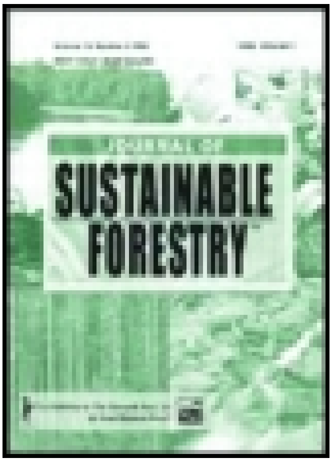

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Agroforestry Systems and Podocarpus National Park, Ecuador: Current Status and Recommendations for Future Work

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Agroforestry Systems and Podocarpus National Park, Ecuador: Current Status and Recommendations for Future Work

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The goal of enhancing human well-being and dignity for the communities surrounding Podocarpus National Park (PNP) is inexorably connected to the goal of protecting ecosystem health and integrity in the southern Andes. While these goals are often viewed as conflicting, one area where they clearly overlap is in agroforestry practices. Agroforestry has the potential to improve food security and economic production while also enhancing forest cover, soil conservation, watershed protection, and habitat quality. A variety of traditional, indigenous, and modern agroforestry practices are available as a foundation for effective sustainability and conservation efforts around PNP. However, the trend of land-use extensification—with large areas dedicated to marginal production of beef and dairy cattle, as well as corn and coffee—continues to lead to new deforestation. Reversing the trend of extensification will require improved technical and resource capacity for agroforestry and reforestation in the region, which can be achieved by strengthening relationships between farmers, farmer organizations, educational and research institutions, and conservation interests. Specific recommendations address agricultural extension/outreach (partnership building), nursery practices, agroforestry species and strategies, and forest regeneration following land abandonment.

KEYWORDS *agroforestry, community-based conservation, intensification, extensification, natural resource management, sustainability*

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INTRODUCTION

Parks are doomed to fail in their mission to perpetuate biodiversity and ecosystem integrity if habitats and vegetative cover can do nothing but shrink back against an onslaught of human encroachment. On the local level, land conversion, local climatic changes, new invasive species, habitat fragmentation, edge effects, and degradation of soil and water quality conspire to reduce the size and viability of the ecosystems in Podocarpus National Park (PNP). In addition, many threats to biodiversity originate far from the park itself: powerful economic and political forces lead to destructive exploitation of agricultural lands, wildlife, and tree resources; development efforts are often not coordinated with conservation needs; and public ownership of areas in need of protection often exceeds the government's resources or ability to manage them (Wells & Brandon, 1992; Bond, this volume). This article focuses on what can be done locally to not only stop, but reverse, the trends of deforestation, habitat fragmentation, and environmental degradation. This goal reflects the common interest of people on local, national, and international scales. Agroforestry activity that supports food security and sustainable economic production is one intervention point to enhance both human and ecological well-being, thereby helping to address the direct and immediate threats to the ecological integrity of the region in and around PNP. However, current conditions create strong economic, political, and social forces that drive harmful practices within and at the edge of the park (see Bond, this volume). These larger pressures are often ignored while local people are "blamed" for the destruction (Dove, 1993). While taking these larger forces into account, the fact is that conservation happens on the ground. There is much that empowered landholders can do in their own self-interest to ensure their local food security and economic production while protecting and improving ecosystem healthy and integrity. "On-farm conservation" is a key component of protecting human and ecological well-being (Jarvis et al., 2000). The term "farmers" in this article is meant to be broadly inclusive of rural resource managers including farmers, ranchers, beekeepers, and others whose livelihoods are directly tied to the land.

The problematic trend is land extensification—the unsustainable exploitation and ultimate abandonment of land. Extensification requires that more land be cleared for production, but less care is taken, leading to: "(a) lower yields for the same work; (b) the encroachment of crops into marginal land, hence a higher risk of land degradation and low yields; (c) longer periods of cropping and shorter fallow periods, which also increases the risk of land degradation and brings on low yields." (de Rouw, 2005, p. 1). The alternative is intensification through practices such as agroforestry—sustainable and regenerative management of land to improve livelihoods while reducing pressures on farmers to clear new land.

Agroforestry is an indigenous practice in Ecuador and elsewhere that has received an infusion of recent attention from scientific and conservation communities. Well-designed agroforestry systems intensify land use and productivity while also serving some of the ecosystem functions attributable to natural forests, including protecting soil and water, increasing vegetative cover, improving soil fertility through nutrient cycling, suppressing of exotic and unwanted weeds, and enhancing ecological balance to reduce pest and disease outbreaks (Kant & Lehrer, 2004). These benefits can be expanded to include wildlife habitat and increased native biodiversity when agroforestry systems utilize native plants (McNeely, 2004; Wiersum, 2004). Strengthening current agroforestry and reforestation practices is a way to alleviate resource pressures on the park and surrounding forested areas and serve local farmers and landholders.

This article has three purposes. The first is to examine the current state of the human and natural resources in and around the park as they relate to rural resource management, assessing trends of land-use intensification and extensification with the focus on identifying positive intensification practices. Second, the article assesses what is working and also what is missing in terms of current human and natural resources, including the status and effectiveness of agroforestry and nursery practices. Third, the article makes suggestions to elevate the resource and technical capacities of rural resource managers through strengthening partnerships and information sharing between farmers, farmer organizations, educational and research institutions, and conservation interests. Specific suggestions for nursery and agroforestry extension are offered to improve the situation and bring desired results: enhanced human and ecological well-being through building relationships and improving successful agroforestry and reforestation initiatives.

METHODS AND STANDPOINT

I visited Ecuador from March 10–19, 2005, as a participant in a Rapid Assessment field trip to PNP for 10 days with 11 other graduate students, one teaching assistant, and two professors from Yale University School of Forestry and Environmental Studies. Information in this article is based on observations made and information gathered during interviews and discussions with people during the field visit. Prior to traveling to Ecuador, I conducted research on pressing issues in and around PNP. During the 10-day field visit, many of my observations regarding existing species and management systems were perforce conducted out the window of the van or during short walks in the mornings around the towns where we stayed. We had one stop at a *campesino* cooperative, Únión Cantonal de Organizaciones Campesinos y Populares de Espíndola (UCOCPE), for a presentation and some direct interactions with farmers. A second farmer visit in Zamora province was planned, but cancelled when a landslide blocked the road. We therefore did not gain firsthand experience of what is happening on the ground in Zamora. More field visits, farmer interviews, and observations would have been preferable.

I have worked for the past 10 years with agroforestry, reforestation, and indigenous land management systems in the Pacific Islands, including managing an organic farm and a reforestation nursery for native tree seedlings. I have also worked on nursery extension for native plants with the U.S. Forest Service. In my experience, agroforestry and nursery development work best when not imposed from outside, based on exotic species and/or systems promoted by "experts" who have never made their living as farmers. While there is competition among agencies and NGOs in and around PNP to show results and to be the "saviors" of the area's ecological integrity (L. Medina, personal communication, March 14, 2005), the primary actors are often farmers and other rural resource managers. In my assessment here I will also emphasize the view that the best agroforestry foundation lies in time-tested species and strategies that are strengthened and enriched, if appropriate, with newer innovations and plant materials.

CONTEXT FOR AGROFORESTRY: HUMAN AND NATURAL ECOLOGY

This section examines the human and natural ecology of the area in and around PNP. It assesses the current natural and cultural resources (systems, species, strategies) as they relate to the issue of land-use extensification versus land-use intensification, with an eye to agroforestry opportunities.

Site Description

PNP is located in Ecuador in the Southern Andes near the Peruvian border. The park covers 145,280 ha of rugged topography and includes areas of lowland Amazon forest, highland cloud forests, and a part of the Cordillera Real mountain range (The Nature Conservancy, 2005). The buffer zone around the park has not yet been legally defined (L. Medina, personal communication, March 13, 2005). Areas within and around the park represent a complex mosaic of climate and soil types, including highlands, lowlands, and wet and dry regions with rainfall averages that range widely from 500–2500 mm/year (Stern, 2005). Soils in the area range from rich and fertile to nutrient-poor, droughty, fragile, and highly erodable (Matallo, Casas-Castaneda, & Migongo-Bake, 2002). The vegetation type within the park is mostly montane cloud forest (Stern, 2005). The park serves as a watershed for a number of rivers including the Jamboe, Sabanilla, Bombuscaro, Numbala, Loyola, Nangaritza, Quebrada de Campana, and Vilcabamba rivers (Tello, Fiallo, & Naughton-Treves, 1998).

PNP has gained national and international attention for its high level of biological diversity. The area is most famous for its birds: Approximately 6% of the world's total number of bird species are found in the park (Tello et al., 1998). Mammals include megafauna such as the spectacled bear, jaguar, mountain tapir, and puma; as well as many other animals such as coati, ocelot, and several species of deer. It has been estimated that the park contains between 3000–4000 species of plants, including the highly valued timber trees cedro (*Cedro montana)* and podocarpus (*Podocarpus* sp.), both currently endangered, as well as fever-bark tree (*Chinchona succirubra*), a source of quinine (Tello et al.).

The People

PNP faces immediate threats to its ecological integrity including habitat fragmentation, deforestation, soil erosion, loss of vegetative cover, and resultant local climate change (L. Medina, personal communication, March 13, 2005). Causes of these threats are varied and numerous, and include an array of social, economic, and political forces (see Bond, this volume). Current physical threats that are symptoms of these forces include gold mining, timber extraction, deforestation, illegal extraction of rare plant and animal species, burning, cattle grazing, and expansion of the agricultural frontier (Tello et al., 1998; Stern, 2005).

There are also some positive historical and modern trends among farmers. For example, biologists in PNP once listed a native papaya (possibly *Carica* × *heilbornii* nm. *pentagona* Badillo) in the same breath as *Podocarpus* and *Cedrela* species when naming species most in danger of extinction. However, the same species was subsequently discovered being widely cultivated and protected in people's gardens and farms all around the park, where its habitat had expanded (L. Ordonez, personal communication, March 13, 2005). This outcome is an example of how human agricultural practices can contribute to conservation.

Currently, communities on the western side of PNP are clustered around a road that runs north–south from Loja to Villadolid (Stern, 2002). Many residents in these communities hold title to their land and have invested capital and labor in *huertas* near their homes with fewer land intensification activities further out. The southern area of the park is more isolated. Settlers to this area have arrived in the past three decades and most do not have official title to their land (Stern, 2002). However, the road from Loja has recently (within the past year) connected the most remote areas to this transportation corridor. Plans to expand the road west/northwest along the southwest/western boundary of the park are in progress (see Bernardi, this volume). The western side is sparely populated with indigenous communities of Shuar and Saraguros who have applied for formal recognition of their territories in the form of a communal title to their lands, as well as recent colonists (Stern, 2005). There is also a Saraguro community beyond the northern edge of the park (A. Gerique, personal communication, March 16, 2005).

This section will briefly describe species utilization, land-use patterns and management strategies for the people who live in or around PNP: the Saraguros, indigenous Quechua-speaking peoples who reside outside the north and southeast regions of the park; the Shuar, indigenous hunter-gatherer-growers of the southeast Amazonian portion; and long-term farmers and recent colonists of the highlands and lowlands.

The saraguros: species and strategies

The Saraguros are a Quichua-speaking people in the Loja Province who were part of the Inca Empire. Inca agriculture prior to the arrival of the Spaniards in the 1530s involved cultivation of more than 70 species of root crops, grains, vegetables, fruits, and nuts—more agricultural species diversity than Europe and Asia combined (National Research Council, 1989). Several crops developed by Quichua-speaking people have become of global importance, including potatoes, tomato, pepper, and lima beans. Many other promising crops remain underappreciated and underutilized (National Research Council), although some (such as naranjilla, *Solanum quitoense*) can be enjoyed in the markets and restaurants of Ecuador today. Evidence and historical accounts also show that the Inca highly valued trees and actively engaged in reforestation and agroforestry to meet their timber and firewood needs (Chepstow-Lusty & Jonsson, 2000). Utilizing terraces, irrigation, and agroforestry, traditional agricultural practices supported roughly the same population levels as live in the area now, without the use of synthetic fertilizers or pesticides, and also without the use of work animals, iron, or the wheel (National Research Council). It has been estimated that traditional cropping systems supplied enough food stores out of surplus to support the population 3 to 7 years in the future (National Research Council).

Many of the traditional and productive management practices, including terracing, native irrigation, and agroforestry, were abandoned during colonization and as indigenous peoples were killed by diseases and war, or taken into slavery (Mecham, 2001). The Saraguros maintained complete self-sufficiency within their communities until the 1960s, producing wool for clothes and growing Inca crops including maize, potatoes, sweet potatoes, quinoa, amaranth, Andean papayas, tomatillo, bidens (*Bidens spinosa*), tomatoes, pepino dulce (*Solanum unatum*), and cassava, as well as harvesting wood from the forest. Missionaries forced Westernization on this group in the 1960s. While some of their traditions remain, many practices and species for traditional agricultural production have fallen into disuse and risk being lost (G. Jiménez, personal communication, March 12, 2005). Traditional Saraguro practices should be assessed as a foundation for future developments of rural resource management in the region, to be enriched and adapted over time by the farmers of the area.

The Shuar: Species and Strategies

The Shuar are an indigenous hunting-gathering-gardening people who reside mostly in the Amazonian lowlands outside the southeastern boundary of the park. Their population numbers about 40,000 people (Becker, 2005). The Shuar lived seminomadically through the 1960s, relying on hunting, fishing, gathering, and gardening for their food. It is widely recognized that "hunter-gatherers" are not passive collectors of available resources, but rather managers of their resources. For the Shuar, the main cultivated food crop is cassava, but they also cultivate maize, sweet potatoes, and plantains (Tello et al., 1998; Becker), usually in swidden agricultural systems. Tapir and other mammals were hunted for food.

While there is documentation of other Amazonian tribes and their effects on the composition and regeneration of tropical forests, little information is available about the Shuar and their indigenous agroforestry and resource management practices. It is known that the Shuar protect trees and shrubs within their cultivated areas to act as attractants for birds, monkeys, and other wildlife (A. Gerique, personal communication, March 16, 2005). Traditionally, agricultural plots were small (less than 1 ha), and low populations resulted in relatively low-intensity resource use (Tello et al., 1998).

Shuar traditional settlement and land-use practices have been greatly altered since missionaries in the 1960s worked to create larger, more agrarian settlements from the more traditional lifestyle of small, nomadic kinship groups. Invasion by agricultural colonists and by miners has also restricted and altered Shuar resource use, as well as bringing new diseases and infrastructure (Tello et al., 1998). It has also been observed that if the Shuar choose to raise cattle, they do so in more forested systems that hide the presence of the cattle, rather than the overt land-clearing for pasture that is the typical mark of cattle-raising on landscapes (A. Gerique, personal communication, March 16, 2005). More information should be obtained about the traditional resource management systems, species, and strategies of the Shuar culture in order to optimize their successes linking conservation and human livelihood.

Long-term Residents and Recent Colonists: Species and Strategies

Long-term residents have been in the area for several generations, and may be of indigenous, European, or *mestizo* (mixed) descent. There are also recent colonists of these same ethnic identities who, driven by desertification to the west or lured by incentives to expand the agricultural frontier to the east, arrived in the area three decades ago or less. These two groups may have very different relationships to the land and distinct motivations for their practices (see Bond, this volume). However, a description of current resource management patterns lends itself better to a discussion in terms of highlands (over 1800-m elevation) and lowlands (under 1800-m elevation) as described below, with residential status discussed for each.

Lowlands

In the lowlands, rainfall averages 800–1000 mm per year, with warm temperatures averaging 18–28°C. Residents of lowland areas around the park are often fairly well-established (Stern, 2005), sometimes with family ties to the region that go back several generations (G. Jiménez, personal communication, March 12, 2005). The average family landholding is often small, less than 10 ha. Some lowland communities have access to paved roads and, therefore, to markets or even a small tourist economy. In some cases, irrigation systems support crop production in lowland areas (Stern, 2005).

Farming in the lowlands includes some intensive agroforestry practices such as the almost ubiquitous use of live fences around homes and to delineate boundaries. Live fence species often include *Erythrina fusca* and *Gliricidia sepium*. Homesites are often surrounded by small, intensive multi-storied home gardens (*huertas*) for subsistence production and limited marketing of fruits, vegetables, and medicinals. Species observed in *huertas* include passionfruit (*Passiflora edulis*), citrus (*Citrus* sp.), mango (*Mangifera indica* L.), avocado (*Persia* sp.), cherimoya (*Annona cherimola* Mill.), naranjilla (*Solanum quitoense* Lam.), canna (*Canna edulis)*, maize (*Zea mays)*, agave (*Agave* sp*.)*, and many others. Commercial crops include coffee, yucca, and fruits including citrus (Stern, 2005). Dairy and beef cows, chickens, and guinea pigs are some of the domesticated animals in the lowlands. Current extensification activities and problematic practices in lowland areas include fires, grazing, timber harvesting, and forest clearing to make way for pasture and agriculture (Tello et al., 1998; Stern, 2005).

Highlands

In the highlands (elevations above 1800 m), rainfall averages about 3000 mm/year, and the climate is cooler, averaging 12°C. This area is more recently colonized, with colonists moving in from lower elevation areas and from the deforested west (Stern, 2005). Average land usage area per family is much larger than the lowlands, about 75 ha per family unit. Because of poorer or nonexistent road systems, communities in highland areas have much more limited access to markets and are thus more directly dependent on natural resources for subsistence and economic activities (Stern, 2005).

Particularly in the Zamora-Chinchipe province, labor is scarce, market access is limited, and land seems more abundant (Tello et al., 1998). As a result, beef cattle raising is overwhelmingly the predominant practice, and often takes place at low densities, less than .7 heads/ha (Tello et al., 1998). There is also some fruit production and some *huertas* for subsistence and market products in this area (Stern, 2005). Current extensification practices in highland areas include timber harvesting (often illegal), land clearing and burning for pasture (and to a lesser extent for agricultural crops), and marginal cattle grazing even on high slopes (Stern, 2005). The highlands also host more extraction of plant and animal species, although this occurs in the lowlands as well. For example, orchid extraction, illegal harvesting of Palma de Ramos (*Cenoxylon panifroma* [Engel] H.) for the heart and for crafts, and the hunting of bears and trapping of cats (e.g., puma, ocelot) for their pelts and other uses take place. Also hunted for subsistence and local meat trade are tapir, several varieties of deer, medium-sized rodents, coati, and birds including pigeons and waterbirds (R. Cisneros, personal communicaton, March 17, 2005).

INTENSIFICATION AND EXTENSIFICATION: PROJECTIONS AND GOALS

When viewed in a bioregional perspective, patterns of both land-use intensification and extensification are occurring around PNP. This section provides a brief overview of these two opposing trends, projects future trends, and defines the goal regarding the problem at hand.

Colonization pressures are especially strong on the south and east edges of the park, while on the western side the population and/or their direct dependence on the local natural resources may be decreasing, leading to land abandonment. Observation of the local landscape in many areas also reveals a pattern of intensive cultivation around homes, while extensification and abandonment take place further upland and further afield.

Extensification involves the clearing of new (and often marginal) land for production. Lands converted to pasture following land clearing tend to degrade quickly, leading to declining productivity, fodder shortages, and ultimately, abandonment as the people and cattle must move on to colonize new areas (Cardoso, Guijt, Franco, Carvalho, & Ferreira Neto, 2001). Regeneration following abandonment is often problematic due to degraded soil nutrient levels and water-holding capacities, absence of propagules and dispersal agents, disturbed communities of beneficial microorganisms, and competition from exotic species of grasses and pioneers. Extensification is currently the predominant trend around PNP, with practices including burning for pasture and agricultural crops, illegal timber harvest, and cattle grazing even on high slopes and highly erodable areas (Stern, 2005). Frontier expansion is taking place on the south and east edges of the park, although fire and grazing pressures are especially high on the western boundary of the park (Tello et al., 1998).

Intensification involves increasing the productivity and/or regeneration processes of land that is already deforested. Around the park there are some positive trends of intensifying land use, of which several examples were observed during the trip. These include the intensive tree-based home gardens (*huertas*) that are prevalent around homes. *Huerta* extension efforts have included the revitalization of indigenous practices through emphasizing traditional species and strategies (G. Jiménez, personal communication, March 12, 2005). Live fences are also a common practice, and some include native species such as *Opuntia cactus* for live fences, fruit production, and combating of desertification (Matallo et al., 2002). Honey producers are protecting and enriching forest plantings for production (O. Ordonez, personal communication, March 17, 2005). Irrigation systems are being installed in some regions to improve productivity (Stern, 2005). Emigration from the Podocarpus area to Spain or other countries has also created a cash infusion of remittances for local relatives, shifting food sources from local subsistence production (for example, of cassava) to purchased food such as rice (G. Jiménez, personal communication, March 12, 2005). This has taken land out of production and created the possibility of restoration.

The future projections of human and ecological health and well-being depend on which of the trends will predominate. Continued extensification would lead to further land degradation and continued encroachment on the park and the surrounding ecosystems. In this scenario, the park becomes a biologically isolated island while edge effects and human pressures gnaw at the edges and eventually fragment the protected areas. In the long run, this trend will lead to increasing instability for ecological, economic, and social systems, ultimately compromising Ecuador's natural resource capital, and risking crisis.

Moderate reforms may stem the tide of deforestation. Maintaining the status quo, however, will likely slow but not stop the ecological degradation that is occurring, as localized climate changes and existing impacts may lead to continued ecological decline.

The alternative is a transition of practices, attitudes, and beliefs, leading to a reversal of extensification practices. Intensification leads to improved human condition as well as to habitat expansion and the restoration of ecosystem services, while corridors prevent biological isolation of plant and animal communities within and around the park. This is the most desirable future scenario, but it is one that can be reached only through vision, commitment, and action. Table 1 summarizes the current trends, conditions, projections, and alternatives.

In and around PNP, much production is subsistence, the landscape is marginal, and economically viable alternatives to mining, logging, and cattle

TABLE 1 Trends, Conditions, Projections, and Alternatives for Intensification and Extensification

Trends	Conditions	Projections	Alternatives
Extensification: unsustainable grazing and timber harvest, fires; forest clearing to make way for pasture and agriculture; land abandonment.	Incentives for extensification practices; larger political and economic forces; poverty; lack of economically viable alternatives; other factors.	Given current conditions, extensification and land degradation is likely to undermine local ecological integrity, fragmenting habitat, degrading watershed quality, and destablilizing communities.	Trend can be weakened by removing the incentives and political and economic factors that drive extensification; closing the agricultural frontier; and facilitating land protection and regeneration after abandonment.
Intensification: regenerative practices; integration of conservation management and economic productivity; agroforestry; *huertas*; beekeeping; sustainable animal husbandry and farming; soil and water conservation practices; watershed protection.	Effective farmer-to-farmer information exchange; land tenure and long-term commitments to community and ecology; incentives; other factors.	Currently more the exception than the rule. Given current conditions, likely to continue and proliferate on a small scale and when required due to lack of extensification alternatives.	Trend can be strengthened by harmonizing conservation efforts with community priorities; improving land tenure and long-term commitments for both PNP and surrounding communities; and building relationships to share knowledge, strategies and tactics for nurseries, resource management, agroforestry, and regeneration on local and national levels.

raising are not widely available. We can define the problem as the unfavorable factors that drive land extensification (rather than intensification) and lead to continued deforestation, habitat fragmentation, and degradation of ecological integrity of the region. The goal is to eliminate, and hopefully reverse, these trends. While problematic trends are driven by larger social, economic, and political factors, one intervention point is to support sustainable and regenerative rural resource management by supporting food security, economic well-being, soil and water conservation, and expansion of vegetative cover and native species, through strengthening the practices of agroforestry and reforestation. At the same time, drivers of extensification trends must be weakened. Such intervention means improving and intensifying resource management practices in some areas, while facilitating native forest recovery in abandoned or marginal areas, and lessening the incentives for extensive activities. The following section makes some suggestions of how to strengthen agroforestry and reforestation practices around the park.

BUILDING TECHNICAL AND RESOURCE CAPABILITIES: SUGGESTIONS FOR FUTURE WORK

This section focuses on recommendations regarding strengthening technical and resource capabilities to achieve the goal elaborated above, including an emphasis on building effective partnerships to share information, resources, and responsibilities. Suggestions to reduce extensification pressures include: (a) focusing efforts on the eastern side of the park, where colonization is occurring rapidly; (b) establishing a park presence in advance of encroachment; (c) clearly delineating the park boundary; and (d) establishing a buffer zone. That said, the mere establishment of a buffer zone will not protect the core of the park; management must allow for interaction and change over time in buffer areas, facilitating a mosaic of healthy and regenerative interactions between people and the park (W. Burch, personal communication, March 23, 2005). Closing the agricultural frontier and diminishing incentives for extensive practices are essential to achieving the goal.

Suggestions to strengthen capabilities for intensification include (a) building strong relationships to facilitate information exchange, and (b) elevating the technical and resource capacities of all actors involved in land management around PNP. This includes improving nursery/tree seedling production and dissemination for native plants, and improving the effectiveness of regional participatory programs to test, prototype, and develop outplanting materials and strategies to benefit farmers and colonists. Because resources in the region are limited, I focus in this recommendations section on a few key leverage points for extension, nursery practice, and agroforestry improvement.

Outreach and Extension: Building Relationships and Creating New Local Knowledge

Building successful management practices around PNP will require more than resources and technologies. It will require building effective *relationships* between individuals and institutions on all levels (Jarvis et al., 2000). Bond (this volume) discusses some of the stakeholder relationships that are necessary for improvements. For agroforestry and nursery practices, I recommend creating a stable extension program consisting of at least two long-term agent positions, one for agroforestry and one for nurseries. Extension's main task should be the building and coordination of relationships between individuals and institutions in order to share resources and elevate the capabilities for all concerned.

The words "extension" or "outreach" may imply that knowledge or information is extended out from one expert source (usually a university or other institution) to farmers. However, effective extension has shifted in recent years from a conventional top-down model ("knowledge extended") to building relationships for mutual learning ("knowledge created") in partnership with individuals and local communities: "Extension has taken its role as educator and facilitator to a new level—building community coalitions to engage in research for community problem solving. Such extension programs create local knowledge to be used in policy and program design" (Warner, Hinrichs, Schneyer, & Joyce, 1998, p. 1). The creation of local knowledge will be particularly important around PNP, where variable environmental and cultural factors will require locally appropriate approaches to resource management and problem solving.

Any extension agent beginning work in the area of PNP will need to distinguish him or herself from ineffective predecessors that have operated in the past (Stern, 2005). This can be achieved if the agent makes a long-term commitment to the area and to the community, and can create some tangible results quickly (Stern, 2005). Extension workers ideally would also take an interdisciplinary, as opposed to conventional, standpoint in order to enhance effectiveness, as illustrated in Table 2 (Clark, Stevenson, Ziegelmayer, & Rutherford, 2001).

TABLE 2 A Comparison of Conventional and Interdisciplinary Standpoints (Clark et al., 2001, p. 49)

Conventional professional	Interdisciplinary professional
Participants know what they want and follow a pre-specified plan or project design; people tend to be rigid.	Participants do not know where projects will lead so work is an open-learning process; people tend to be flexible.
Assumption of single, tangible reality, which is generally known to participants; "correctness" is clear and "right and wrong" actions are known.	Assumption of multiple realities; reality is partly socially constructed and must be discovered by participants; "correctness" and "right and wrong" to be decided by participants.
Method of participation tends to be singular, disciplinary, reductionistic, positivistic, and narrowly ideological (cause and effect, predictions), often with a special interest focus; thought and actions "bounded."	Method of participation tends to be holistic and interdisciplinary, broadly ideological, with a common interest focus (empirical, systematic); thought and actions "unrestricted."
Policy and information are extracted from situations that should be controlled; authority, control, and dominance are at issue.	Policy understanding and appropriate focus of attention emerge from interaction with context; authority and control are important issues, but focus is on solving common problems fairly.
Problem solving is blueprint-like; a "formula" is known and it should be used to address problems.	Problem solving is process-like; guidelines are known to address problems as well as general standards (e.g., reliability) to aid problem solving.

Nursery Practices: Organize the Arena, Remove Bottlenecks, and Facilitate Outplanting

The lack of high quality seedlings of native and culturally important plants for reforestation and agroforestry around PNP remains a problem. For farmers, tree planting represents a considerable investment not only for seedling propagation, but also for land, site preparation, outplanting, and short- and long-term maintenance. The long time before potential benefits of tree planting can be realized adds to the uncertainty of the investment (Huxley, 1999). For these reasons, the decision to plant or maintain trees on agricultural land is not undertaken lightly by farmers. The availability and quality of plant materials is a factor that deeply affects farmer choices. When high quality plant materials are available for outplanting, the farmer's up-front investment can be greatly reduced. Healthy seedlings propagated from good genetic material often establish more quickly and have better survival rates than poor quality material (Landis, Tinus, McDonald, & Barnett, 1994). In contrast, seedling unavailability acts as a disincentive, with the result that trees are not planted or that farmers must invest even more to establish their own private nurseries. Almost worse than no seedling availability is availability of only poor quality seedlings, which may have low survival rates and/or extremely poor outplanting performance, forcing farmers to work harder to keep trees alive and reducing any benefits farmers may receive. Poor quality seedlings and inferior cultivars are a disincentive, as farmers who invest in outplanting are disappointed with the return on their investment. Word-of-mouth information can lead to local beliefs that ouplanting native trees is a time-consuming, labor-intensive, high-risk undertaking, whereas the opposite effect can be achieved from high-performance outplanting experiences.

During our visit, the need to build relationships and share information and resources among nursery managers was evident. Some nurseries seemed unaware of each other's existence, and it appeared in essence that each nursery manager was forced to reinvent the wheel in each separate location in order to learn how to propagate native plants. Plant quality appeared highly variable in nurseries that we visited, and in many cases quality was suboptimal. There has been some extension work in the past to create a publication for community nurseries in Ecuador (L. Ordonez, personal communication, March 17, 2005), and there are reportedly some small-scale, farm-run tree nurseries in existence around the park (O. Ordonez, personal communication, March 17, 2005). However, quality native tree seedlings are simply not widely available. For example, one informant who was conducting a research project near PNP that required native seedlings had hoped to purchase plants locally; ultimately, however, the researcher grew his own seedlings because he could simply not find any plant materials (A. Gerique, personal communication, March 16, 2005).

The scale of nursery efforts around PNP should be considered. Given transportation difficulties and varying soils, flora, and microclimates in the region, large, centralized seedling production is likely not a desirable option. However, due to the complicated nature of native plant propagation and the effort and skill required to start and operate nurseries, it would not be feasible for every farm or small community to make the investment to establish a nursery. An intermediate-scale solution must be found. It should be noted that Ecuador clearly has the capability to produce and outplant high-performance seedlings where the political and economic will exists, as evidenced by the many pine (*Pinus radiata*) and eucalyptus (*Eucalyptus* sp.) plantations in the region. Some of the machinery that produced these exotic seedlings can be retooled to produce native and culturally important plants on a more intermediate scale.

On the other hand, the decentralized success of on-farm conservation and habitat expansion of the aforementioned endangered native papaya also illustrates the potential for farmer-initiated plant propagation. Another useful model may be found in examining the local Inca native reforestation practices that thrived in Ecuador before the Spanish invasion (Chepstow-Lusty & Jonsson, 2000). It is likely that the most effective scale would be to work with intermediate-sized nurseries, at least one per ecoregion of the park (for a total of five), operated by community-based practitioners who receive information and support from a dedicated nursery specialist for the region.

I recommend creating a nursery extension specialist position for the communities around PNP. The extensionist should have a long-term commitment to the communities and coordinate sharing of information, resources, and responsibilities. This person's role could include building relationships between those who benefit from and could potentially share the costs of tree planting (i.e., wider society), those who grow seedlings, and farmers who might want to plant trees. Exploring creative ways to provide incentives for farmers to plant trees, such as cost-sharing or labor-sharing arrangements or other financial or social incentives, would also be helpful (Bond, this volume). The extensionist should focus not only on species but also on strategies, working with farmers to develop and share regionally appropriate systems.

Another key role for the nursery extensionist should be to build relationships and facilitate information exchange. For example:

- create an annual meeting for current and aspiring nursery managers, reforesters, and seed collectors around PNP for information exchange and mutual support (Thomas D. Landis, personal communication, April 15, 2005);
- act as an information clearinghouse for what is known about how to successfully propagate, outplant, and manage the local species, perhaps a non-web-based effort similar to the USDA's recent success in developing

the Native Plant Network, where nursery managers write and share propagation information (see http://nativeplants.for.uidaho.edu/network/search.asp for an example of information to be gathered);
- build bridges between local knowledge and national- or internationally-generated information through research and networking;
- facilitate assistance with nursery set-up and propagation advice; and
- harmonize efforts and facilitate partnerships and information sharing between local universities, private nurseries, farmers, and farmer organizations.

Seed availability for native trees and plants is also an urgent problem that should be addressed. Currently seed collection is haphazard, unfunded, and disorganized. For example, farmers trained in seed collection who make the effort to collect seeds reportedly earn less than US$20 per year for their efforts (O. Ordonez, personal communication, March 17, 2005). Until a concerted investment can be made in seed research and orchard establishment, one or several of the local university or technical colleges should be subsidized to train collectors in order to maintain genetic diversity of the seed supply. Since time and funding is in short supply, this effort need not be elaborate. Simply paying a wage for collectors, providing collection equipment, and following some basic practices to maintain diversity—such as collecting from at least 30 individuals and collecting from different parts of the tree (Dawson & Were, 1997)—may be enough to ensure a viable future and continued evolutionary processes for PNP's tree species.

Agroforestry: Strengthen Effective Regional Participatory Programs to Test and Develop Materials and Strategies

The areas around PNP have some strong examples of successful community-based resource management (for a description of organizations and programs see Bond, this volume). The ubiquitous presence of *huertas* and live fences observed during the trip is a testimony to past partnerships between individuals, farmer organizations, and regional conservation concerns (L. Ordonez, personal communication, March 17, 2005). A partnership between honey producers and conservationists in the Vilcabamba area is leading to forest conservation and enrichment as a beneficial economic practice for producers (Stern, 2005; L. Ordonez, personal communication, March 17, 2005). Also, while it is not a model to emulate, the presence of pine and eucalyptus plantations suggests that tree planting on degraded land can take place on a large scale where the political will exists. However, both current agroforestry work and reforestation with pines and eucalyptus fall short of what is possible with on-farm conservation. The *huertas* extension was focused primarily on subsistence, not on economic production, and was also more oriented toward agricultural gains than conservation

(L. Ordonez, personal communication, March 17, 2005). The pine and eucalyptus projects took place in a way that was disconnected and largely unsupported by surrounding communities, and also focused on economic production exclusively, rather than on conservation (O. Ordonez, personal communication, March 17, 2005). This section briefly makes some suggestions regarding how to strengthen effective initiatives in order to improve both human well-being and ecosystem integrity.

As with nursery practices, the many independent and isolated agroforestry efforts could, with a relatively small investment, be integrated to elevate the technical and resource capabilities of all concerned. A dedicated extension position is one example of how this process could be facilitated. In some areas around the park, there are respected local farmers (women and men) who have also received some formal technical training and are now involved in farmer-to-farmer extension initiatives (L. Ordonez, personal communication, March 17, 2005). This is the beginning of a positive process to strengthen and develop local human resources and capacity around PNP by empowering, training, and then employing farmers as extensionists. The success of the honey production project, which has farmers engaged in actively protecting and even practicing enrichment planting of native forests to strengthen their own economic production of honey, is another example of technical training facilitating farmer extension (L. Ordonez, personal communication, March 17, 2005). In addition to being an effective and relatively low-cost way to facilitate development, such local networks also help ensure the continuation and continued evolution of agroforestry efforts (Current, Lutz, & Scherr, 1995).

Developing prototypes and field examples of effective agroforestry practices would also be helpful. The intention should be to showcase some potential models and materials that could be adopted or adapted by farmers for future plantings, not to suggest a standard design. In most cases, resource managers benefit more from the provision of information about performance and requirements of various agroforestry species and strategies (Current et al., 1995). For example, providing a "menu" of tree species available for planting, their multiple uses and products, their environmental and management requirements, and time expected to reach a certain size, could be very valuable in facilitating decision making. An extension program should also work to implement adaptive comanagement and facilitate a continual learning process (Cardoso et al., 2001).

Optimal agroforestry systems and strategies for the area around PNP will be best developed by local farmers in cooperation with conservation concerns. Implementation of some of these practices may require incentives or subsidies if no immediate economic gain is involved for farmers. One possibility includes establishing vegetative erosion barriers along the contours of steep agricultural and pasturelands. Vegetative contour barriers could utilize species such as nitrogen-fixing trees or shrubs (i.e., *Erythrina* sp. or *Cajanus cajan*, both of which have edible or useful products), or herbacious species such as the medicinal plant comfrey (*Symphytum* spp.), and the essential-oil-producing seedless variety of vetiver grass (*Vetiveria zizanioides*). Planted densely along contours, the vegetative erosion barriers form thick hedges that retain soil on their uphill side, creating terraces over time with a fraction of the work involved in conventional earthwork terracing. Crops or animals can be cultivated in between the contour plantings. This practice could prevent further loss of valuable soil and fertility, while providing secondary economic products.

Improved practice might also focus on increasing the integration and effective use of local nitrogen-fixing trees, shrubs, and ground covers for soil fertility and regeneration. There is widespread use in live fences of *Erythrina* species, for example, but we often saw that the trees had been pollarded and the woody cuttings left on the ground. More frequent cuttings would yield a more nutrient-rich leafy mulch which could be applied around crops to enrich the soil, rather than bound up in the woody material or dried and returned to the air as in current practice. Other appropriate species already present in the area are faique (*Acacia macracantha)*, guato and relatives (*Erythrina* sp.), huilco (*Anadenanthera colubrina*), guaba (*Inga* sp.), and aliso (*Alnus jorullensis*; Stern, 2005).

Integrating long-term native tree crops for timber or other farm uses as windbreaks, shelterbelts, boundary markers, or contour barriers could provide farmers with a "savings account" with valuable yields over time, as well as providing some bird habitat or other corridor possibilities (Wilkinson, Elevitch, & Thaman, 2000). Potential native species for this purpose include: guayacan (*Tabebuia chrysantha*), nogal (*Juglans neotropica*), *Alnus jorullensis, Anadenanthera colubrina,* and *Cedrela* species (Stern, 2005). In wet areas, local people might also consider exploring the possibilities of clumping varieties of timber bamboos (for example, *Guadua angustifolia*), which produce high-quality timber often on short cycles and have been successfully used elsewhere in South America. It would be advisable to explore other practices to integrate native trees with production, such as the interplanting systems utilized for coffee agroforestry in "shade-grown" systems of Central America. These systems often involve just three species (coffee, *Erythrina* sp., and *Cordia alliodora*), yet have been documented as secondary only to native forest in terms of bird habitat provided (Smithsonian Migratory Bird Center, 2005). Farmers have exploited the conservation benefits of their practice in global markets, and it is possible that regional crops of Ecuador might gain such global appeal.

Other solutions may be found through facilitating change in patterns of local land use to enable the regeneration of forests on the highest slopes, which would protect watershed and habitat, while keeping lower areas in cultivation (Stern, 2005); strengthening markets and regenerating sustainable practices for traditional crops such as Andean root crops and unusual fruits such as naranjilla, cactus fruits, and the native papayas (National Research Council, 1989), as well as other economic products; and exploring forest-friendly alternatives to beef production such as the cultivation of coati, a native forest-dwelling animal and popular meat whose market price is reportedly twice as high as beef, and whose productivity (pounds of meat produced) per hectare may be higher than cattle (F. Nogales, personal communication, March 14, 2005).

The ideas and insights of local farmers are far more valuable than anything an outsider could suggest. The key will be to develop effective regional participatory programs to develop and test outplanting materials and strategies (prototypes) that will enable farmers and conservationists to work together to achieve their common goals.

Protection and Regeneration: Remove Incentives for Extensification and Degradation

If protected areas did not exist, societies could continue to practice deforestation and land abandonment until resource loss forced intensification practices because there would be no other alternative. The establishment of protected areas such as PNP is a proactive choice by society to conserve a higher level of ecosystem health and diversity, but this choice also forces intensification. The social, political, and economic factors that drive extensification are still very strong around PNP, and these must be reversed if the park is to survive (see Bond, this volume). On a local level, the agricultural frontier should be closed. Where new colonization is taking place, particularly on the eastern side of the park, it is imperative that the park define its boundaries and the area of its buffer zone and establish a clear presence in the area.

The scars of past extensification practices on the lands around PNP represent a unique opportunity for conservation. Particularly on the western side of the park, land use is transforming through land abandonment. Valuable second growth forests are regenerating, and these can be protected from suburbanization and fragmentation in the future. Natural regeneration following pasture abandonment may also be facilitated through some management of factors that impede forest succession. For example, it is known that the presence of grasses may affect seedling survival through shading, allelopathy, competition for light and nutrients, and alteration of macro- and micro-fauna populations (Holl, 2002). One of our informants suggested that some soil preparation to knock back the grasses facilitates secondary forest regeneration (L. Ordonez, personal communication, March 17, 2005). As another example, establishing a few islands of shrubs or trees may suppress grasses through shading, and facilitate seed dispersal by birds, accelerating forest recovery (Holl).

CONCLUSIONS

The goal of enhancing human well-being and dignity is intimately linked to the goal of protecting ecosystem health and integrity around PNP. Harmonizing the benefits of biodiversity conservation with the needs of farmers will call for a systems approach to management, with agroforestry an essential component that provides economic benefits to local communities (McNeely, 2004) and also extends conservation beyond the edges of the park. Traditional and indigenous species and strategies are the most appropriate foundation for future agroforestry and reforestation in the region, though these species and strategies can be adapted and strengthened, where appropriate, with new innovations (Clarke & Thaman, 1993). There are many examples of traditional systems around PNP, including terracing, reforestation, multi-storied home gardens, and live fences; these can be utilized as leverage points for future improvements. The key will be to facilitate and strengthen these and other forces that result in sustainable intensification of land use and in land regeneration following abandonment, while weakening the forces that drive extensification and land degradation. A path toward implementing this strategy is to elevate resource and technical capabilities of farmers in the region. This is best achieved through cultivating connections between individual farmers, farmer organizations, educational and research institutions, and conservation interests on all levels to share resources, responsibilities, and information.

Suggestions to improve practice include a developing a long-term strategic extension program to coordinate nursery and agroforestry efforts around PNP. Building relationships to share knowledge and more importantly to create new local knowledge and foster the social capacity to evolve and adapt systems and strategies over time will be essential. Specific suggestions to strengthen nursery efforts (a current technical bottleneck in effective agroforestry and reforestation) include fostering communication through annual meetings of nursery managers; creating an information clearinghouse for propagation, species use and systems information; strengthening seed saving, research, and production; and building bridges between community nurseries, universities, and national and international plant propagation programs. Suggestions to strengthen agroforestry efforts include developing more effective regional participatory programs to test and develop materials and strategies, building on the successes of *huertas*, live fences, beekeeping, and other regional models. Potential agroforestry models for the region are best developed by local farmers in cooperation with research programs, but possibilities include: greater utilization of native nitrogen-fixing species for soil enrichment and economic production; vegetative contour plantings to build terraces on steep slopes; windbreaks or hedgerows integrating high-value native timber trees for bird habitat expansion and long-term economic products; and exploration of market opportunities to create unique regional market niches for unusual native and traditional meats, fruits, vegetables, Andean root crops, and timber bamboos. Suggestions were also made for how to facilitate the protection and regeneration of abandoned lands. These and other efforts addressed in this volume may help reverse the trend of extensification and facilitate sustainable and regenerative land use—a common-interest goal for local farmers around PNP as well as for Ecuador and the world at large.

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