Ecological Restoration for Future Conservation Professionals: Training with Conceptual Models and Practical Exercises

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ABSTRACT

In the context of a new international master's degree program, "Biodiversity in Tropical Areas and its Conservation," we led a two-week module on ecological restoration in Ecuador for 34 future conservation professionals from nine nations, including seven from Latin America. One week was spent in the cloud-forest life zone, a second in the lowland tropical forest. The ranges of biomes and socioeconomic and historical settings that commonly occur in tropical regions were discussed. We saw these students as future communicators engaged not only in management of protected areas, but also as deeply involved in outreach, negotiation, and consensus-building among stakeholders. Students were introduced to concepts and techniques for evaluating a degraded landscape in order to determine past and present land uses and conflicts of interest among stakeholders. They were instructed on how to select a reference model using sequential reference sites and to incorporate nine attributes of satisfactorily restored ecosystems into restoration plans. In nine small groups, the 34 participating students prepared proposals to obtain funding for a restoration project in their home countries or in one of the two regions of Ecuador that were visited in the module. For this purpose, each group developed a schematic model showing how the target ecosystems were degraded and landscapes fragmented. In a second schema, they proposed a program to restore or rehabilitate different landscape units and to reintegrate fragmented landscapes. Highlights and lessons learned from this modular exercise are presented and discussed.

Keywords: natural capital value, proposal writing, reconciling conservation and economic development, reference models

Tropical countries are home to the world's richest biodiversity, but most knowledge about those areas is generated and published elsewhere—often in more developed "rich" countries and with low returns in terms of capacity building or research training in tropical places. In 2008, an international master's program called "Biodiversity in Tropical Areas and Its Conservation" was launched in Ecuador. Its goal is to offer proficient Latin American students the opportunity to receive a European MS degree in the areas of biology, ecology, forestry, agriculture, and related fields that could lead to further academic, research, and employment opportunities. Such programs are scarce in Latin America, and those that exist are usually inaccessible to a majority of the qualified students. Many students with great research and professional potential simply cannot afford the costs of competitive degrees, which would aid them in becoming academic or research leaders in their home countries. This expertise, in turn, would promote our knowledge of tropical biodiversity more quickly.

The innovative program we present here was created by the International University Menendez Pelayo (UIMP) and the National Research Council (CSIC) of Spain in collaboration with the Universidad Central del Ecuador (UCE). The government of Spain, through the CSIC, funds the program and provides scholarships to help train future conservation scientists and protected area managers who are working or planning to work in Latin America, especially in tropical countries. The course is open to European and other non-Latin American students as well. Following an organizational model widely used in Spain, the MS program's 19 two-week modules focus on conservation biology, biostatistics, park management, planning and executing a research project, and ecological restoration—all centered on the tropics. Each module is taught by instructors experienced in their subject areas. Graduating students earn credit towards an MS degree from UIMP for a course completed in a tropical country. Opportunities exist for motivated students to continue in a PhD program in any university in Spain and other European countries, since the program is included in the "European Space for Higher Education." Additionally, each academic

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year, the CSIC funds provide a full fellowship for one outstanding student among the graduates to go on to conduct the PhD research in one of its institutes. The program is advertised through its Web site (www.masterenbiodiversidad.org) and also the CSIC, UIMP, and UCE Web sites, along with various more informal, although very efficient, online listservers and forums.

In the first year, participants included 24 MS students from seven Latin American countries, along with three from Spain and one from the United States. Many students already had considerable background in conservation biology, protected area management, and fundamental ecology, but none were previously exposed to the science and practice of ecological restoration. Six additional students audited our program. Of varying ages, these students were enrolled in an undergraduate program called "Restoring Natural Capital," at the Universidad Alfredo Pérez Guerrero, Extensión Gualaceo.

Core Concepts

The major conceptual issues we decided to address were why restore and how to plan, organize, and monitor the progress of a restoration project, with special emphasis on the use of reference models for planning and project integration within larger biophysical and socioeconomic settings. An additional area of emphasis was monitoring and evaluation and the usefulness of the list of "attributes of restored ecosystems" (SER 2004) for those purposes. At the beginning of the course, we discussed the difference between restoration and other environmental repair activities. We noted that restoration—the process of assisting the recovery of an impaired ecosystem in terms of structure and functioning (SER 2004)—differs from rehabilitation, which aims at the recovery of ecosystem processes without necessarily the recovery of the entire inventory of indigenous biota. We also explained that both restoration and rehabilitation seek to recover, reactivate, or return an impaired ecosystem to a desired state or trajectory as embodied by a reference model or reference site (see Clewell and Aronson 2007). In contrast, some damaged sites, with longstanding and widespread alteration of ecosystems and where people will be living and working on the land indefinitely, will be reallocated to entirely new uses.

The need for reintegration, sensu Hobbs and Saunders (1992), of fragmented landscapes was also discussed. Fragmented landscapes require reconnection both ecologically in terms of their natural ecosystems and socioeconomically in terms of their production systems and built-up areas at a spatially explicit landscape scale (see also Hobbs 2002). We introduced the idea of a combined RRR (restoration, rehabilitation, and reintegration) model. We suggested that for degraded landscapes all three activities should be planned simultaneously in order to recover biodiversity, productivity, and natural services of benefit to people. Planning should be conducted in close collaboration with local stakeholders. We discussed ecosystem values and particularly the conflict between the need to support an agrarian economy and the concerns for nature conservation. The article by Clewell and Aronson (2006) on the motivations for restoring ecosystems served as the foundation for group discussions on how values mold land-use decisions in various regions and contexts.

To complete the introductory portion of the course, we introduced the restoration of natural capital (RNC). We presented the different forms of natural capital (Costanza and Daly 1992, Capistrano et al. 2005), including biodiversity and well-functioning ecosystems. We explained that in economic terms, renewable natural capital can be considered to be a *stock* from which flow ecosystem goods and services upon which human societies rely. We introduced the idea that, from a socioeconomic perspective, it is convenient and appropriate to consider ecological restoration and indeed RRR in toto as an effort to restore or augment stocks of renewable natural capital, not only for their inherent, nonmonetary values, but also to ensure or increase flows of ecosystem goods and services. In this approach, the seeming dichotomy between investing in environmental infrastructure—yet another name used for renewable natural capital—and national or local economic development disappears. Restoring natural capital from this perspective means investment in natural capital stocks and their maintenance in ways that improve the functions of both natural and human-managed ecosystems, while contributing to the socioeconomic well-being of people (Aronson et al. 2006, 2007a, 2007b, 2007c, Clewell and Aronson 2006, 2007). Ways to achieve restoration of natural capital include holistic restoration of ecosystems, ecologically sound improvements to farm lands, fish farms, tree farms, and so on, and improvements in the utilization of extracted natural resources. Additionally, anything that promotes or facilitates greater knowledge and awareness of the value of natural capital in daily activities also can be considered as a form of restoration (Aronson et al. 2007b).

In order to provide some concrete examples of restoration and rehabilitation projects in Ecuador, a very biodiverse tropical country with high levels of human poverty and underdevelopment in rural areas, one of us (NA) presented several detailed case studies of restoration of abandoned pastures, which constitute a large part of the unproductive land base in the country (Aguirre 2007, Aguirre et al. 2006, Günter et al. 2007, 2009). For the reestablishment of productive forests in these areas, we suggested natural regeneration on areas with minor disturbance, and enrichment plantings or full-scale plantations on land where natural recovery cannot be guaranteed or, from a socioeconomic perspective, that would need too much time to recover. At a minimum, projects aim to return the land to more economically productive uses in an acceptable time period. As Knoke and colleagues (2009) put it:

> Ongoing discussions on reducing emissions from deforestation and degradation (REDD), conservation of non-market values such as biodiversity, and integration of deforestation into the international carbon markets by means of payments for ecosystem services (PES) are condemned to fail, both socially and economically, if the local people's needs are not taken into account in that debate. (p. 548)

To be effective, restoration in all tropical countries must be reconciled and integrated with regional efforts aimed at maintaining biodiversity, restoring degraded ecosystems, and supporting sustainable economic development for local farmers, landowners, and communities (Aronson et al. 2006, 2007a, Blignaut et al. 2007, Blignaut and Aronson 2008).

Finally, we invited students to form small groups to work together to prepare short proposals to obtain funding for an actual restoration project, either in a familiar region in their home countries or else in one of the two regions visited during the module. We arranged in advance to spend one week with the students in the cloud-forest life zone near Gualaceo in southern Ecuador and a second week in the lowland tropical forest of eastern Ecuador, in the Amazonian cordillera of Cutucú-Shaimi. These two locations allowed students to experience at least part of the broad range of biomes and of socioeconomic and historical settings that occur in the tropics. These proposals served as the basis for our evaluations of the students' work in the module. All student groups were asked to present the history of degradation and fragmentation in their study areas and to suggest possible responses from a spatially explicit RRR perspective. Following are some highlights of the work done in the field and a discussion of the work of two of the student groups.

Field Work

We spent the first week of the module in the Andean town of Gualaceo (Azuay province), which is in the cloud forest life zone. The region we examined was representative of vast areas of upland Latin America, where forest and mineral exploitation, along with various imported systems of agriculture and animal husbandry, have drastically altered and fragmented landscapes, even though they still harbor many rare and endangered plants and animals.

We took several half-day trips to observe the predominantly agricultural mosaic in the immediate region. We discussed the concept of "reading" a landscape for clues to the ecological history of land use and misuse. We considered the prospects for, and obstacles to, ecological restoration at the locations visited. This was the first time that most students had been introduced explicitly to this kind of landscape-scale perspective or to the meanings and nuances of the various terms relevant to ecological restoration.

The second week was spent in the Wisui Biological Station in the Cordillera de Cutucú-Shaimi. This newly created station was funded by the MS program and by the Center for Conservation and Sustainable Development of the Missouri Botanical Garden. Now it is administered by a local association created for this purpose in the Wisui village in collaboration with the MS program, the Universidad Central del Ecuador, and the Missouri Botanical Garden (see www.masterenbiodiversidad.org/wisui.php). The station is inside the Cutucú-Shaimi Protector Forest, which covers 312,000 ha of Amazonian forest in a series of largely inaccessible mountainous ridges, much of which is nearly pristine and exceptionally rich in biodiversity. A third of the reserve, however, is moderately modified forest occupied and used by communities of Shuar Indians.

Case Studies and Practical Exercises

Building a Relevant Reference System

To guide work and discussion on conceptual issues, we presented a general model of ecosystem degradation and the three possible responses to it (restoration, rehabilitation, and reallocation) at a landscape level, using the model of Aronson and coworkers (1993a, 1993b, Aronson et al. 2007a, 2007b), which includes consideration of ecosystem goods and services as well as the broad notion of RNC.

Next, we introduced the concept of reference ecosystems or models (Egan and Howell 2001, SER 2004, Clewell and Aronson 2007, 80–89). The advantages of having a reference model were spelled out in terms of monitoring, evaluation, and communication to both scientists and stakeholders. To summarize, "Reference models provide targets towards which to restore and distinguish ecological restoration from other kinds of environmental repair such as rehabilitation and species introductions, which do not necessarily return ecosystems to historic ecological trajectories" (Clewell 2009, 244). We discussed the increasingly prevalent idea of restoring ecosystem *processes* as an alternative, or complementary strategy, to the use of historical references, and we introduced foundational literature on the subject (White and Walker 1997, Egan and Howell 2004).

We then presented a series of multidimensional reference models that serve as goalposts for successive stages of ecosystem restoration (Aronson and van Andel 2006, Clewell and Aronson 2007, 81). This approach addresses not only biodiversity, but also the flow of ecosystem goods and services to people, as concurrent and equally

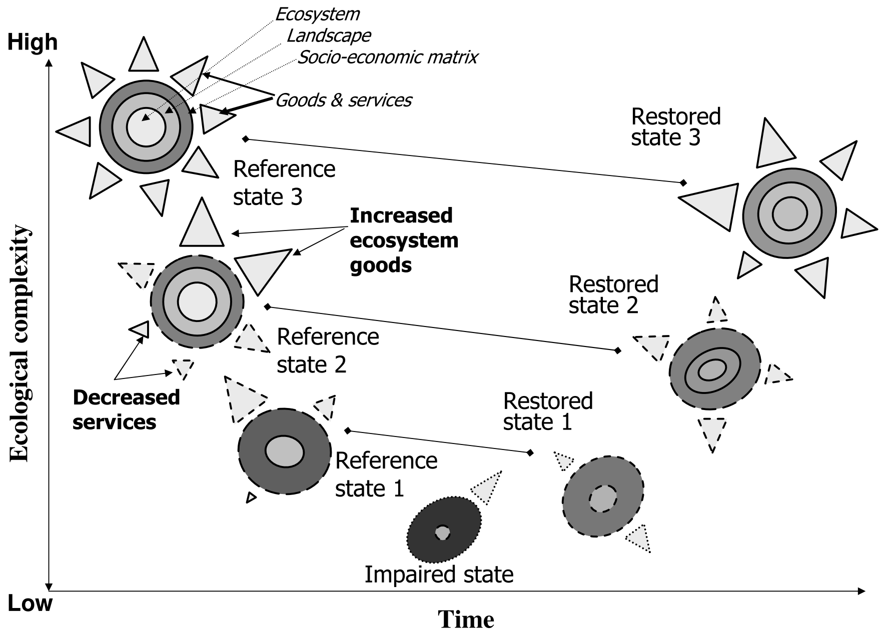


Figure 1. In this conceptual model of sequential references in ecological restoration, dashed lines represent degraded or fragmented conditions as compared to a "whole" system and integrated landscapes (from Clewell and Aronson 2007, 81). The inner circles represent the ecosystem. The one or two outer circles represent the landscape and the socioeconomic matrix in which the ecosystem undergoing restoration is embedded. The triangular appendages represent various natural goods and services that accrue from an ecosystem and that grow or decline in size as a function of their use and management by people. Reproduced with permission from Island Press

essential goals of restoration, especially in developing countries and indeed all areas outside of parks and other set-aside lands and wetlands.

Writing a Grant Proposal

We next asked students to break into small groups to begin development of draft restoration project proposals as if they were going to seek funds to carry out real RRR programs. In this way, they could "learn by doing." Nine projects were produced, comprising a cross-section of biomes and ecoregions that facilitated discussions on similarities and contrasts.

The main body of the proposals described explicit interventions to be undertaken, including RRR and also remediation where needed. The methodology for RRR and any socioeconomic and educational programs deemed necessary was explained. Protocols for monitoring and data evaluation as well as anticipated results were described, followed by products (or "deliverables"), a concept with which most students were unfamiliar. For monitoring and evaluation, we recommended that the students consult the nine attributes of satisfactorily restored ecosystems as outlined in the SER (2004) *Primer for Ecological Restoration* and by Clewell and Aronson (2007).

We asked for a detailed five-year timetable and a budget. A list of references was also required, along with appendices as necessary. Nearly all students were inexperienced in writing a short summary, and thus we required all groups to prepare an executive summary of no more than 250 words. To orient the thinking about interventions, timetable, and budget, a multiple-reference model was to be developed, following the general example shown in Figure 1.

Outcomes

The nine projects reflect a very broad spectrum of biophysical and socioeconomic contexts, ranging from mangroves in the Galapagos Islands, where high-end, international tourism is the main industry in the coastal areas, to páramo grasslands in the high Andes, where subsistence agriculture is the main source of income for almost everyone. Yet another project concerns Mediterranean woodlands in northeastern Spain, while a fourth addresses problems related to an oil field deep in the Amazon. One dealt specifically with the Gualaceo area and one with the Cutucú-Shaimi cordillera where one of the two week-long field sessions was held (see sidebar). Notably, each working group found a different combination of attributes of restored ecosystems to be most useful for their proposed restoration projects (see www.rncalliance.org/). In general, they made a selection from the list of nine attributes proposed in the SER primer. But two groups also developed an additional list of attributes related directly to the delivery of ecosystem services, a novelty that should be incorporated in the next version of the SER primer, in our opinion.

Feedback was very positive from almost all the students who participated in this course. The interactions among the students from all parts of Ecuador and nine different countries were enriching and stimulating for all of us. The task of writing an integrated RRR research and development plan proved to be a valuable learning exercise both in terms of conceptualization and in practical skills development. Indeed, several of the groups intended to pursue funding for their projects.

Comments from the students emphasized the value of working on an abstract, budget, and timetable. One item that all groups considered essential for success of an RRR program, and that was not adequately underlined in our initial presentations, was the need for environmental education (the subject of several papers in this special theme). Outreach was considered to be paramount, whether by the media, workshops, or other formal and informal means of communication. The pros and cons of nature-based tourism received much discussion, as did the search for sustainable forestry and agriculture. The students arrived at a consensus that

SIDEBAR

Degradation, Restoration, Rehabilitation, and Reintegration in Southern Ecuador

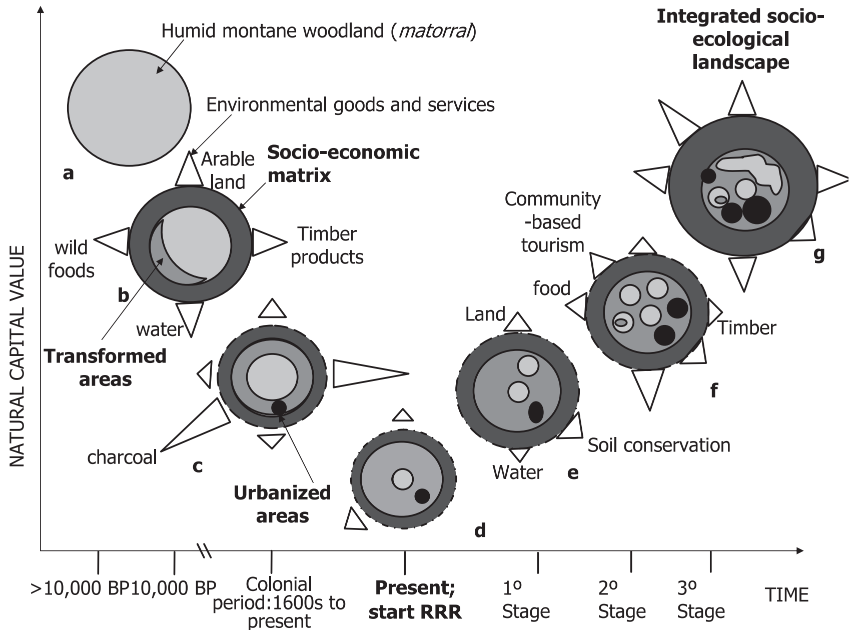
Ecological transformation processes over 10 millennia in the Gualaceo region (southern Ecuador) and proposed interventions, RRR (restoration, rehabilitation, and reintegration), are summarized schematically in seven stages (see figure):

a) The slopes of Gualaceo dominated by humid montane shrubland or woodland (*matorral*) (light gray) prior to the arrival of humans.

b) A relatively small proportion of the area is transformed by agricultural activities (darker gray) of the Cañaris and—much later—the Inca cultures. With human presence, a socioeconomic matrix (black) represents the environmental goods and services (triangles) that supported people. The size of the triangles represents the flow or intensity of use or extraction of natural goods, whose numbers vary over time.

c) With the arrival of Europeans in the 16th century the transformed areas increase rapidly, as do the urbanized areas (black dot), while the flow of some environmental goods and services also increases, especially timber for the construction of houses and charcoal for heating. Other environmental services, however, diminish (flow of water, soil conservation, wild foods, etc.) The socioeconomic matrix begins to degrade, as indicated by the broken line representing it.

d) At the present time, only about 2% of *matorral* survives in the gorges and other inaccessible areas around Gualaceo; almost 98% of the area has been transformed to cattle pasture and other farmland. Environmental services such as water and arable land have been greatly reduced, and flows of other goods and services are no longer available. The urban areas have increased. Ongoing landscape degradation is reflected by a highly perturbed socioeconomic matrix. An integrated RRR program would be beneficial.



Schema prepared by the student group working on the local Gualaceo landscape in Azuay, Ecuador, shows degradation and transformation process over ten millennia, and proposed interventions to increase the value of natural capital at landscape scale. Original work of Diana Fernández, Berenice Trovant, and Josué López. This and other fine examples of student work can be seen by clicking on RNC Students at www.rncalliance.org.

e) In the first stage of the RRR project, an increase of the area of *matorral* is achieved by connecting the existing fragments and replanting selected native species, even though the urbanized areas continue to expand. Attention is given to improving the socioeconomic matrix, among other things, through improved environmental planning and education. Some environmental benefits, such as soil conservation, begin to show improvements immediately.

f) In the second phase of RRR, the area of *matorral* continues to increase thanks to the implementation of living fences and various agroforestry activities using native woody species. In addition, community-based tourism becomes possible, thanks to the rapid recovery of the native ecosystems with their resident flora and fauna. The urbanized areas continue to grow, but with better planning the negative impacts of urbanization are minimized and compensated for by investments in restoring natural capital.

g) In the third and final stage of the RRR project, the area occupied by reconnected patches of *matorral* continues to increase, even as the urbanized areas increase. The areas of *matorral* are now largely connected by corridors to facilitate movement of wild organisms. Furthermore, the various environmental services increase, especially in relation to water. Both ecological and socioeconomic processes are pursued and monitored holistically and the socioeconomic matrix is now much more robust than in the past. The number and value of environmental services has grown considerably.

an RRR approach is essential in countries like Ecuador, Peru, Colombia, Bolivia, Argentina, Honduras, and others from which the students came. They agreed that nature conservation cannot be attained in isolation from the search for sustainable economic development.

In conclusion, the international master's program "Biodiversity in Tropical Areas and Its Conservation" is well oriented now to offer Latin American and other students the opportunity to receive a European MS degree that could lead to further academic, research, and employment opportunities. In February, the first-year students finalized the independent project reports to fulfill their degree requirements, and the second year of the program is well underway. The restoration module will be presented again, in May 2010, along similar lines to what has been presented here. We continue to think that the choices made in terms of course content were and are especially relevant to the broad educational goals of this program, and also provide a useful template for restoration education that could be applied anywhere.

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