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Community-based monitoring of fog capture and biodiversity at Loma Alta, Ecuador enhance social capital and institutional cooperation

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Abstract. Monitoring of fog capture and bird communities helped to build social capital for conservation at Loma Alta, Ecuador and encouraged the local community to protect 3000 hectares of tropical forest. Data collected during monitoring were used to facilitate action and cooperation at local, regional, national, and international levels for conservation of biodiversity in western Ecuador, including the designation of an Important Bird Area in the region. Through involvement with the monitoring efforts, local people became more aware of the value of ecosystem services, learned about local birds and their conservation status, became familiar with ecotourism, and began to include conservation of biodiversity with sustainable development planning in their community. The context of monitoring, the objectives and participants, field methods, impacts in terms of conservation action, and the costs and benefits of the two monitoring initiatives are described.

Introduction

There is widespread agreement that a global extinction crisis is occurring today (Soulé and Wilcox 1980; Ehrlich and Wilson 1991; Lubchenco 1998). To slow the loss of species, numerous organizations around the world are working to protect biodiversity 'hotspots' (Myers 1988) and areas with many endemic species (Stattersfield et al. 1998). Many areas of high priority for biodiversity preservation are located in tropical developing nations. Thus, slowing human-caused extinction of plants and animals depends on local, regional, national, and international efforts in countries near the equator. Unfortunately, people living in high diversity sites in the tropics often degrade species-rich habitats simply to meet their basic survival needs.

Monitoring of biodiversity is critical for preventing and slowing biodiversity loss (Stevenson and Morris 2004). Monitoring can provide a measure of changes in species and their distribution over time verifying improvement or deterioration of biodiversity. Progress has been made at national and global

levels with development of databases containing information on the spatial-temporal distributions of species (e.g., GBIF 2000; NBII 2001). These databases along with museum collections, rapid environmental assessments, voluntary species counts, and baseline scientific inventories of plant and animal communities underpin the conservation strategies of major institutions working to sustain biodiversity (e.g., Conservation International, The Nature Conservancy, Birdlife International, national and regional conservation NGOs). However, large databases have limited ability to affect conservation at the local level. On-the-ground biodiversity conservation depends on linking bioinformatics with social capital at a local level (Pretty 2003), and on institutional nesting to reinforce local conservation initiatives (Ostrom 1990). Social capital refers to the strength of social bonds and norms in society that tend to lead to collective action (Pretty 2003). Institutional nesting is the idea that collective action occurs across multiple scales, from local to international due to connectedness in networks and groups.

This paper reviews a case study in western Ecuador where monitoring of fog capture followed by monitoring of bird communities over an extended period of time provided information that led to action at local, regional, national, and international levels resulting in conservation of important ecosystem services for local people and preservation of biodiversity of value internationally. We discuss the context of monitoring, the objectives and participants, field methods, impacts in terms of conservation action, and the costs and benefits of the two monitoring projects. This case illustrates that resource monitoring can enhance social capital and institutional nesting to effect conservation in tropical developing nations.

Context of monitoring at Loma Alta, Ecuador

In 1937, the *Law of the Comunas* established land tenure rights for rural peasant communities throughout Ecuador and at that time the community of Loma Alta was given legal title to a 6842 hectares watershed ranging in altitude from 50 to 830 m (Figure 1). Currently, about 4000 people, mainly subsistence and small market farmers live in the Loma Alta watershed. There are two population centers in the watershed, Loma Alta and El Suspiro. People living in El Suspiro are more economically dependent on forest resources as they live closer to the northern third of the watershed, covered by premontane moist tropical forest. This type of forest harbors many endemic plants (Gentry 1977) and birds (Best and Kessler 1995) making it an important site for biodiversity preservation.

In 1995, People Allied for Nature (PAN), a non-profit conservation organization based in New York, collaborated with the International Forest Resources and Institutions (IFRI) research program (Ostrom 1998) to study the condition of Loma Alta's moist forest. PAN's objective, convincing the local community to protect wildlife habitat, fit well with IFRI's academic research

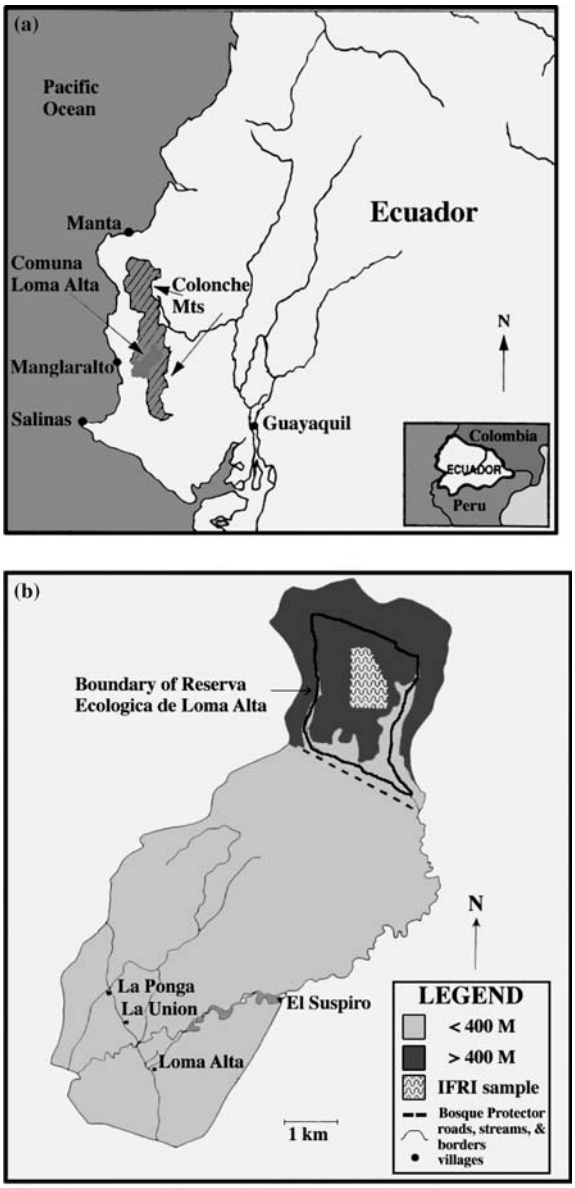

Figure 1. Location of the study area at Loma Alta in Ecuador (a), and location of the protected area Reserva Ecologica de Loma Alta (RECLA) in the Loma Alta watershed (b).

on local rules for use of forest resources and forest condition. Using Participatory Rural Appraisal (PRA) techniques, IFRI researchers engaged the community in a two-month study of its relationship with moist forest resources

in the community owned watershed. At the time, community members were familiar with institutions outside of the community (PAN, Ecuador's Nature Foundation, Ministry of Agriculture) promoting protection and recovery of forest cover in order to conserve soil or wildlife. The community held meetings regarding conservation, participated in reforestation projects in the arid lowlands, but had made no rules controlling use of moist forest areas in the uplands of their watershed. As a consequence it was only a matter of time until the Loma Alta forest disappeared because timber harvesters, ranchers, and Panama Hat fiber growers all had reasons to cut down the moist forest. There were many socio-economic reasons for the local failure to protect forest (Gipson and Becker 2000), but a fundamental one that became important for eventual forest preservation was that local people lacked full appreciation of a key ecosystem service provided by the forest: trapping water in the form of fog (Becker 1999). In such a dry area, fog capture is critical for lowland water supply for basic human needs and agriculture (Becker 1999). In addition, some of the potential benefits associated with sustaining a diverse plant and animal community, such as income from nature tourism, had not been fully exploited by communities. It was assessed that monitoring would help change community awareness of these issues and options (Becker 2002). By helping measure fog, local community members would appreciate fog capture more fully. By helping monitor birds, a subset of the community would learn about endemic and endangered species and about the fact that bird watchers might pay to see their unique forest and its birds. Those helping with monitoring would share knowledge with others curious about what the scientists were doing and in the small highly interrelated community the knowledge would spread.

Monitoring fog

In May 1995, PAN and Earthwatch Institute trained several Loma Alta villagers to monitor through-fall, the quantity of water dripping off trees and other plants, during the fog season (June–November). Locally known as *garúa*, fog and mist forms over the Pacific ocean, flows inland, where it is intercepted by vegetation, especially on windward slopes of coastal mountain ranges. Native trees were found to trap much more water than agricultural fields or pasture (Becker 1999). Monitoring over a year revealed that in the 1995 fog season, an average of 2.24 million l of water from fog per hectare was trapped by trees at an elevation of 600 m on the windward slopes of the Loma Alta watershed (Becker 1999). Clearing the forest to make pasture here resulted in an estimated loss of 1.9 million l of water per hectare per year. Given the overly conservative estimate that only 10% of drip-fall becomes available as ground water and the fact that some 200 hectares had been cleared they were losing about 38 million l ($\sim$10 million US gallons) of water per year. Since agriculture in this area is water-limited and water there sold in 1997 for

50 Sucres per US gallon in 1997, the estimated annual cost of deforestation was 500 million Sucres. At 3900 Sucres/US dollar (1997 exchange rate) this loss equated to about $128,000 dollars. When divided among the 200 households in the community the loss of $640 dollars was roughly equivalent to half a local family's annual income. The value of fog capture alone (just interception of horizontal precipitation) averages 40–58% of this value, or $256–371 per household.

PAN representatives circulated leaflets and gave talks at schools about the water collected by trees during the fog season. Those participating in fog monitoring were featured in a video explaining fog capture. Community response was dramatic even without a detailed economic explanation. Six community meetings were held on the topic of establishing a forest ecological reserve to protect water resources. Leaders tabled the final vote several times to permit villagers with land use rights in the area proposed for the ecological reserve to consider the proposal sufficiently. On August 10th, 1996, a majority (95% of 110 voters) voted for a reserve. On August 24th, 1996, an official agreement drafted by community leaders and PAN was read to community members detailing rules of use and location of the reserve boundaries. An area of about 1000 hectares was officially declared as the Reserva Ecológica Comunal de Loma Alta (RECLA, Figure 1b). The reserve has since been expanded to about 3000 hectares and deforestation has been completely curtailed there.

Monitoring bird communities

In December of 1996, a long-term monitoring project focused on birds was started in Loma Alta's ecological reserve (RECLA). One goal was to determine the conservation value of RECLA in terms of numbers of threatened species and restricted-range birds (those species with breeding ranges $<$50,000 km^2, cf. Stattersfield et al. 1998). Birds are frequently used in biodiversity monitoring as they are well-known taxonomically (Best and Kessler 1995) and are responsive to habitat changes like fragmentation and shifts in habitat quality or extent (Greenberg 1996).

We used mist-nets and strip counts to monitor birds in RECLA during the wet and dry seasons. Each year, teams of Earthwatch volunteers and local villagers spent between 4000 and 24,000 net hours sampling birds. (Net hours are calculated by multiplying the number of nets by the number of hours each net is operated. We placed 10 or 20 mist-nets [12 m $\times$2.7 m of 36 mm mesh] at a sampling site and operated nets for 5 h from sunrise on three consecutive mornings). Twenty variables, including species, were recorded for each individual bird captured. Data were entered in Statview, a statistics and spreadsheet program.

The Loma Alta bird database currently has over 8000 records and the information is maintained on computers at Loma Alta, at a regional NGO,

and at University of New Mexico (US). During each sampling session we also recorded birds seen along trails, covering about 20 hectares (two trails, approximately 2 km long, 50 m wide).

Monitoring data allowed us to make a quick assessment of the conservation value of the new protected area in terms of avian biodiversity (Becker and López-Lanús 1997). In 1999, we began monitoring birds around villages in the lower reaches of the Loma Alta watershed in degraded tropical dry forest. We involved local children in bird watching activities and informed local people about the different birds we were finding during the monitoring efforts. We made a popular video about our monitoring activities in the *garúa* forest and showed it at schools and for evening events. Our goal was to raise awareness and appreciation for biodiversity in the reserve.

Further monitoring and assessment (Estudillo and Becker 2002) revealed that the watershed at Loma Alta provides year-round habitat to 14 threatened or near-threatened bird species, and serves as a breeding area for two endangered woodstar hummingbirds, 20 other hummingbird species, and 79 restricted-range bird species (endemic species) (Table 1). In 2002, Birdlife International and national partner CECIA, Ecuador's bird conservation organization, invited nominations for Important Bird Areas (IBAs) in Ecuador. Important Bird Areas are strategic areas for conservation that typically have significant numbers of one or more globally threatened species, are one of a set of sites that together hold a suite of restricted-range species or biome-restricted species, or have exceptionally large numbers of migratory or

Table 1. Species and number of species meeting Birdlife International's criteria (A1–3) for designation of Loma Alta, Ecuador, as an internationally Important Bird Area (IBA).

Crypturellus tranfasciatus	Pale-browed tinamou (NT)
Leucopternis occidentalis	Gray-backed hawk (E)
Ortalis erythoptera	Rufous headed chachalaca (V)
Leptotila ochraceiventris	Ochre-bellied dove (V)
Aratinga erythrogenys	Red-masked parakeet (NT)
Brotogeris pyrrhopterus	Grey-cheeked parakeet (NT)
Chaetocerus berlepschi	Esmeraldas woodstar (E)
Chaetocerus bombus	Little woodstar (E)
Synallaxis tithys	Blackish-headed spinetail (V)
Hylocryptus erythrocephalus	Henna-hooded foliage-glearner (V)
Attila torridus	Ochraceous attila (V)
Lathotriccus griseipectus	Gray-breasted flycatcher (V)
Pachyramphus spodiurus	Slaty becard (NT)
Carduelis siemiradzkii	Saffron siskin (V)
Restricted range bird species (Stattersfield et al. 1998):	
A2: Species unique to Tumbesian endemic bird area	33
A3: Species from adjacent endemic bird areas	46
Total	79

Criteria A1: restricted-range species with conservation ranking: critical (C), endangered (E), vulnerable (V), and near-threatened (NT) (Collar et al. 1994; Stattersfield et al. 1998).

congregational species. To date, some 7000 IBAs have been identified in 130 nations (Birdlife International 2004). To be an IBA a site must meet certain criteria based on occurrence of bird species that are vulnerable to extinction or whose populations are irreplaceable. For example, an IBA must be amenable to conservation action and management, be large enough to support self-sustaining populations of as many as possible of the key bird species for which it was identified or, in the case of migrants, fulfill their requirements for the duration of their presence (Birdlife International 2004).

Aves de Ecuador, a regional conservation NGO, nominated Loma Alta as an IBA emphasizing the data in Table 1. In January of 2004, after evaluation at national and international levels, the entire Loma Alta watershed was designated an IBA.

Benefits of biodiversity monitoring at Loma Alta

The data on fog capture clearly enhanced local awareness about ecosystem services sufficiently to spur collective action to create an ecological reserve (see also Becker and Ghamire 2003). As illustrated in Figure 2, monitoring of bird diversity provided benefits well beyond data for scientific papers and records on the distribution and abundance of bird species in this region. Local awareness about the value of biodiversity was greatly enhanced by the monitoring project and this influenced local children's artwork and songs, and helped generate community interest in developing nature tourism. Our published surveys (Becker 2002; Becker and Ghamire 2003) found that attitudes and knowledge at Loma Alta became more ecologically oriented due to the monitoring projects. In another community where no monitoring effort was

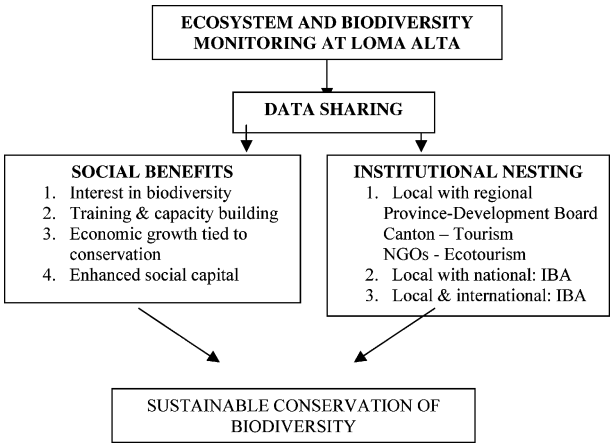

Figure 2. Monitoring of natural resources at Loma Alta, Ecuador created multiple social benefits and institutional nesting making conservation of local biodiversity more sustainable.

being made only 5.6% of respondents ($n = 18$ heads of households) stated that the highland forests were important for water, whereas 41% of respondents from Loma Alta mentioned water when asked why the highland forests were important to them. Since bird monitoring and results have been shared with the community via videos and presentations several murals have been painted on schools and private residences that feature some of the endangered and endemic speices.

The monitoring project has been a training ground for high school and college students locally, regionally, and internationally mainly due to support from Earthwatch Institute. Internships provided to students from the community and from regional universities combined with participation by volunteers from around the world leads to cross-cultural interactions including city–rural, and international–local contributing to social capital at multiple scales. Each two-week Earthwatch Institute monitoring session contributes $2000–4000 to the local economy: rent for food and lodging, rental of local trucks, mules, and horses for transportation, and salaries to research assistants and camp cooks. There are typically two or three Earthwatch projects conducted at Loma Alta each year and other funding supports bi-monthly monitoring by trained community members.

The establishment of RECLA attracted several regional organizations to Loma Alta. Proyecto Azul (Project Blue Planet) provided a 10-week training program for locals interested in becoming naturalist guides that included rudimentary training in English. As a consequence, the community has become proactive about the development of ecological tourism. They set their own entrance fee rules and secured funding to build a visitors cabin in the forest. They improved the community office for receiving visitors and obtained proper receipts for their entrance fees. Craft groups increased production of tagua jewelry in anticipation of visits by nature-oriented tourists. Community interest coincided with provincial planning for tourism along the coastal areas of the province of Guayas and development offices at both the cantonal and provincial levels have included Loma Alta in their promotional materials for tourists visiting coastal Ecuador. As shown in Figure 2 these are some specific examples of the ways in which institutional nesting is leading to sustained conservation of the community's fog forest and its biological diversity.

Our monitoring data on birds were critical for achieving international attention sufficient to make Loma Alta an Important Bird Area (IBA). Becker and López-Lanús (1997) outlined the conservation value of Loma Alta for bird diversity, but this had little immediate impact beyond putting Loma Alta on the map in the field guide to the Birds of Ecuador (Ridgely and Greenfield 2001). What proved more valuable for conservation of biodiversity were the social connections developed in the process of doing long-term monitoring including networks of local, regional, national, and international organizations (Figure 2). Two interns on the project started their own NGO called Aves de Ecuador and worked with community leaders to present the bird monitoring data to national and international organizations responsible for declaring

IBAs. Had the project been a study without the interns and community participating it is unlikely that IBA status would have been given to Loma Alta. These relationships were key for achieving IBA status at Loma Alta. IBA status further enhanced institutional nesting for sustaining biodiversity at Loma Alta. For example, government officials from Guayas Province attended a press conference about the IBA designation at Loma Alta and promised to assist the community with development of nature tourism and forest protection. Specifically, they agreed to improve the main road to Loma Alta's village center and to stop a plan for building a road through the protected area.

Discussion

Globally consistent databases on natural resources serve to guide conservation strategies, but data collected with local participation about local resources may often be more effective at sparking local conservation action (e.g., Bennun et al. 2005; van Rijsoort and Jinfeng 2005 (this issue)). Stevenson and Morris (2004) found that citizen–scientist partnerships in the US enhanced local efforts to build community understanding and support for biodiversity conservation. Locally relevant data about fog capture helped local people at Loma Alta understand the loss of this ecosystem service prompting them to protect their *garúa* forest. Data from the monitoring of birds has helped local people develop a new appreciation for the value of biodiversity in their watershed and resulted in the Loma Alta area being declared an internationally Important Bird Area. IBA status appears to be enhancing nature tourism in the Colonche Hills, but more information on this theme is needed.

The importance of RECLA for biodiversity and fog forest conservation is substantial as there is only one other protected area with these biological elements in the region – Machalilla National Park. RECLA could serve as a core area for a larger fog forest protected area. Adjacent communities could follow Loma Alta's example of protecting their forested hills for water conservation and these community-protected areas could be linked and made into an official 'ecological reserve.' Given that communities in the Colonche Hills region participate in a Federation of Communities, an institutional mechanism is in place for making such expansion.

Our case shows that what natural resource is monitored has ramifications for how quickly a conservation project succeeds and what other organizations are attracted to and support the effort. In the Loma Alta case, fog-capture surveys prompted forest conservation with great speed. In less than 2 months after monitoring data were presented a decision had been made and implemented to make a protected area at Loma Alta. This was largely because water conservation was understood by local decision-makers, and community benefits were extremely clear to everyone. After the community protected their forest, there was little interest in continuing to monitor fog. In contrast to water, forest preservation for bird diversity would not have been understood or supported

enthusiastically by the Loma Alta community. However, bird monitoring over a 9-year-period provided a better framework than fog monitoring for institutional linkages among regional, national, and international NGOs. By sharing data at various institutional levels, bird monitoring elevated the status of Loma Alta's forest to such an extent that nature tourism based mainly on bird watching now contributes $6000–10,000 to the local economy each year.

The community–forest relationships (1995) and fog monitoring (1996) projects cost about $30,000 each, but these costs were born by teams of Earthwatch Institute volunteers and students, whose greatest expense was transport to Loma Alta from Europe or North America. If the approach – participatory monitoring of local resources of importance, reporting on results to the community, and making conservation action suggestions – was repeated by regional or national NGOs in any developing nation, the cost would probably be an order of magnitude lower. However, the benefits of having the international attention and intercultural sharing should not be underestimated. Support for local schools, donations of English lessons, books, clothing, scholarships to attend secondary school, internships for local university students, have all been additional benefits of the social capital provided by Earthwatch Institute volunteers and NGO staff external to the Loma Alta community.

In addition to developing social capital for conservation, the monitoring process at Loma Alta has changed how some local people perceive themselves. When we started working at Loma Alta people said they were poor farmers with few options, or 'people at the end of the road.' Now more people at Loma Alta are expressing pride related to the community protected area and are talking about ideas for future work in nature tourism (Becker, unpublished surveys).

While bird monitoring at Loma Alta has effected conservation in many ways, it is not sustainable at a local level without external inputs. Annual monitoring of birds at RECLA by locally trained people and a regional biologist could be done for as little as $6000 per year. However, there is no local community budget for such an expense and regional NGOs have not offered to contribute funds for the effort. Currently, fees charged to visit RECLA are not sufficient to cover basic maintenance, much less monitoring and research. Income from visitor fees is currently used for trail maintenance, upkeep of tourist cabins, partial salaries to guards, and administration.

The current protocol for bird monitoring is too specialized and technical for high quality data to be consistently collected by community members. Despite training, species identification errors are common, species names change and it takes a specialist in ornithology to keep abreast of these changes. There are still no good field guides to birds of Ecuador written in Spanish. None of the community members have the background to manage the database and do the statistical evaluations and reporting that is needed to affect local and regional conservation policy. A specialist is required for these tasks. Given the fact that annual bird surveys in Ecuador are relatively inexpensive for NGOs based in the US or Europe, that they sustain local enthusiasm for conservation, and

provide for positive cross-cultural exchange, there may be little merit in trying to make monitoring exclusively sustainable by the local community. Perhaps an Ecuadorian NGO (Aves de Ecuador or CECIA) will adopt the bird monitoring and database management effort at Loma Alta in the future. Still such external funding is notoriously unreliable as NGOs have their own set of sustainability issues. Interestingly, the community has been able to attract a variety of NGOs to help with stewarding their reserve and improving living conditions at Loma Alta. Seeking NGO support has been part of election politics at Loma Alta for many years. Leaders who are successful at attracting donors and projects appear to be considered better than those who do not (unpublished notes).

In conclusion, there were multiple benefits of biodiversity monitoring at Loma Alta far beyond scientific discovery and securing protected area status. These include economic development in terms of local jobs and training in conservation, exposure of local people to ecological tourism, generation of educational materials for schools and local guides, and stimulation of local and regional pride related to biodiversity conservation. In this particular case, had there been no monitoring project there would be no protected area for *garúa* forest and no international Important Bird Area in the Loma Alta region of the Colonche Hills of western Ecuador. The positive outcome for biodiversity conservation was dependent on a blend of external expertise and local decision-making in response to monitoring of natural resources. Monitoring was community-based, involving locals, and this helped to build the social capital that resulted in the institutional nesting that made biodiversity conservation in this global 'hotspot' a reality.

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