos de la verificación de campo por sus pocos productores. Bastantes variables locales y específicas de la industria determinarán la forma precisa de las relaciones curvilíneas y el punto óptimo de esfuerzo de verificación. Por ejemplo, nuevas tecnologías de producción o monitoreo podrían mejorar la confianza del consumidor sin que le cueste más a los productores.

El esfuerzo invertido en la verificación para evaluar el cumplimiento con estándares de certificación depende de manera crítica en qué se mide y por quién se mide. La verificación por terceros ofrece a los consumidores la máxima confianza pero incurre en los costos más elevados. Los campos de biología de conservación y ciencia de biodiversidad han discutido las medidas o indicadores de conservación exitosa por años, y varias conclusiones han surgido. Cuando se intenta proteger la mayor parte de la biodiversidad en la propiedad de una empresa, el uso de un solo indicador como índice del estado de conservación está condenado a fracasar. Actualmente se recomienda usar múltiples indicadores con diferentes tolerancias ambientales y diferente susceptibilidad a las actividades humanas. Al escoger cada uno su propio set de indicadores cuidadosamente, se espera que las posibilidades de que una especie sin cuantificar desaparezca disminuyan. Para las eco-etiquetas de persuasión que se enfocan en una especie, el indicador debe ser la amenaza más urgente y severa para esa especie. Es improbable que las medidas indirectas de la amenaza sirvan como buenos representantes. Por ejemplo, la medición de capturas accidentales de delfines de vuelta en el puerto podría no ser suficientemente precisa si los pescadores arrojan dichas capturas al mar. Para las eco-etiquetas de protección —particularmente aquellas enfocadas en una sola especie— uno debe enfocarse en los indicadores significativos de sobrevivencia o rendimiento reproductivo si uno anhela que la población esté protegida. No existe ninguna especie indicadora aceptable, y las medidas del estado de conservación deben ser escogidas bien para confirmar o rechazar el éxito de la conservación.

La diversidad de productos con eco-etiquetas también afectará los métodos de verificación. Muchas, o la mayoría, de las eco-etiquetas están ligadas a uno o varios productos o mercancías (ver Tabla 1). Dichas eco-etiquetas de “cobertura limitada” incluyen productos como pescado cosechado de manera sostenible y plantas de vivero sembradas de manera sostenible. En contraste, algunos estándares de certificación se aplican a una amplia variedad de mercancías conectadas por un beneficio ambiental deseado. Entre las eco-etiquetas de “amplia cobertura” se han certificado empresas muy diferentes (por ejemplo, aquellas que venden alimento, ropa, juguetes, etc.). La cantidad de productos cubiertos por una eco-etiqueta determinará también cuántos productores buscarán o calificarán para la certificación.

Con respecto a los productores, los analistas traen a discusión el equilibrio óptimo de la rigurosidad estándar y la captación de productores. Algunos argumentan que expandir la piscina de productores diluye los estándares ambientales y le sirve a los intereses de empresas mayores en vez de a pequeños productores (Guthman 1998). En una evaluación de las industrias pesqueras certificadas de Marine Stewardship Council, Searle, Colby y Milway (2004) apoyaron menores estándares iniciales para atraer más productores, mientras se incluyen exigencias para que dichos productores mejoren continuamente sus procesos de producción. Ejecutados adecuadamente, dichos compromisos podrían permitir que los nuevos esfuerzos de comunicación sobrevivan y capten muchos productores, también como ayudar a difundir prácticas más sustentables a través de una industria. De hecho, a varios esfuerzos de certificación se les acredita aumentar la conciencia del consumidor sobre las amenazas al ambiente y sobre prácticas de manufactura menos dañinas (Bartley 2003; Oosterhouis, Rubik, y Scholl 2005; Ottman, Stafford y Hartman 2006).

Alianzas novedosas para la certificación

Los productos eco-etiquetados deben prepararse para entrar a un mercado abarrotado con cientos de marcas y etiquetas que ofrecen cualquier número de beneficios para el consumidor. De manera similar, los obstáculos para triunfar en el mercado van más allá de las marcas, e incluyen regulaciones de cambio, demanda de calidad y volumen por parte de minoristas, y otros innumerables impedimentos para las ventas veloces. Las organizaciones de conservación de vida silvestre parecen estar mal preparadas para este entorno. A los que intentan trabajar con eco-etiquetas les vendría bien colaborar con personas expertas en negocios para diseñar campañas de mercadeo efectivas y organizarse colectivamente, de manera que la experiencia en verificar la conservación de la vida silvestre esté conectada con la experiencia en alcanzar a comerciales minoristas y mayoristas, y en persuadir a los consumidores. Las organizaciones de conservación de vida silvestre y los nuevos estudiantes egresados con experiencia en el monitoreo ambiental podrían encontrar nichos como verificadores de procesos de manufactura amigables con el medio ambiente.

Conclusiones

Hemos resaltado las ventajas y desventajas relacionadas con las eco-etiquetas de conservación de vida silvestre: una verificación transparente y efectiva incrementa la confianza del consumidor pero disminuye el incentivo de los productores por cambiar sus prácticas y aplicar para certificación. Este conflicto fundamental entre productor y consumidor presiona a los certificadores para que relajen los estándares o recorten los costos de verificación, o en cualquier caso para que aumenten los costos de los productos eco-etiquetados. La práctica anterior diluye el significado y el valor de la etiqueta pero expande el acceso al mercado, mientras que la última práctica crea un mercado de nichos poblado por pocos consumidores específicos.

Las eco-etiquetas de apoyo —aquellas que donan ganancias a la conservación— nunca alcanzarán el mayor nivel de credibilidad porque las mejoras en el ambiente son indirectas y opacas. En contraste, las eco-etiquetas que alientan que las empresas cambien los procesos de producción (eco-etiquetas de persuasión) y aquellas que demostrablemente conservan el ambiente (eco-etiquetas de protección) pueden ganar mayor credibilidad. Sin embargo, enfrentan obstáculos para el éxito de mercadeo debido a los costos de producción y de los productos. De hecho, la rentabilidad generalizada para los esquemas de certificación de persuasión y protección podría no ser un objetivo realista. La conservación exitosa de vida silvestre a través de esquemas de eco-etiquetación requiere la planificación cuidadosa de una producción amigable con la vida silvestre, equilibrando las necesidades de los productores y de la fauna con las necesidades de los consumidores.

Las necesidades de la fauna suscitan preguntas prácticas y éticas más generales acerca de emplear mecanismos basados en el mercado para alcanzar los objetivos de conservación. ¿Puede el consumismo contribuir con la conservación, o fortalece los incentivos perversos que conllevan a la degradación del ambiente? Si una moda pasajera desfavorece a un producto eco-etiquetado en particular, ¿podrían los productores certificados rechazar al animal detrás de ese producto? Los opositores a las iniciativas de conservación basadas en el mercado podrían ver al gobierno como la autoridad más legítima para regular las prácticas de producción de un bien público, en este caso un ambiente protegido; a pesar de esto, las eco-etiquetas ofrecen una respuesta práctica a la urgente crisis global de pérdida de biodiversidad. En este informe, intentamos aclarar las variadas afirmaciones de las eco-etiquetas y cómo los consumidores podrían discriminar entre ellas en base a su efectividad funcional en la conservación de la vida silvestre.

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TENURE BRIEF

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Market Financing for Biodiversity Conservation and Strategic Tradeoffs for Wildlife-Friendly Eco-Labels

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Consumers buying products labeled "eco-friendly" may hope to help conserve the environment, yet the credibility of eco-labels varies. Wildlife conservation poses special challenges for eco-label claims because wild animal populations fluctuate naturally and field verification of impacts can be slow, complex, and costly. This brief defines three types of eco-labels according to their potential to conserve wildlife, and examines the obstacles to convincing consumers of eco-label claims.

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Environmental conservation organizations have long sought to use market-based financing to protect nature. Ecotourism, hunting fees, and conservation banking are some of the many market-driven efforts to conserve wildlife and protect wild lands from destructive activities. More recently, the biodiversity sector has sought consumer financing for conservation incentives. Among these efforts are various product-labeling and certification schemes—eco-labels—meant to offer a price premium or enhanced market access to producers who support wildlife conservation (Amstel et al. 2007). Given the growing interest in eco-labels, this brief examines the reliability of claims that products are wildlife friendly.

Connecting conservation-minded consumers to wildlife-conserving producers

Uniting consumers and producers as constituencies for wildlife conservation demands two things: (1) a direct incentive for producers to conserve wild animals that have meaning to consumers, and (2) an explicit and commonsense link between a preferred system of production (manufacture or collection) and the conservation of iconic wild animals (Searle, Colby and Milway 2004; Fischer et al. 2008).

The search for wildlife-friendly economic activities may rule out approaches that could conserve wildlife but do not mesh with the expectations or behaviors of consumers or producers. For example, reimbursing producers for the costs of coexistence with wildlife (for example, providing compensation for wildlife damage to property) can generate perverse incentives, such as negligent defense of property or retaliation against the animals that caused the damage **(**Naughton-Treves, Grossberg, and Treves 2003; Bulte and Rondeau 2005**)**. In contrast to these approaches, linking revenues directly to successful reproduction or survival of wildlife may foster pro-wildlife attitudes among producers **(**Mishra et al. 2003; Schwerdtner and Gruber 2007; Zabel and Holm-Muller 2008). "Pay for living wildlife rather than dead livestock" is a common way of articulating the latter strategy and its link to conservation.

The need to recruit consumers to a particular wildlife conservation strategy demands different approaches from those used with producers. For example, sustainable harvest of wildlife has long been used as a tool in conserving certain species (Loveridge, Reynolds, and Milner-Gulland 2007), but many consumers in wealthy nations view hunting as inhumane or anti-conservation (Peterson 2004). This suggests that market approaches to wildlife conservation will be most effective when they can be understood as wildlife friendly by the widest possible set of consumers. The communication role of eco-labels, therefore, is critical to consumer recruitment.

Eco-labels are intended to signal to consumers that purchases contribute to positive environmental outcomes. Choosy consumers in a crowded marketplace confront an array of signals with varying information content and reliability (Amstel et al. 2007). When the interests of both conservation-minded producers and consumers align, then a reliable message from the producers can effectively change consumer buying habits (Dunwoody 2007). Therefore, many eco-label schemes embrace transparency, explicit standards, and third-party verification to convey their reliability and the accuracy of their information content (Amstel et al. 2007). These steps may build a bond to some consumers but do not assure market success.

Eco-labels face three challenges common to many environmentally preferable, product-marketing efforts. Following Ottman, Stafford and Hartman (2006), we call these the three Cs.

Consumer value. Most people buy products based on perceived quality or convenience, not the diffuse benefits of positive environmental outcomes (Oosterhouis, Rubik, and Scholl 2005). Thus, environmentally preferable products must also surpass the competition in one or more salient dimensions. Wildlife-friendly eco-labels may enjoy access to dedicated markets, which insulate them from competition with more mainstream producers.

Credibility of claims. Eco-labels face consumer skepticism and also environmental watchdogs, consumer interest groups, competitors, and a free press that may investigate the veracity of claims. This scrutiny has sunk eco-labeled products unable to prove their claims (Ottman, Stafford and Hartman 2006).

Challenges to verifying whether a business conserves wildlife

- wildlife ignore jurisdictional, property boundaries
- wild animal populations experience complex, stochastic, long-term demographic changes that obscure the putative influences of humans
- many species of conservation concern are wary from past human persecution, which makes monitoring expensive and difficult
- a number of the larger wildlife damage property or threaten people, so incentives must offset losses to prevent retaliatory killing
- wild animals share complex ecosystems with other interdependent organisms that may be adversely affected by human activities, making efforts to conserve one focal species dependent on the conservation of others

Calibrate marketing messages to reduce confusion. Consumers face dozens of competing claims about products without the time or wherewithal to evaluate the claims. Producers must communicate the benefits of their goods quickly and easily to their target consumers.

In the following section we explore reliability, verification, consumer confidence and producer incentives as they relate to wildlife conservation claims of eco-labels.

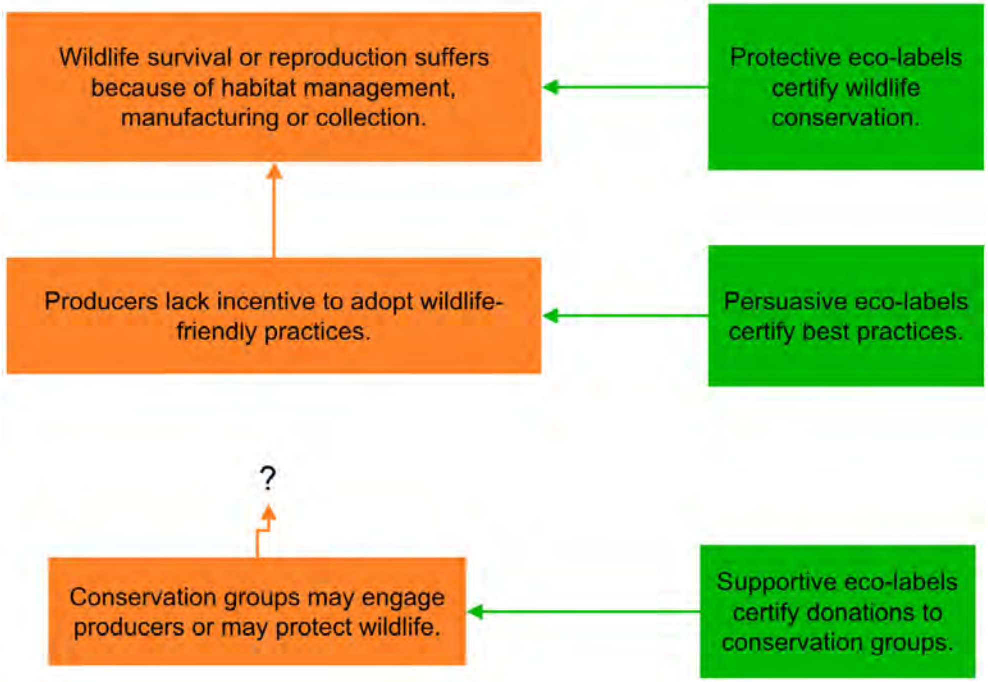

Figure 1. Focal point of three types of eco-labels acting on conservation groups, producers, or wildlife.

Framework for understanding wildlife conservation claims

Many charismatic species are iconic in wealthy countries and may be attractive marketing emblems, yet verifying successes and failures with wildlife conservation can be complex, technical, and costly. Therefore, wildlife conservation eco-labels vary widely in their claims and certification standards. We use "verification" to mean gathering information specific to a product or business for systematic comparison with explicit standards, and we use "certification" to mean the decision by an authorized body to permit or prohibit use of an eco-label, based on explicit comparison of data collected during verification against a consistent set of pre-existing criteria (in other words, standards).

Various claims posed by labels have different implications for wildlife conservation. Our review of company websites, as well as the academic and gray literature, suggests three functional types of eco-label: *Supportive, Persuasive,* and *Protective* (Figure 1). Each type has a different relationship to wildlife, threats, and the indirect factors contributing to those threats.

Products that claim to donate to conservation organizations (supportive eco-labels) ostensibly provide funds to remote actors who may conserve biodiversity. However, verification is complicated by the transfer of funds to a third-party recipient, which usually is not accountable to the consumers. Thus the methods of verification cannot go far beyond audits.

Persuasive eco-labels claim to change manufacture, collection, or producer behavior in some way. These certify improved methods of production but not wildlife conservation itself. Verification varies from affidavits to third-party inspection of the production sites.

Protective eco-labels claim to help conserve particular wild animals or the ecosystems on which they depend. Verification rests on evidence that the animals survived or reproduced in and around the certified businesses, and can range from producer reports of wildlife sightings to systematic, third-party monitoring of the survival or reproduction of focal wildlife.

Some eco-labels bridge the persuasive and protective types by requiring that producers protect habitat and by verifying such habitat conservation through site inspections (Table 1). (We discuss the use of habitat as a proxy for wildlife conservation below.) The functional differences among these three types of eco-labels have important implications for consumer confidence and producer recruitment. By "consumer" we mean both the end-user of a product and consumer advocates. By "producer" we mean the manufacturer(s) or collector(s) responsible for assembly or production of an eco-labeled product.

Consumer confidence may conflict with producer incentives over a fundamental tradeoff in verification efforts (Figure 2). The short-term effort needed to satisfy certifiers and verify applicants' claims will reduce producer participation and recruitment despite the potential long-term increase in consumer confidence that results. If the certifier and producer attempt to defray the costs of certification and verification, consumers may have to pay higher prices for the labeled products. In short, increasing the verification effort will cut into profits but raise consumer confidence, creating a conflict of interest between producers and consumers. The certifier is caught in the middle and will experience pressure to dilute standards or cultivate a niche market of dedicated consumers willing to pay premium prices.

Consumer confidence depends in part on how claims are verified and in part on who communicates with the consumer. Recent research suggests consumers do not generally make significant efforts to compare eco-labels before purchasing (Oosterhouis, Rubik, and Scholl 2005). Third party informants—such as retailers, brands, consumer advocates—may enjoy more consumer trust than the producers themselves, unknown brands, unfamiliar messengers, etc. (Dunwoody 2007). Communication with consumers is beyond the scope of this review. Instead we examine how the different conservation claims of eco-labels may be verified and the implications for consumer confidence.

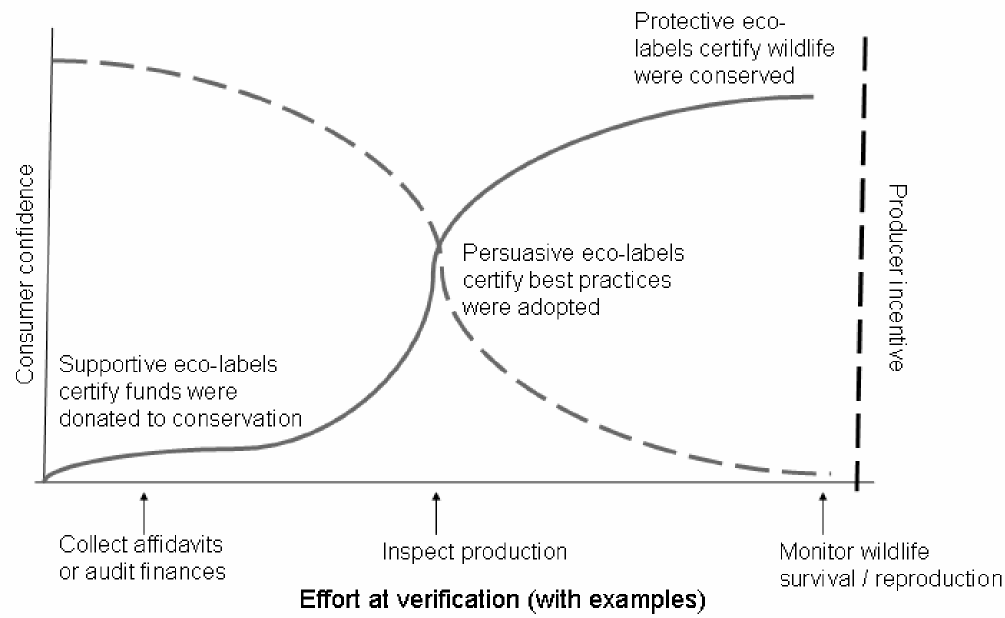

Figure 2. The theoretical relationship between verification effort (horizontal axis), consumer confidence in eco-label claims (solid vertical axis, left), and producer incentives to participate (dashed vertical axis, right). Examples of verification procedures are arrayed under the horizontal axis and line up with three distinct types of eco-labels within the graph. A pair of curves depicts hypothetical producer incentives (dashed gray) and consumer confidence (solid gray).

Table 1. Eco-labels evaluated and classified

Label	*Our classification*	*Products*	*Habitat Protection**	*Website*
Marine Stewardship Council	**Protective**	Fish	Mandatory	www.msc.org
Tiger Friendly	**Protective**	Herbs	Mandatory	www.tigerfriendly.ru
Certified Wildlife Friendly	**Persuasive/ Protective**	Food, apparel, toys	Mandatory	www.wildlifefriendly.org
FairWild	**Persuasive/ Protective**	Wild plants	Mandatory	www.fairwild.org
Snow Leopard Enterprises	**Persuasive/ Protective**	Wool products	Voluntary	www.snowleopard.org
Rainforest Alliance Certified	**Persuasive/ Protective**	Food products	Mandatory	www.rainforest-alliance.org
FishWise	**Persuasive/ Protective**	Fish	Ambiguous	www.fishwise.org
Aurora Certified Organic	**Persuasive**	Food products	Mandatory	www.demeter.net
Baystate Certified Organic	**Persuasive**	Food products	Voluntary	www.baystateorganic.org
Bird-Friendly Coffee	**Persuasive**	Coffee	Mandatory	nationalzoo.si.edu/ConservationAndScience/ MigratoryBirds/Coffee/roaster.cfm
Various Certified Organic: CCOF, COFA, and CO State Dept. Ag	**Persuasive**	Food products	Voluntary	www.ccof.org, www.cofa.net, www.certifiedorginc.org, and www.colorado.gov/cs/Satellite/Agriculture-Main/CDAG/1167928162828
Demeter Certified Biodynamic	**Persuasive**	Food products	Mandatory	www.demeter-usa.org
Dolphin Safe	**Persuasive**	Tuna	Ambiguous	www.earthisland.org/dolphinSafeTuna
Fair Trade Certified	**Persuasive**	Food products	Voluntary	www.transfairusa.org
Food Alliance Certified	**Persuasive**	Food products	Mandatory	www.foodalliance.org
Forest Stewardship Council	**Persuasive**	Wood products	Mandatory	www.fsc.org
Global GAP	**Persuasive**	Food products	Mandatory	www.globalgap.org
Green Seal	**Persuasive**	Manufactured goods, hotels, lodging	Voluntary	www.greenseal.org
Predator Friendly	**Persuasive**	Honey, wool products, meat & eggs	Voluntary	www.predatorfriendly.org
Protected Harvest	**Persuasive**	Food products	Mandatory	www.protectedharvest.org
Salmon Safe	**Persuasive**	Food products; urban areas, parks, natural areas	Voluntary	www.salmonsafe.org
Veriflora	**Persuasive**	Cut flowers, potted plants	Mandatory	www.veriflora.com
Organic Bouquet Wildlife Conservation Roses	**Persuasive/ Supportive**	Cut flowers	–	www.organicbouquet.com
Endangered Species Chocolate	**Supportive**	Candy	–	www.chocolatebar.com
MyLipStuff Charitabalms	**Supportive**	Lip balm	–	www.mylipstuff.com/charitabalms.html

* Mandatory: habitat protection required for certification. Voluntary: habitat protection recommended.

Verification of eco-labels

The effort invested in verification should be optimized to match the standards for certification and the target level of consumer confidence. Certification standards range from trust in producer testimonials (affidavits from certified businesses) through independent (third-party) field verification using approved scientific methods. The three types of eco-labels we categorized above—supportive, persuasive and protective—experience different functional limits to credibility because of inherent constraints on the verification methods each can apply.

The funds generated by supportive eco-labels can be audited, but going beyond this is practically impossible because there is no legal obligation for the recipient to report precisely how it used funds. For example, Endangered Species Chocolate is a supportive eco-label because it claims to donate "10% of net profits to help support species, habitat and humanity" (www.chocolatebar.com). Its website indicates the company donates to various causes, wildlife conservation being one of several. Therefore, the consumer must be satisfied with the reputations and philanthropic messages of recipient organizations. Although an auditor can account for use of funds, the skeptic will wonder if funds are well spent.

Persuasive eco-labels address production and its putative impact on wildlife and habitats. These tend to enjoy more credibility than supportive eco-labels. Some persuasive eco-labels rely on producers' affidavits to demonstrate adherence to conservation practices. Other persuasive eco-labels use site inspections to verify producer behavior. For example, Salmon Safe is a persuasive eco-label because it certifies various businesses based on their pollution, land use, and other practices that may affect salmon watersheds. Use of the label is not contingent on verification of salmon survival or reproduction within the sphere of influence of each business. Similarly, Dolphin Safe tuna certifies fishers who adopt practices that reduce by-catch of dolphins during tuna fishing. Dolphin Safe verges on being a protective eco-label because its monitoring collaborator, International Marine Mammal Project, collects and publishes statistics on reduced dolphin by-catch worldwide as evidence of wildlife conservation. However, the consumer may doubt that buying the tuna conserves dolphins; the persuasive eco-label depends on aggregate data from vast areas, not verification of the individual tuna fisher's impact on dolphins or the tuna industry's indirect impact on dolphin prey and ecosystems.

Protective eco-labels certify that wildlife survived or reproduced in and around the participating producers' areas. Most wildlife-conservation eco-labels aspire to reach this level of certainty. Verification of improved survival of individuals of key wildlife species or upward trends in threatened species' population indices could earn higher credibility than other types of eco-labels. However, verification involves time-consuming wildlife monitoring, which may require trained staff and sophisticated methods. As a result, ideal verification may be prohibitively expensive. The producer incentive to participate is likely to drop more quickly.

Relating credibility to consumer confidence and producer incentives

If one assumes the profit curve in Figure 2 correlates strongly and positively with the incentive for producers to undergo certification, and one assumes the confidence curve correlates with the number of conservation-minded consumers who purchase the eco-labeled products, then one can see two distinct strategies. To the left of the intersection of the two curves are inexpensive products with eco-labels whose claims are opaque or unverifiable (low consumer confidence) but which have high volumes and low prices (many producers on board). By contrast, the right side of the cross-over point shows lower-volume, more costly products with verifiable claims that garner high consumer confidence and demand premium pricing to offset the costs of field verification for their few producers. A number of industry-specific and local variables will determine the precise shape of the curvilinear relationships and the optimal point for verification effort. For example, new monitoring or production technologies may enhance consumer confidence without costing producers more.

The effort invested in verification to assess compliance with certification standards depends critically on what is measured and by whom. Verification by a third party offers consumers the most confidence, but incurs the highest costs. The fields of conservation biology and biodiversity science have debated the measures or indicators of successful conservation for years, and several conclusions have emerged. When attempting to protect most or all of the biodiversity of a business property, the use of a single surrogate as an index of condition is doomed to fail. Current recommendations are to use multiple surrogates with diverse environmental tolerances and diverse sensitivities to human activities. By choosing one's set of indicators carefully, the odds of an unmeasured species vanishing are expected to diminish. For persuasive eco-labels that focus on one species, the indicator must be the most severe and urgent threat to that species. Indirect measures of the threat are unlikely to serve as good proxies. For example, measuring dolphin by-catch back in harbor may not be sensitive enough to detect if fishers dump by-catch out at sea. For protective eco-labels—particularly those with a single focal species of concern—one must focus on the key indicators of reproductive performance or survival if one wishes to ensure that the population is protected. There is no acceptable surrogate species, and the measures of condition must be chosen well to confirm or reject conservation success.

Diversity of products under an eco-label will also affect the methods for verification. Many, if not most, eco-labels are tied to one or a few products or commodities (see Table 1). Such "narrow scope" eco-labels include sustainably harvested fish and sustainably grown nursery plants. In contrast, some certification standards apply to a wide variety of commodities connected by a desired environmental outcome. Among "broad scope" eco-labels very different businesses (for example, those selling food, apparel, toys, etc.) have been certified. The breadth of products covered by an eco-label will also determine how many producers will seek or qualify for certification.

Regarding producers, analysts debate the optimal balance of standard stringency and producer recruitment. Some argue that expanding the producer pool dilutes environmental standards and serves bigger business interests rather than small producers (Guthman 1998). In an assessment of Marine Stewardship Council certified fisheries, Searle, Colby and Milway (2004) advocate low, initial standards to recruit more producers, while attaching requirements that such producers continually improve their production processes. Properly executed, such compromises may allow fledgling certification efforts to survive and recruit many producers, as well as help spread more sustainable practices throughout an industry. Indeed, several environmental certification efforts are credited with raising consumer awareness of threats to the environment and of less damaging manufacturing practices (Bartley 2003; Oosterhouis, Rubik, and Scholl 2005; Ottman, Stafford and Hartman 2006).

Novel alliances for certification

Eco-labeled products must prepare to enter a crowded market with hundreds of brands and labels touting any number of benefits to the consumer. Similarly, the obstacles to success in the marketplace go beyond branding, and include trade regulations, quality and volume demands of retailers, and innumerable other impediments to swift sales. Wildlife conservation organizations seem ill prepared for this arena. Those attempting eco-labeling would do well to collaborate with business experts to design effective marketing campaigns and organize collectively, so that expertise in verifying wildlife conservation is connected to expertise in reaching retail and wholesale outlets and persuading consumers. Wildlife conservation organizations and new graduates with expertise in environmental monitoring may find niches as verifiers of eco-friendly manufacturing.

Conclusions

We highlighted a tradeoff with regard to wildlife-conservation eco-labels: transparent and effective verification increases consumer confidence but lowers the incentive for producers to change practices and apply for certification. This fundamental conflict between producer and consumer puts pressure on certifiers to relax standards or cut costs of verification, or else raise the costs of eco-labeled products. The former practice dilutes the meaning and value of the label but expands market access, whereas the latter practice creates a niche market populated by few, dedicated consumers.

Supportive eco-labels—those donating profits to conservation—will never attain the highest level of credibility because improvements in the environment are indirect and opaque. By contrast, eco-labels that encourage businesses to change production processes (persuasive eco-labels) and those that demonstrably conserve the environment (protective eco-labels) can gain higher credibility. However, they face obstacles to success in marketing due to the costs of operation and products. Indeed, widespread profitability for persuasive and protective certification schemes may not be a realistic goal. Successful wildlife conservation through eco-labeling schemes demands the careful planning of wildlife friendly production, balancing the needs of producers and wildlife with the needs of consumers.

The needs of wildlife raise broader ethical and practical questions about employing market-based mechanisms to achieve conservation goals. Can consumerism contribute to conservation, or does it reinforce perverse incentives that lead to environmental degradation? If a current fad disfavors a particular eco-labeled product, will the certified producers reject the animal behind that product? Opponents of market-based approaches to conservation may see the state as the most legitimate authority for regulating production practices to produce a public good, in this case a protected environment; yet, eco-labels offer a practical response to the urgent, global crisis of biodiversity loss. In this brief, we attempted to clarify the varied claims of eco-labels and how consumers might discriminate among eco-labels based on functional effectiveness in conserving wildlife.

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TENURE BRIEF

NO. 7; AUGUST 2007

UNIVERSITY OF WISCONSIN — MADISON

BALANCING THE NEEDS OF PEOPLE AND WILDLIFE:
When Wildlife Damage Crops and Prey on Livestock

Adrian Treves: University of Wisconsin-Madison

This LTC Brief draws from experience on three continents to outline recent advances in understanding and managing human-wildlife conflicts, with twin objectives of biodiversity conservation and poverty alleviation.

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WHETHER ONE CONSIDERS LIONS, tigers and bears preying on livestock or elephants, parrots and deer feeding on crops, conflicts arise when the activities of wild animals coincide with those of people. Although damages by wildlife do not have the regional impact that drought and disease have, they do have critical, political and environmental significance for the conservation of biodiversity. They also can have catastrophic economic consequences for vulnerable households.

The fringes of protected areas and landscapes with a mix of human development and wild land see most human-wildlife conflicts (HWC). Each year, thousands of people lose their lives and billions of dollars are lost in property because of HWC globally. Traditionally, people respond to wildlife threats by killing "problem" animals and eliminating wild habitat to prevent further losses. The scale of biodiversity and economic costs is hard to estimate for developing countries, but data from developed nations are indicative. The US government responds to roughly $1 billion in agricultural damage nationwide by killing approximately 2.5 million wild animals annually. In 2004, this included 107,044 wild carnivores, of which about 3% were threatened or endangered species or killed unintentionally when other species were targeted.

There is no evidence that agricultural damages by wildlife are decreasing in the United States, but in the developing world conditions are more volatile. On the one hand, severe habitat loss has diminished wildlife populations, reducing the number of households affected by HWC, *at great cost to biodiversity*. On the other hand, where nature protections have succeeded, threatened wildlife may recover and cause property damage or loss of life for households once far from wild lands, *at great cost to rural economies*. Recent advances in HWC research and management promise to interrupt the wasteful spiral in either direction and simultaneously promote biodiversity conservation and poverty alleviation.

Over the past two decades, scientific research has identified a handful of principles of HWC and distilled a number of recommendations for management. This brief outlines the wildlife dimensions of HWC, reviews our understanding of affected people's perceptions of risk and resolution, traces paths to successful intervention through participatory planning and co-management, and examines the key role of research in the resolution of HWC.

Wildlife dimensions: the behavior of problem individuals

The fate of wildlife depends on human tolerance for them. Thus HWC is now seen as a major challenge for conservation, particularly for large animals that require large areas and often exploit the same resources as do people. In the case of large carnivores, few protected areas are large enough to support a viable population and the predominant causes of mortality in all carnivore populations studied thus far come from humans.

Worldwide, spatial analyses emphasize the patchy nature of conflict with wildlife. Some localities will suffer heavy losses while others go unscathed. Indeed, a minority of individual large mammals pose a threat to crops, livestock or people, just as a minority of households suffer the majority of losses. The patchiness of HWC reduces the cost-effectiveness of large-scale and non-selective wildlife control efforts. For example, culling has repeatedly failed as the problem wildlife were missed and uninvolved animals were removed. However, people often perceive lethal methods as a "final" solution, so other approaches may require persuasion, a subject addressed in detail in the next section.

Also "problem" animals change their behavior when living in and around human property. Timing their activities, modifying vocal behavior and choosing micro-sites to avoid detection and reprisals by people have all been reported. The elusiveness and wariness of problem carnivores is legendary. For example, in Ecuador, nine Andean bears were killed by local farmers before they felt satisfied that they had eliminated the single bear believed to be attacking cattle. In sum, identifying likely culprits in HWC is a critical step in protecting a wildlife population from disproportionate

Definitions

Co-management: Management shared between affected communities and governmental agencies or NGOs.

Coping mechanisms: Steps taken to reduce individual or household vulnerability, which range from individualized self-protection to collective insurance based on social reciprocity. The former depend heavily on individual access to land, labor, and capital, which depend in turn on wealth and political influence. By contrast, communal coping mechanisms depend on kinship networks, traditions of sharing, reciprocity, and joint land management.

Local stakeholders: Affected communities and the nationally appointed authorities charged with wildlife management at a site. While it can be a challenge to identify the appropriate unit of social organization to be involved in management, the natural and obvious unit is composed of the individuals and households affected by human-wildlife conflict in a given locality.

Management: Planning, intervention, and monitoring (including baseline applied research).

Risk: The likelihood of loss for a given locality. (Compare to "vulnerability.")

Vulnerability: Individual or household capacity to cope with risk.

Wildlife: This brief focuses on terrestrial vertebrates (larger than one kilogram) rather than smaller organisms that typically produce greater economic losses, because larger organisms pose a greater immediate physical threat and provoke more political strife between environmental interests and other stakeholder groups.

human retaliation. It is also a step that typically requires research.

Even selective lethal control of wildlife may not be cost-effective, if new animals quickly replace the ones removed, and if distinguishing the culprits from uninvolved animals is fraught with error, as is usually the case. Thus, non-lethal deterrence may be more cost-effective and is usually preferable from a biodiversity conservation standpoint as well.

Wild animals are usually neophobic—wary of new stimuli. Thus, the most successful non-lethal interventions are varied and flexible, using several different deterrents in combination or serially in order to avoid habituation by wildlife. Because a wild animal deflected from one property may move to another, non-lethal deterrents should usually be applied to multiple, neighboring properties. However, the full extent of such installation (for example, fencing) should reflect the ranging behavior of the problem animal, not some sociopolitical unit. This may require working across jurisdictions, which emphasizes the potential benefits of stakeholder participation in planning.

Human dimensions: vulnerability and perceptions

HWC can turn affected communities against wildlife conservation initiatives and, in some cases, cause local governments to de-gazette protected areas. Local resentment over damage by wildlife can preclude discussion of other environmental issues, such as soil erosion, pollution, and water management. Downplaying or ignoring the problem can generate added resentment.

Perceptions of HWC influence complaints, tolerance for wildlife, approval of management, and cooperation in proposed solutions. Local perceptions of HWC are complementary to systematic, scientific measures of loss and equally important in managing the problem. Three reasons for this follow.

Catastrophic losses versus averages. Perceptions are shaped by catastrophic events more than frequent, small-scale losses, notwithstanding the higher cumulative, economic costs of the latter. By contrast, most scientific studies of HWC emphasize averages, not extremes. Regional averages can mask the few individuals or households suffering devastating losses. For example, elephants can cause catastrophic damage to a farm but few are affected and only rarely. Yet many farmers will complain bitterly about elephants whereas few mention widespread, chronic losses caused by monkeys.

Time scale and spatial scale. Human perceptions may be distilled from long memories and stories from distant associates. This breadth and depth is rarely captured in scientific studies, which usually sample a smaller area over a briefer period.

Audiences. Affected communities and lay audiences often find personal stories more convincing or comprehensible than scientific data. By contrast, systematic measures can be more compelling to authorities, scientists and outsiders, who may want to see quantitative evidence before investing time and effort.

Perceptions are a management reality. Perceptions of HWC may shape expectations about proposed interventions. In Japan, a majority of surveyed farmers opposed lethal control of suspected crop-raiding monkeys because the monkeys were perceived as physically similar to humans. Furthermore, because perceptions are shaped by catastrophic, rare events more than by small-scale, frequent events, successful interventions against common, small-scale damages may not reduce complaints about HWC, even if economic losses are significantly lessened. Similarly, some highly effective interventions may clash with sociopolitical norms of behavior or cultural traditions.

Interventions against HWC should not appear one-sided in addressing human behavior; this can be seen as "blaming the victim." Simultaneous changes in husbandry or human behavior alongside interventions against wildlife behavior may equalize the burden of change. This will usually entail implementing two or more interventions, which also matches recommendations from recent studies that show single interventions rarely work for long.

Local people often fear or resent wildlife as a symbol of government property. (Photo by Leela Hazzah)

Perceptions of HWC are shaped not only by the severity and frequency of losses but by numerous social and biophysical factors relating to individual vulnerability and risk. We define "risk" as the likelihood of loss for a given locality. In contrast, "vulnerability" pertains to individual or household capacity to cope with that risk. Neighbors facing identical risk of Andean bear damage to maize fields may have very different vulnerabilities based on their resources and the protective measure in which they have invested. If one of the neighbors has a second job that precludes guarding her farm, then she may suffer more bear damage but her second income may compensate for the losses. The tradeoffs between alternative coping methods and their outcomes for vulnerability emphasize that coping methods are experiments.

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Changing conditions alter these tradeoffs, so we must monitor the outcomes of different coping methods, causes and consequences of differential vulnerability across households, and fluctuating external risk factors—especially if we put in place material and technical interventions in regions of marginal productivity. For example, the five-year, multi-million dollar India Eco-Development Project (IEDP) tried to protect a national park containing tigers, while also protecting crops form wildlife and increasing local incomes. Economic incentives of many sorts were provided in consultation with the beneficiary communities. But biodiversity monitoring was cut from the budget and long-term monitoring of economic interventions was not included in the project plan. An independent study conducted five years after the IEDP ended found that the majority (66%) of material contributions—for alternative livelihoods and for crop defense—were not used or maintained (Gubbi 2007). Furthermore, the author's survey revealed no difference in conservation attitudes between IEDP beneficiaries and non-beneficiaries around the same park. This is a sobering reminder that incentives for conservation must be paired with sanctions or the inputs become entitlements and attitudes or behaviors will not change. Moreover, efforts to protect affected households from HWC must take into account traditional coping methods and the long-term sustainability of whatever interventions are attempted.

Coping with HWC

Coping mechanisms range from individualized self-protection to collective insurance based on social reciprocity. The former depend heavily on individual access to land, labor, and capital, which depend in turn on wealth and political influence. By contrast, communal coping mechanisms depend on kinship networks, traditions of sharing, reciprocity, and joint land management. The poorest, migrant households face compounding vulnerability. Without large landholdings or kin networks they cannot buffer themselves from wildlife conflict, nor can they hire additional labor.

Some settings limit the use of social coping mechanisms (for example, recent migration by new ethnic groups, incentives for individual land ownership). Of course a continuum exists from individual to fully communal, social coping methods, and affected households may participate in both.

Because HWC often leads to destruction of wildlife and wild lands or political clashes over biodiversity protection, outside groups often become involved. At that point, proposed solutions multiply and traditional coping methods may be forgotten. The risk in such cases is that traditional coping methods are often more understandable, sustainable, and cost-effective for affected households than are novel solutions advocated by stakeholders who are less directly affected by HWC. Moreover, the affected communities are sometimes wholly disenfranchised if wildlife authorities and outsiders step in to control HWC.

To avoid the extremes—either traditional, unregulated control of wildlife, which often spirals into unsustainable killing, or novel, technical solutions imposed upon affected peoples—this brief focuses on co-management, including participation by affected households in decision-making, implementing experimental interventions, and even monitoring HWC.

Participation and co-management

Our starting assumption is that participation should be *optimized*. Namely, participation in planning, implementation and monitoring has potential advantages and disadvantages. The disadvantages reflect the transactional costs of meeting, building consensus and organizing actors into coordinated roles, as well as potential political clashes that arise from differences of opinion or conflicts of interest. The advantages include recruiting influential stakeholders as partners, generating additional ideas for implementation that a subset might have overlooked, combining resources and personnel to attain a shared goal, and providing a model for more democratic and transparent decision-making. The optimal level of participation maximizes the ratio of benefits to costs at a given site and at each step in a project cycle. In short, participation should be tailored to local conditions and considered strategically as a means to a goal, not an end in itself.

Ideally, affected individuals and households would manage HWC independently without permanently damaging biodiversity. However, several conditions demand collaboration between affected households and other stakeholders. For one, many conflicts occur at the borders of protected areas or involve endangered species, which may fall under the jurisdiction of wildlife managers. A third party (for example, an NGO or outside researcher) may be needed if there is a history of mistrust among local stakeholders. However, outsiders must avoid being seen as allies of central authorities rather than local communities.

Participatory planning of HWC projects requires defining joint objectives, identifying obstacles (or indirect threats) and opportunities (the facilitating environment that will improve the probability of successful intervention), followed by discourse on selection and design of interventions and monitoring methods. Joint objectives should include both protecting human welfare and abating threats to wildlife. If these two objectives do not get equal attention and equal investment—as in the example of the IEDP above—the project is likely to fail. One sure-fire way projects to manage HWC will fail to conserve wildlife is if the varied wildlife interest groups are under-represented or disadvantaged in the decision process. It is easy to weigh the votes of affected households more heavily than the votes of the wildlife and easy also to focus on economic costs and benefits over non-material costs and benefits of HWC situations. By keeping the twin objectives foremost and designing projects with optimal participation in mind, these pitfalls may be avoided.

Among the benefits of participatory planning for HWC projects are the following.

1. Because interventions, research and monitoring often require access to private properties and possibly other intrusions on people's lives, efforts to build community understanding, involvement and ownership of a HWC project usually make implementation easier.
2. Similarly, many interventions require a change in human behavior. No one likes being told what to do, especially if long-held beliefs or traditions are put in jeopardy; hence, affected individuals or households are more likely to accept changes if they have defined the need for change and identified the change they wish to make, or at least chosen among options offered to them.
3. Sanctions against destruction of wildlife are essential in balancing HWC management goals, lest interest in wildlife conservation be subordinated entirely to development activities, which are easier to persuade stakeholders to accept. Co-management structures allow affected communities to police themselves, if designed properly. For example, conservation groups working in Mongolia and Nepal have been using bilaterally negotiated contracts with livestock producers in snow leopard range for many years. The local communities' households make wool products from domestic sheep, the conservation group sells the products in developed nations at a premium price, and a pre-negotiated portion of the proceeds is paid to each producer. Also, the community as a whole gets a substantial bonus distributed equally among its members if monitoring of snow leopards and their prey shows that conservation goals were met that year. Community members have turned in outside poachers on their community lands to avoid losing the bonus.

Clearly, the benefits of participation require legitimate representatives of local stakeholders, including fair attention to the differential distribution of vulnerability due to gender, ethnicity, wealth, etc. Because those who complain loudest may not be the most vulnerable, allowing affected households to discuss the distribution of costs and benefits openly and transparently may promote equity in interventions.

Interventions

Sociopolitical acceptance of interventions can be as important as cost-effectiveness. Familiar, inexpensive interventions—those that require little new technology and minimal change to existing behavior—are most likely to succeed. For example, one of the snow leopard teams mentioned above provided modest financial and technical support to build a communal corral after villagers identified this as the most appropriate intervention. In this case, corrals were in wide use but communal herd management was not traditional.

From the outset, it is important to dispel hopes for money or "silver bullet" interventions.

Naturally, many people suffering losses to wildlife want compensation and final solutions. Such solutions are rare or illusory. Yet careful analysis of the factors that make households vulnerable and the factors that elevate risk, in conjunction with information on wildlife behavioral ecology, will usually bring to mind an array of direct and indirect interventions. Combining direct and indirect interventions promises to balance wildlife and human needs most effectively.

Direct interventions. Most HWC situations involve wildlife encountering untended or undefended property or being attracted to more palatable or nutritious food sources than are found in the wild. Accordingly, most direct interventions attempt to defend property (guards, barriers, removal of wildlife) or reduce its attractiveness (repellents) or some combination of the two (changing the type, timing or location of human activities). Few have tried to increase the relative attractiveness or availability of wild foods, which might be classified as the latter form of intervention. Most direct interventions have been tested experimentally or been subject to generations of testing by producers under operating conditions. This is not true of indirect interventions that grew out of the wildlife conservation movement.

Indirect interventions. Because HWC only requires intervention if the affected households cannot tolerate it, some managers of HWC advocate raising people's tolerance as an indirect means to reduce conflicts. The most common form is compensation—payments after losses have occurred. Compensation has been criticized from every conceivable perspective using both theory and empirical evidence. It is particularly subject to fraud, corruption and inequity; it discourages investment in defense of property and can forestall investment in more permanent solutions; once begun, its costs inevitably rise and it is very hard to terminate; and it gives greater weight to the voices of wealthy, outside donors in HWC decision-making. On the other hand, compensation does spread the costs of wildlife conservation more equitably across society; it can also bring hostile stakeholders to the discussion and give a stronger voice to wildlife protection interests.

Classification of methods to mitigate HWC

Direct methods reduce the severity or frequency of wildlife damage:

- Barriers (fences, trenches, walls, buffer zones, etc.)
- Guards (human or animal)
- Changing the type, timing or location of human activities
- Repellents (chemical, auditory or visual aversive stimuli)
- Removal of wildlife (capture, killing, sterilization)

Indirect methods raise people's tolerance for conflicts with wildlife:

- Compensation and incentives
- Participation
- Research and environmental education

Providing incentives in the form of material or technical inputs *before* losses occur to avert retaliation against wildlife should be superior to compensation for balancing human and wildlife needs, because incentives support prevention while compensation promotes reaction and dependence on a donor. The caution accompanying the above statements is that incentive-based conservation is an untested idea, despite its recent popularity.

As mentioned, participation of affected households may increase their tolerance for a HWC mitigation project. It may also improve their tolerance for wildlife damages. This is somewhat speculative, but preliminary anecdotes suggest people's complaints soften when something is being done about HWC. Presumably, planning is not sufficient but perhaps interventions are sufficient even if effectiveness has not been demonstrated.

Finally, research and ensuing dissemination, often called environmental education or outreach, is sometimes credited with improving people's tolerance for threatening wildlife. We have abundant evidence from studies of human attitudes that people with more formal education are more tolerant of large carnivores. However, individuals that specifically have greater knowledge of wildlife, including carnivores, are not always more tolerant. Hence we need a rigorous experimental test because the need for environmental education is an assumption of many environmental projects.

> There is no substitute for a thorough understanding of the behavioral biology of conflict-causing species, especially as it pertains to their interactions with people.

Role of research

Collecting baseline information is a vital first step in managing HWC because understanding the timing and locations of conflicts, the behaviors of the involved individuals (wildlife and human), and the perceptions of affected stakeholders is essential to planning. Large gaps in knowledge will render inefficient or ineffective any efforts to select and design interventions or monitor the success of such interventions. Research often enjoys a measure of tolerance because it is generally minimally intrusive on people's lives and its product (knowledge) is often clear. However, this positive scenario is not guaranteed. Rural people often want reimbursement or interventions against HWC, not research. One farmer facing elephant crop damage wanted "food, not numbers." Communities marginalized by political conditions may distrust and reject research if it has been used to their detriment in the past. Research itself can be politicized because the things one measures, how one frames questions, and how one interprets the results, may favor one side or another. Care should be taken to remain impartial as an honest broker of information; that is, the researcher must relinquish control over the outcome of negotiations between stakeholders.

Human dimensions. Means to study and measure perceptions, vulnerability and coping methods vary and vary in effectiveness. Group meetings are valuable sources of insights into perceptions, but they often only air publicly-sanctioned views or the majority experience. Capturing more representative opinions should improve understanding of HWC and can build trust among stakeholders. Gender, economic, and political inequities may require confidential communications. When one interviews people similar to oneself, one may capture more nuance and insight into perceptions. Host-country nationals should probably lead monitoring teams, and it is even better if local community members do so. Even so, interviews with women may not be possible if men block access. By conducting interviews in women's ambits, one may find women perceive and report different wildlife threats than do men. Participatory mapping exercises are usually helpful because HWC is unevenly distributed in space and many people encode natural resource information spatially in mental maps. A hard-copy map can also be brought to individual interviews to gain more nuanced views of the social and spatial distribution of conflicts. However, two-dimensional representations of space are not salient to all individuals or cultures.

Wildlife dimensions. One must have basic measurements of damage location, timing, severity and which species were involved to select the appropriate interventions or install them effectively. If feasible, collect ecological and behavioral data on the wildlife in and around human use areas rather than relying on studies from wilderness. There is no substitute for a thorough understanding of the behavioral biology of conflict-causing species, especially as it pertains to their interactions with people.

Testing candidate interventions. Research findings may also be useful to catalyze dialogue about interventions, especially when the research has been invited and co-designed by local stakeholders. Avoid choosing the first solution that comes to mind. Any proposed solution is an experiment and should be treated as such.

Monitoring interventions

Monitoring is essential to judge the effectiveness of interventions, which are, by their nature, experiments. Monitoring should include three hierarchical measures of performance:

- Were interventions put in place as planned?
- Did the level of HWC diminish?
- Was biodiversity maintained or restored? Was human welfare improved?

At a minimum, monitoring should distinguish background fluctuations in HWC, wildlife populations and human welfare indicators, from the effects of interventions.

Having designed long-term monitoring protocols, project planners would be well advised to prepare alternatives that are less intrusive on affected households. Having two or more options gives the subjects a choice as to the level of intrusion into their affairs. The two alternatives should be nearly equal in information gained, but differ in logistical features that affect community involvement or interruptions to community schedules. For example, a team discussed two plans to study and ameliorate cattle losses in Bolivia. The first was simplest for the wildlife managers (ask livestock owners to pool their small herds in one valley with a communal system for rotating between valleys), but the team expected low tolerance for such a plan given the community's reputation for individualism. So they devised a second proposal that was deemed simpler for livestock owners (park guards located in town would inspect cattle carcasses in every valley). In both cases, most incidents of cattle mortality would be detected and investigated (less quickly or reliably in the second plan), yet the first plan involved more change in traditional activities.

Conclusions

This brief outlines the wildlife dimension of human-wildlife conflicts, reviews recent advances in understanding affected people's perceptions of risk and resolution, traces paths to successful intervention through co-management, and finally examines the key role of research in the resolution of human-wildlife conflicts. Our approach emphasizes social science input because HWC is as much a social problem as a technical challenge. Although the steps are simple and straightforward, site-specific details can be maddeningly complex.

The capacity to effectively manage wildlife-related threats to human safety and property—without compromising wildlife population viability or human life and livelihoods—is within our grasp. To do so, we believe co-managers must combine technical expertise with local knowledge and embrace transparent and democratic processes of participatory planning, with the sacrifices this entails.

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