4. Conservation to sustain ecological processes and services in landscapes of the Americas

Edwin Castellanos (rapporteur), Michael McClain (chair), Marikis Alvarez, Michael Brklacich, Julio Calvo, Heitor L. C. Coutinho, Juan Jimenez Osornio, and Michael Schellenberg

Ecosystem services are fundamental to the development of sustainable landscapes but are largely ignored or taken for granted in land management strategies. Ecosystems, and the ecological processes that define them, form the natural infrastructure supporting human activities to enhance the economic and social well-being of communities. This chapter draws upon results from across the IAI research network and associated programs to review our current knowledge of ecosystem processes that should be considered when making decisions on designing areas for protection in cultural or highly-intervened landscapes. Taking ecosystem services into consideration will help decision-makers identify the different components of a landscape that are providing essential services and which should be preserved within a sustainable landscape development plan.

Why should ecosystem services be conserved?

Ecosystem services are the products of natural ecosystem processes that have value to humans. The Millennium Ecosystem Assessment classifies ecosystem services as supporting, provisioning, regulating, and cultural (MEA, 2005). The most fundamental processes supporting life on the planet are classified as *supporting services* and include soil formation, nutrient cycling, and primary production. Ecosystem services that provide the basic goods on which humans and other organisms depend are classified as *provisioning services* and include food, water, fiber, and fuel. *Regulating services* are those that influence the supply of goods by purifying water, controlling disease, regulating climate, and regulating pollination of plants. Finally, *cultural services* reflect the importance of ecosystems in fulfilling the aesthetic, spiritual, educational, and recreational needs of humans.

We start with the hypothesis that undisturbed, functionally diverse ecosystems offer a full spectrum of supporting, regulating, and provisioning services, each operating at its nominal capacity given local controlling factors (climate, geology, successional status, etc.) and each interacting with adjoining ecosystems to support landscape-scale ecological processes. Forest and woodland ecosystems provide goods such as food, fiber, fresh water, and medicines, as well as important regulating services to purify air, conserve soils, control floods, and control disease outbreaks (Nunez et al. 2006). In this age of global climate change, forests and woodlands are also important areas for carbon sequestration. Dry land ecosystems provide many of these same services to lesser magnitudes as a function of local climate and relative abundance of vegetation (Shakleton et al. 2007). River, lake, and wetland ecosystems are a landscape's most valuable sources of water, but they also provide regulating services that control flooding and pollution, retain sediments, and reduce disease. Examples of critical landscape-scale connections include the riverine transport of water derived from headwater forests to support drier downstream ecosystems and the annual migrations of birds, fish, and other organisms between ecosystem types to complete individual biological cycles.

Virtually all landscapes have been subjected to some degree of human intervention, the most widespread of which are agriculture, ranching, and silviculture for food, fiber, and bioenergy production. Intensive development of these activities is usually accompanied by damming and diversion of rivers and draining of wetlands. In the course of these interventions, regulating and supporting services of the converted land are commonly degraded and landscape scale ecological linkages and processes are disrupted. While there are important examples of landscapes that have supported mixed human use for centuries (Grove and Rackman 2001, Plieninger et al. 2006), degradation of supporting ecosystem services more commonly leads to declines in the yields of crops, livestock, and plantations. Such declines are clear indicators of a loss of ecosystem services, although they may not be recognized as such by land managers. When this occurs, land managers and the larger society are forced to invest additional resources to substitute or restore supporting services. Some services, such as water supply and regional biodiversity that depend on landscape-scale ecosystem configuration and connectivity, may be severely degraded and recoverable, if at all, only at enormous social and economic cost (e.g. the $8 billion Everglades Restoration Program in Florida USA).

In order to sustain productive uses of landscapes at minimal costs, strategic action should be taken to conserve ecosystem services. This can be accomplished by conserving the ecosystems that provide the services (e.g. wetlands for flood protection) or by emulating natural ecological processes on managed lands (e.g. maintaining vegetation buffers around orchards to provide habitat for pollinators). In either case, effective maintenance of ecosystem services requires knowledge about the ecological processes providing the services, and of the mechanisms that link these processes across landscapes. The specific type of ecological knowledge useful to decision-makers will vary according to the intensity and configuration of land use in a given landscape. For example, in landscapes in developing regions characterized by low-intensity use, knowledge of ecosystem services linked directly to the provision of food, fiber, and water may be most important. Conversely, in high-intensity use landscapes dominated by agriculture and urban areas, knowledge of ecosystem services linked to pollution reduction may be most important.

Cost-reduction is a powerful motivation for the conservation of ecosystem services, and the valuation of these services is a major area of economic research (Turner et al., 2003). Decision-making processes at all levels would certainly benefit from a science based cost-benefit valuation framework to assess ecosystem services and conservation interventions (Naidoo and Ricketts, 2006). For example, the externalities represented by soil erosion control, hydrological regulation, and sustained nutrient cycling, if incorporated into the cost-benefit analysis of a project that will deforest a spring-rich region, would clearly influence conservation decisions. The same principle could be applied to a managed system, where the costs of conversion to a more sustainable agricultural production system could be compensated by the economic gains represented by the restoration of carbon to the soil, or by the increased infiltration of water to the underground reservoirs.

What ecological knowledge is necessary to advise decision makers on the most important ecosystem services to be conserved or restored when defining conservation areas?

While agreement within the scientific community has converged on the need to sustain ecosystem services such as hydrological regulation and soil erosion control, land use decisions are not generally influenced by existing ecological knowledge. This is true even when land use decisions involve setting aside areas of the landscape for conservation. Commonly this may be done to preserve one defined service of the ecosystem such as water production or the protection of a given species but little or no consideration is given to other services. Aside from the declaration of large, relatively pristine areas for conservation, where most ecosystem services are included in the conservation effort by default, the identification of areas for conservation in a landscape highly modified by humans should include a careful analysis of the services that need to be preserved. There is a wealth of data and information describing and demonstrating the consequences of impairment of vital ecosystem services caused by major land use changes across the globe. These include significant impacts on soil water infiltration rates, affecting flood regulation and soil erosion control; soil organic matter turnover rates, affecting carbon sequestration and nutrient cycling; and vegetation cover, affecting primary productivity, evapo-transpiration, and climate regulation.

Despite this, regions such as the Cerrado in Brazil continue to undergo widespread de-vegetation giving rise to erosion prone cultivated lands. The Pampas natural grasslands in Argentina are giving way to commercial forests that draw down the water table (Coutinho et al., chapter 8, this volume), fragile montane forest of the eastern slope of the Andes is converted to mountain-side cultivation that accelerates landslides and nutrient losses on steep slopes (McClain et al., chapter 11, this volume), and the Yucatan forests in Mexico are being converted to commercial plantations that cause contamination of the local honey production (Jimenez et al., chapter 6, this volume). Will ecological knowledge affect land use decisions so as to conserve or restore ecosystem services? If so, what knowledge is required?

Land managers are most likely to change their decisions when visible and meaningful indicators expressing the status of critical parameters of the populations´ livelihoods point to the need of interventions or adjustments of human conduct. The most important ecosystem services for humanity are the provision of food and of water. Without them sustained development is impossible. Ecological knowledge related to these services, expressed in the form of measurable and meaningful indicators, is therefore valuable for decision makers. We will comment on these two major ecosystem services (water provisioning and food security), and then elaborate a few case studies of environmental and social problems caused by land use change, highlighting possible solutions derived from ecological knowledge.

Water quantity and quality is a sensitive issue for decision makers both at the local scale (farmers, municipal authorities) and the national and global scales (policy makers and multilateral funding agents). Most ecosystem functions have implications for water resources, and their impairment threatens the provision of water of good quality at sufficient quantities to societies. Soil water holding capacity, especially in the tropics, depends on adequate levels of soil organic matter content to maintain soil structure (density, porosity, and aggregation). Reduction of soil holding capacity increases water losses via storm runoff and reduces groundwater recharge and dry season stream flows. Erosion control reduces the transfer of sediments and soil nutrients to the water system, thus conserving soil and water quality. Maintenance of this important ecosystem service can be achieved by conservation of the soil organic matter content and soil vegetation cover. As a last line of defense against sediment and contaminant fluxes to streams and rivers, riparian vegetation buffer strips can be maintained. These are important issues both in areas of rapid land use change, affecting rural populations that depend on the water for agricultural production, as well as in urban centers in need of hydroelectric energy and drinking water. Many cities suffer from high sediment loads and pollutants transported by rivers as a result of being located downstream of land that underwent land use change . The costs of making water from such sources potable are extremely high. This segment of the decision making process will certainly be influenced by ecological knowledge on the potential gains of conservation measures to improve water resources.

Some ecosystem services also affect food security, especially in marginal lands. Soil degradation in the tropics due to erosion and organic matter depletion significantly reduces the productive capacity of the land. The rural population in these critical areas faces serious problems of food security, as shown by Salcedo and Menezes (chapter 10, this volume) in the semi-arid Northeast of Brazil. Those authors demonstrate that restoration of ecosystem services through sustainable landscape management of the land is able to alleviate food security problems resulting from past land use changes. Ecological knowledge should then inform the different levels of the decision making process (farmers, government, etc.) about the risks and opportunities of manipulating and/or conserving ecosystem services of natural and managed environments, considering the resulting status of critical resources for the livelihoods of rural and urban populations.

If there is an urgent need to conserve these vital ecosystem services, how can ecological research influence this process? It requires a process of communication, in transforming ecological information into a format easily accessible and meaningful to decision makers at the different levels. Decisions are often based on immediate threats and risks posed to economic sustainability. Therefore ecological knowledge must relate to such potential threats. This is examined further in a separate chapter in this book (Stewart et al., chapter 2, this volume). The following case studies from the Americas illustrate some of the challenges of communicating the right information to the appropriate stakeholders.

Water availability in dry ecosystems

In tropical dry landscapes there is a highly contentious conflict between increasing human demands on water resources and the varying water needs of the different components of the landscape such as forest, mangroves, wetlands. The biological wealth is currently endangered by growing human water demands. Increasing and uncontrolled use of limited water resources for irrigation, human consumption, and tourism - a phenomenon that translates into new dams, deviation of rivers, and the use of river discharge during low-flow seasons - jeopardizes the future of tropical dry forest ecosystem. In this scenario, decision makers are faced with the imperative need to limit river flows and groundwater withdrawal to save the aquatic and terrestrial ecosystems as well as to cope with society demands. In this scenario scientific information about river, estuarine, wetland and marine ecology is a must. Additionally, information about the hydrological interactions of different types of land covers is required for the development of a sound water management plan. Last and more importantly, climate change, understood as a rise in air temperature and a modification of rainfall regime, modifies the hydrological cycle, altering the ecosystems functions and services which in turn will increase the vulnerably of the society and make sustainability more difficult to achieve. Maintaining and enhancing ecosystem functions will increase the landscape resilience to global change.

Pollination and pesticides

Pollination is one of nature's services often taken for granted. Pollinators are essential for crops, as well as for maintaining plant populations. Native and locally managed European honeybee colonies provide this service. In addition, apiculture can be an important source of income for rural communities. Unfortunately, insecticides used to kill agricultural pests in rural areas can also kill beneficial pollinators.

In the Yucatan Peninsula beekeeping has been an important economic activity as nearly 40% of Mexican honey production comes from this region. At present, this activity has been affected by land use change, as well as pesticide utilization. A consequence of pesticide utilization is the decrease of hives and the quality and marketability of honey, as the honey gets polluted with agrichemicals making it unsuited for organic international markets that require certification of the product. In order to maintain and improve this activity, it is necessary to decrease the use of pesticides through the establishment of other pest control methods. Since pollinators depend on native plants and habitats to live and feed, conservation of native vegetation can contribute to improve apiculture, as well as produce habitat for predators and parasites that control pest populations.

Intensive agricultural cropping practices often rely on mono cultural practices. Monocultures are prone to pathogen and pest damage. Allowing biologically diverse strips (hedge rows, native plant community remnants) to exist adjacent to these fields provides habitat for organisms which prey on the undesired organisms.

Drought resistance

Hamel et al. (chapter 17, this volume) highlight the potential benefits to ecosystem function of increasing the number of plant species. Climate models indicate a climatic change for the Canadian Prairies towards greater aridity. The present agricultural annual crops and monoculture forage could potentially have insufficient capacity to produce economical viable biomass. Stands of multiple drought-adapted species may provide greater biomass than the typical single species pasture. They note a trend towards greater drought resistance with increased diversity, possibly linked to greater exploration of the soil resources and to greater soil microbial diversity, which endow the system with greater water and nutrient use efficiency. Restoration of plant diversity in this instance restores ecological services.

Soil erosion and flooding regimes

The Taquari river watershed belongs to the Paraguay river sub-basin, part of the La Plata river basin. It has an area of 80,000 km^2, 50,000 km^2 of which is in the Pantanal lowlands, and the remaining 30,000 km^2 comprising the headwaters, located in the Brazilian Cerrados. Its sandy soils, irregular topography, and annual precipitation of 1500 to 2000 mm, concentrated in one rainy season from November to March, make it highly susceptible to soil erosion. The last 30 years witnessed the loss of most of the native vegetation of the Upper Taquari river basin, and its substitution by soybean and cultivated pastures, with the predominance of the latter (Silva et al., 2005a). The result was widespread severe soil erosion, with the formation of enormous gullies along the drainage lines of valleys, and the destruction of a significant portion of the riparian vegetation (forests and *veredas*). Apart from the obvious effects of the depreciation of eroded land and loss of agricultural yields resulting from the depletion of organic matter and impairment water regulation, effects in the down-stream Pantanal region are highly significant. The Taquari River suffers severe siltation, and the seasonal flooding regime of the Pantanal lands was seriously affected. Many farmers abandoned their properties and numbers of *colonos* lost their livelihoods, which largely depended on cattle ranching on the previously productive natural pastures (Silva et al., 2005b; Curado, 2005). Currently, decision makers are seeking solutions. Ecological knowledge could provide a better understanding of how carbon allocation and organic matter decomposition is regulated in the Cerrado's natural and managed degraded systems. This knowledge could aid in the development of improved managed systems, with increased carbon inputs and retention in the soils to enhance soil organic matter content and enabling the recovery of the soil water holding capacity. This should regulate the flow of water and reduce soil loss through erosion. Additionally, knowledge on hydrogeology and biodiversity can guide decisions regarding the areas to set aside for preservation.

Multiple Benefits from Riparian Conservation to Preserve Soil Fertility

In inter-montane valleys of the Andean Amazon, fertile soils on level surfaces are largely confined to alluvial deposits in riparian zones bordering streams and rivers (McClain et al. chapter 11, this volume, McClain and Cossio 2003). Indigenous and colonist communities in the region perceive the value of these areas and actively conserve them to protect processes maintaining soil fertility. As a consequence, agricultural activities in riparian zones are largely confined to cultivation of high protein crops that will not grow effectively on upland soils without the application of fertilizers.

Inhabitants of the region do not, by and large, perceive the many ecosystem services of riparian forests in protecting the quality of surface waters from land-based sources of pollution (sediments and solutes) and providing critical habitat and food to aquatic biota. While people do not perceive them, these services are critical to the health and well-being of local people because they take the majority of their drinking water from these surface water sources and obtain a large part of their nutritional requirements from the rivers (McClain et al. 2001).

How do local values, knowledge, and institutions affect decisions about conservation of ecosystem services?

Knowledge about the conservation of ecosystem services does not come exclusively from ecological scientific research; it may be derived from peoples with long traditions of successful use and management of the landscapes in which they live. Sustainable development requires decision-making attitudes towards production, consumption, and lifestyles that are compatible with the needs of environmental protection (Antrop 2006). It has been well documented that local communities generate knowledge about their surrounding environment over time that allows them to address problems of resource optimization.

Some indigenous groups like the Mayans in Mesoamerica have done this for centuries in a mosaic of landscapes and in changing environments, implying knowledge and management of local variables like soil and plant species despite the complexity of the system (Rainey, 2005). More recent colonizers of the American continent like the ranching communities of North America, the Brazilian Pantanal, and the Argentinean Pampas also show a profound understanding of the grassland ecosystem that supports them, they "know the land." This knowledge is mainly derived from long term anecdotal experience, often over generations. In Saskatchewan, Canada, this can be seen in the correlation between the location of extensive cattle production systems and remnant native prairie. Decisions to retain the native prairie landscape are often based on topography, soil textures, local climate, forage potential and lifestyle.

Similar examples could be found in other regions of the Americas, but it is important to keep in mind that traditional knowledge is not complete and not always based in fact. It is therefore important that traditional knowledge is confirmed and complemented by science. In most cases, the most effective way forward will be to hybridize knowledge derived from the ecological sciences and local people, as this may catalyze communities to actively participate in and benefit from sustainable management of the landscape.

The motivation for engaging local peoples stems not only from a desire for knowledge they might provide but also from an obligation to provide support to their efforts. The farmers and communities in the Americas, especially those in fragile and more vulnerable underserved areas, require support to strengthen their capacities to improve the management of their landscapes. In cases where their voices are unheard and politically marginalized, they have little influence on ecosystem management policy formulation and implementation. In many instances they are located in areas where access to agricultural and ecosystem management research support services are inadequate or lacking. Therefore, they do not benefit from scientific and technological advances in a timely manner, particularly under the challenges of climate change. There is, therefore, a need for research institutions to support integrated research and extension on the management of ecosystem services, to assist these under-represented and sometimes under-served communities. The IAI's network of scientists with similar missions, should contribute to the process of informing policy, communities and other stakeholders that have a direct and recognized need for the ecosystem services.

Local knowledge systems can to contribute to sustainability in diverse fields such as biodiversity conservation and maintenance of ecosystems services, soil quality monitoring (Barrios et al., 2006), sustainable water management and management of other natural resources. Conservationists at the national and international level can benefit from working with local communities to identify crucial areas in landscapes that should be managed to preserve important services. The number of pristine ecosystems that can be protected under the traditional concept of a National Park is quickly diminishing, and the new conservation efforts should be focused on managed areas and the ecosystem services they provide.

Considering local knowledge contributes both to the equity, security and empowerment of local communities, which makes them stronger stewards of the sustainability of their natural resources. Local knowledge helps in scenario analysis, data collection, management planning, designing of the adaptive strategies, in learning and feedback and institutional support to implement policies.

Local knowledge and scientific knowledge can be complementary but this requires a dialogue between holders of knowledge and acknowledgement of differences in value systems. A system for managing biodiversity can then be formulated in a way that not only respects these two sets of values, but also builds on their respective strengths. Local perceptions and values can be used and improved to restore and manage natural resources. Therefore, participatory approaches are needed to convey scientific knowledge to reinforce local existing knowledge.

Urban consumers, removed and detached from the land, have a strong influence on production choices of rural producers. There is a trend among wealthier sectors of society towards more environmentally friendly produce. In turn, producers in the field can potentially influence consumer choices by communicating the ecologically sound practices used in the production of their goods. The chapter by Castellanos and co-authors in this volume (chapter 5) examines further this two-way communication between household-level decisions at the farmer level and worldwide commodity chains.

How sustainable landscapes can contribute to solutions to global environmental changes

Many of the global environmental changes we are currently experiencing are the sum of smaller-scale changes that humans have caused in various ecosystems. Such changes have been induced to increase benefits from a particular ecosystem service (food, energy, fiber, etc. production) at the expense of reducing the benefits from other services. We now understand that we cannot modify substantially one particular ecosystem through our technological advancements without modifying other ecosystems that are interconnected, which in turn will impact regional or global conditions. The level of global impact will of course depend on the size and type of local disturbances; but even small disturbances, if repeated in many places, can produce global changes.

The interconnectivity among ecosystems at the regional and global level can be complex, making it difficult for scientists to fully understand processes linkages, and increasing the uncertainty of future scenarios. The effect of global warming on species distributions illustrates this interconnectivity. One can argue that a change in species ranges will leave gaps within communities which permit the invasion of alien species. Within the sagebrush communities of the US Great Plains, the invasion of *Bromus tectorum* has resulted in a change in the local microclimate. Also, *B. tectorum* has a rapid growth cycle with a flush of growth during the cool, moist spring and an early onset of senescence resulting in large amounts of dry litter accumulating during summer months. This dry litter results in increased frequency an intensity of fires. The result is a degraded ecosystem with a severe reduction in productivity, decreased carbon sequestration (loss of the sagebrush component) and an environment that no longer supports the original ecosystem. This particular case illustrates the connectivity between climate change, biodiversity and nutrient and water cycling. To reverse this process would require concerted effort and energy.

Trajectories resulting from global environment change are not necessarily all negative. The very fact that we have been able to impact negatively the way that our world functions by making seemingly local modifications to our ecosystems suggests that we can redesign the modifications of our environment to include basic principles of ecosystem functioning and our managed ecosystems more sustainable. If critical ecological services are identified early enough (potentially through monitoring and identification of trends and indicators), steps can be taken to maintain and reinforce them for a positive outcome.

Sustainability should not only be viewed in a temporal scale (making sure that ecosystem services be available for future generations) but also in a spatial scale which varies in size depending on the particular ecosystem service considered. In the long term, it does not matter if one can keep a particular system producing a particular service for many years if the very existence of that system is threatened by problems of regional or global proportions. For example, one could determine the sustainability of an agricultural field by monitoring its productivity during time. But productivity can be maintained through nutrient cycling, pest control and water availability which a farmer can artificially maintain for his field for some time. Yet he will do so at the expense of high energy and material inputs that will result in a high potential of polluting neighboring ecosystems, which in turn will reduce overall sustainability.

Increasing the resilience of ecosystems, particularly of the services they provide, will lead to less vulnerable landscapes and provide a buffer against global environmental changes. Biodiversity of the appropriate level (still to be determined for many ecosystems) provides redundancies which decrease the risk of complete ecosystem failure. An approach being explored to potentially ensure that the right species and components are present in a system looks at their functionality (Finegan et al., chapter 13, this volume). Other examples of actions that conserve ecosystem services to help us buffer against global changes include: defining the environmental flow regime at which the aquatic, estuarine and marine ecosystems will be less vulnerable to a drought; promoting drought-resistant crops and pastures for farmers to be better prepared to face water scarcity; promoting urban populations, industry, and agro industry to be more water and energy efficient; and promoting the restoration or creation of wetland ecosystems in coastal or low-lying regions prone to flooding.

Concluding remarks

Demands from growing populations and greater needs for basic services of clean water, food, and energy, are placing a stronger pressure on most ecosystems of our planet. The era of protecting pristine ecosystems in reserves with very little human intervention is now giving way to a time when land managers face the more complicated question of optimizing the different components of human-modified landscapes to optimize the production and sustainability of services and goods. In doing this, it is important to consider not only the usual and more obvious services of food and water production, but also other, less evident, but equally important services. Services such as soil nutrient regulation and cycling, surface and ground water flow control, and climate regulation are not always evident to people making decisions on land use changes, in part because they act at longer time scales and on larger geographical areas.

If we want to achieve sustainability in land management practices, we must take into consideration different temporal and spatial scales in our analysis of the various services provided by our surroundings that are fundamental for our subsistence. Such ecological thinking should permeate discussions outside academia to help decision-makers at all levels, from the farmer deciding on a cropping system to the national-level bureaucrat discussingenvironmental protection. Even highly-modified ecosystems are providing different levels of supporting, provisioning and regulating services that are crucial to the sustainability of a given region and eventually of the world. When we visualize individual, local decisions as adding up to larger, global impacts, we will be on the right path to mitigate global environmental changes and to adapt to these changes through the development of more resilient land use systems that include the right combination of production and conservation.

Literature Cited

Antrop, M., 2006. Sustainable landscapes: contradiction, fiction or utopia? *Landscape and Urban Planning* 75: 187-197

Barrios, E., Delve, R. J., Bekunda, M., Mowo, J., Agunda, J., Ramisch, J., Trejo, M. T., Thomas, R. J. 2006. *Indicators of soil quality: A South–South development of a methodological guide for linking local and technical knowledge*. Geoderma 135:248-259.

Curado, F. F. 2005. *As populações tradicionais e os "arrombados" no Baixo Taquari.* In: Impactos Ambientais e Socioeconômicos na Bacia do Rio Taquari – Pantanal (eds.

S. Galdino, L. M. Vieira & L. A. Pellegrin). Corumbá – Embrapa Pantanal. p. 321-331.

Grove, A.T., and Rackham, O. 2001. *The Nature of Mediterranean Europe – An Ecological History,* Yale University Press, London p. 384.

McClain, M. E., Aparicio, L. M., and Llerena., C. A. 2001. *Water use and protection in rural communities of the Peruvian Amazon.* Water International 26: 400-410.

McClain, M. E., and Cossio, R. E. 2003. *The use and conservation of riparian zones in the rural Peruvian Amazon. Environmental Conservation* 30: 242-248.

Millenium Ecosystem Assessment. 2005. Living Beyond our Means: Natural Assets and Human Well-Being. *Statement of the MA Board*. Available at http://www.maweb.org/en/BoardStatement.aspx

Naidoo R, and Ricketts TH. 2006. Mapping the economic costs and benefits of conservation. *PLoS Biol* 4(11): e360. DOI: 10.1371/journal.pbio.0040360

Nunez, D., Nahuelhual, L., Oyarzun, C. 2006. Forests and water: The value of native temperate forests in supplying water for human consumption. *Ecological Economics* 58: 606-616.

Plieninger, T., Hochtl, F., and Spek, T. 2006. Traditional land-use and nature conservation in European rural landscapes. *Environmental Science and Policy* 9: 317-321.

Rainey, S.J. 2005. Folk Classification and Capability Assessment of Soils in two Highland Guatemalan Municipals. *Journal of Latin American Geography* 4(1): 77-106.

Shackleton, C. M., Shackletona, S.E., Buitenb, E., and Bird, N. 2007. The importance of dry woodlands and forests in rural livelihoods and poverty alleviation in South Africa. *Forest Policy and Economics* 9:558-577.

Silva, J. S. V., Santos, R. F., Abdon, M. M. 2005a. *Avaliação do uso da terra na Bacia do Alto Taquari* em 2000. 139-152.

Silva, J. S. V., Abdon, M. M., Souza, M. P., Hanashiro, M. M. 2005b. *Impacto da inundação na sócio-economia da planície do baixo Rio Taquari.* In: *Impactos Ambientais e Socioeconômicos na Bacia do Rio Taquari – Pantanal* (eds. S. Galdino, L. M. Vieira & L. A. Pellegrin). Corumbá – Embrapa Pantanal. p. 303-319.

Turner, R.K, Paavola J., Cooper P., Farber S, Jessamy V, and Georgiou S. 2003. *Valuing nature: Lessons learned and future research directions.* Ecological Economics 46: 493–510..