Ranching for Environmental Services: Public Benefits From Private Lands

Patrick J. Bohlen and Hilary M. Swain[1]

ABSTRACT

Animal grazing systems represent the single largest land use globally and thus provide an equally broad range of opportunities for sustaining multiple ecosystem services in the landscape. High intensity grazing systems provide significant food production but little in the way of other ecosystem services; whereas low intensity grazing systems overlap with natural systems, and provide a heterogeneous landscape with a broader suite of ecosystem services. These services include: provisioning services, such as production of food and raw materials; cultural services, such as preservation of cultural and natural heritage, and opportunities for recreation and education; and regulating services, such as water purification and carbon sequestration; and. The degree to which grazing lands provide these services depends upon the management practices, historical legacies, and surrounding context of these lands.

Faced with the global trajectory toward agricultural intensification, urbanization and land use change, it is imperative to develop sustainable grazing systems, especially in regions where conversion from grazing land to more intensive uses significantly diminishes a region's ability to provide ecosystem services. The grazing lands of south Florida are a prime example of grazing lands that provide critical ecological services in a rapidly developing landscape. Eighty percent of Florida's cattle production occurs in this region, stimulating significant economic activity. These ranchlands are a central part of the region's colorful history and harbor a significant portion of the region's biological diversity, including threatened and endangered species. Ranchlands in this region have a significant impact on water quality and supply, a major environmental concern linked to restoration of the Everglades, a vast wetland system of global importance.

The challenges of maintaining the multiple ecosystem services provided by ranches while remaining economically viable in the face of mounting development, regulatory and market pressures, are enormous. A vast array of programs are available to encourage conservation these programs have insufficient funds to compensate for the services being provided, lack coordination, are not targeted for optimal performance. Better targeting will benefit from better tools to quantify the ecosystems services provided by grazing lands and other land uses. It will be difficult and costly to sustain the ecosystem services provided by this region without sustaining large areas of low to moderate intensity, privately owned grazing lands. This is unlikely to occur unless landowners, state and federal agencies and conservation organizations work together to develop innovative programs that pay ranchers for providing these services.

GRAZING LANDS AND ECOSYSTEM SERVICES

Grazing lands are the most extensive land use in the United States, comprising 27% of the landscape in 2003 (USDA-NRCS 2006). Privately owned grazing lands provide opportunities to generate income for producers, and also provide opportunities to generate environmental services for society (Table 1). These grazing lands include a wide range of land use intensity, ranging from intensively managed pastures to rangelands, forests and other natural lands. Because of this wide range of land use intensities, grazing lands represent an equally wide potential for producing a range of goods and services of value to society. Although grazing lands include among the least intensively managed agro-ecosystems, they have undergone fundamental alterations in biogeochemical cycling, flows of energy and nutrients, biodiversity, land use, and hydrological regimes.

The degree to which grazing lands provide environmental services may be counterbalanced by the extent to which the ecological processes upon which ecosystem services depend have been modified (Table 1). Many practices in grazing land management, such as intensive drainage and non-native forage grasses, have been implemented without anticipating their future environmental costs. Understanding how the broad range of land use intensity affects the potential of grazing lands to provide environmental services as well as economic return, and the degree to which the ecology and economics of grazing lands interact with one another, is central to the sustainability of grazing systems.

Ecosystem services is a unifying concept for evaluating the impact of human activity on the environment. This concept grows out of efforts to quantify the flow of goods and materials from natural systems in terms of human welfare and economic value (Costanza et al., 1997; Daily et al., 1997; Carpenter and Turner, 2000). In its most general sense, the concept of ecosystem services is "the benefits people obtain from ecosystems." It includes *provisioning* services such as food production, fuel, fiber, and water supply; *cultural* services, such as the aesthetic, spiritual, recreational and educational aspects of ecosystems; and *regulating* services, such as climate regulation, flood regulation, water filtering, and maintaining soil fertility. The conservation of biodiversity does not seem to be clearly classified into one of these three ecosystem services. We place biodiversity in all three categories: conserving genetic resources to enhance our ability to continue to produce food, fiber and other goods; as part of the cultural heritage of our landscapes; and as a key component of the ecological processes upon which the maintenance of regulatory services depends.

Humans have altered the environment at an unprecedented rate in recent decades and these alterations threaten the ability of many ecosystems to continue to provide humans with the services they currently provide, or provided in the past (Millennium Ecosystem Assessment, 2005). We will not be able to employ existing knowledge and technology to sustain ecosystem services fully until we stop treating these services as free and limitless goods, but account for their full value. Unfortunately, policy makers tend prioritize the provisioning components of ecosystem services, and undervalue the regulating components (and the associated ecosystem processes they are based upon), thus undermining the long-term viability of the provisioning services (Carpenter et al., 2006). The effort to

[1] MacArthur Agro-ecology Research Center and Archbold Biological Station, Lake Placid, Florida 33852

Table 1. Examples of ecosystem services provided by grazing lands, and counterpart threats to ecological processes that support these ecosystem services (based partially on 17 services categories presented in Costanza et al. (1997)

Ecosystem services	Examples of ecosystem services provided by grazing lands	Examples of counterpart-losses in processes that sustain these services
Provisioning		
Food and feed production	Meat, milk, other animal food products, hay, silage, game hunting	Over-hunting, introduction of invasive non-native animal species, forage grasses, and plant and animal diseases
Raw materials	Minerals, wood products, biofuels and other renewable bioproducts	Unsustainable extraction, biofuel or timber crops replacing native habitats
Genetic resources	Livestock breeds, plant and wildlife genetic resources	Loss of native genetic resources — improved forage grasses etc
Cultural		
Cultural Heritage	Regional history, valued way of life, rural communities	Loss of traditional way of life, decline in rural communities
Conservation values	Natural heritage, species conservation, threatened and endangered species	Loss of habitat, decline in native species distribution and abundance, species loss
Other	Recreational opportunities, aesthetic value, educational opportunities	Loss of recreational and educational opportunities, decline in aesthetic value
Regulatory		
Disturbance regulation	Prescribed fire/fire regimes, flooding, grazing, regional climate (e.g. winter freezes)	Negative effects of altered fire regimes and hydrological cycles on natural systems
Water regulation and supply	Flood abatement , groundwater recharge, regional ecohydrology	Excessive drainage, consumptive water use
Soil formation	Vegetation management, carbon sequestration	Soil erosion, fertilization and soil amendments, loss of fertility
Nutrient cycling	Nutrient storage and nutrient cycling, grazing influences	Excess nutrient losses, fertilization
Biodiversity and ecosystem function	Biotic regulatory functions (nutrient cycling, disturbance, atmospheric), pollination, disease spread	Loss of biodiversity and its regulatory functions, irreversible state changes

address the full suite of ecosystem services will require coordinated effort among policy makers, government institutions at all levels, and private landowners, and must be based on sound scientific principles and information.

The concept of ecosystem services is useful for defining specific provisioning cultural and regulatory services, and the trade-offs among these ecosystem services in explicit terms, such that they can be quantified by the scientific community, and grasped by policy makers, producers and the public. The concept has already worked its way into federal research and conservation policy and had been a central topic at recent conferences on achieving environmental quality in agricultural landscapes. These include a workshop in April 2005 on "Building the Scientific Basis for Green Payments" sponsored by the U.S. Department of Agriculture, CSREES, World Wildlife Fund, and The Elton R. Smith Endowment at Michigan State University (Lynch and Batie 2005); a national conference held in October 2005 on "Valuation of Ecosystem Services in Agriculture" at the Kellogg Biological Station's long-term ecological research site for row-crop agro-ecosystems; and a workshop held in Kansas City, Missouri in October 2006, "Managing Agricultural Landscapes for Environmental Quality: Strengthening the Science Base," organized by the Soil and Water Conservation Society. These recent conferences highlighted many scientific challenges to managing private agricultural lands for environmental goods and services, such as determining the appropriate scale of measurement, what to measure, and how to measure it, as well as some of the policy and institutional challenges to incorporate environmental services into decision-making and policy. These challenges apply equally to grazing lands as to other agricultural production systems.

It is recognized that sustainability of ecosystem services from agricultural lands requires attention to both economic and ecological viability (Robertson and Swinton 2005, Carpenter et al., 2006), but the relationship between economic returns and ecosystem services and how they change over time is not well understood. Models of the relationship between land use intensity and ecological services often emphasize the trade-off between production and environmental quality, in which the diversity of ecological services declines with increasing management intensity (Farley and Daly, 2006). For example, intensive crop production systems excel at producing food, but sometimes provide little in the way of other ecological services, such as biodiversity and water quality. Assessing trade-offs between economic viability and among ecosystem services in grazing systems, which encompass a wide range of intensity, poses extraordinary challenges. Such trade-offs are difficult to compare and evaluate, yet decisions about trade-offs have enormous impacts. Sustaining these multiple functions in grazing systems will depend upon strategic approaches that consider the interaction between economic viability, ecosystem services, and ecological impacts. Understanding these interactions is vital because grazing lands have a critical role globally in sustaining ecological functions within managed lands, due to their wide extent and broad range of services they can provide.

The Threat of Grazing Land Conversion

The potential conversion of grazing lands to other more intensive land uses or urban development threatens the sustainability of grazing lands in the US (and globally), but the pressure for such conversion differs greatly among different regions of the country.

From 1982 to 2003 there was a 5% decline in the area of grazing lands in the coterminous US, from 610.9 million acres (247.4 million ha) in 1982 to 576.4 million acres (233.4 million ha) in 2003 (USDA-NRCS 2006). The loss of grazing land in particularly acute in places such as Florida where burgeoning population growth and accompanying urban and residential development is replacing grazing lands.

South and central Florida stand out nationally as an area with high conversion rates of rangeland from 1992–1997 (USDA-NRCS 2001). Examination of changes in the extent and distribution of grazing land in Florida shows and uneven rate of loss, with counties close to the coast and urban areas showing greater losses that interior counties farther from large urban areas. The overall loss of grazing land in Florida, including south central Florida, from 1982 to 2003 was nearly 14%, and over 50% in some counties. The relationship between grazing lands and environmental services is particularly acute for this region because these grazing lands overlap with some of the most environmentally sensitive land in the US (Swain et al., 2007).

In the following section, we will discuss the ecosystem services provided on ranchlands, citing some of the research from the MacArthur Agro-ecology Research Center (MAERC) at Buck Island Ranch, a Division of Archbold Biological Station, in Highlands County, south central FL (www.maerc.org Swain 1998). The Ranch is operated at full commercial scale (~3,000 cow-calf pairs) to allow research the unique opportunity to examine the ecology of a working ranch under real work economic conditions, and provide information to support sustainable ranching systems in the region.

EVALUATING ECOSYSTEM SERVICES ON GRAZING LANDS: AN ILLUSTRATIVE EXAMPLE FROM FLORIDA

Over 9 million acres (3.6 million ha) of the Florida's 34.5 million acres (14.0 million ha) are used partially or mainly for cattle production (Hogue et al., 1999), although as noted above conversion of grazing land to other land uses is occurring apace. About one million head, dominated by beef cow-calf units, are supported on pasture and rangeland, mostly in south central Florida. This distribution overlaps with some of the most sensitive ecological systems in the country. Understanding the ecosystem services these grazing lands provide is critical to understanding the impact of converting grazing lands to other land uses, or of altering management regimes within grazing lands, in a region that is experiencing explosive population growth and rapid development..

Provisioning ecosystem services of Florida's grazing lands

Florida ranks 12th nationally and 3rd east of the Mississippi River in beef calf production (USDA-NASS 2006). Cattle production contributed $348 million to the state's economy in 2003. In addition to cattle revenue, ranches also produce other agricultural products, such as citrus, sod and forest products, so their economic impact goes beyond revenue from cattle. Cattle ranchers significantly support Florida's interstate economy and a vast network of associated businesses, including feed, heavy machinery and fertilizer. Hunting leases on ranches meet a strong demand for hunting opportunities that is inadequate on public lands, and provides significant revenue for many ranches.

Cultural ecosystem services of Florida's grazing lands

No history of Florida is complete without considering the cultural contributions of the cattle industry (Ackerman, 1976). In 1521 Ponce de Leon brought horses and cattle to Florida, making it the oldest cattle raising state in the country. The Florida landscape includes a vast area dedicated to raising livestock; the industry has remained pivotal to the state, contributing both environmentally and economically. Multi-generational family ranches still own much of the land and their histories are part of Florida's rich heritage and unique environment.

In addition to the human aspects of the cultural services of Florida's ranchlands, we include here the value of Florida's species, habitats and landscapes on cattle ranches as part of the cultural ecosystem services. The distribution of grazing lands in Florida significantly overlaps with the distribution of threatened and endangered species in the state (Fig. 1). Floridians value elements such as threatened and endangered species, forests, and wetlands that occur on grazing lands, not for consumptive or extractive uses, but for their intrinsic value. The public in Florida has been willing to pay for these values through conservation easement and other programs. Polling suggests public support is based largely on knowing the lands are conserved and will be protected for future generations. Maintaining habitats on ranches will meet public interest in the cultural values of these lands, by conserving species and providing the extensive landscapes with low disturbance, and large contiguous tracts that can support critical species such as the Florida Panther and Black Bear.

One species that has been shown to depend upon private ranchlands in south central Florida is the Crested Caracara, *Caracara cheriway,* a threatened bird of prey that occurs only in the central Florida in the United States. Breeding pairs of Caracaras in south central Florida occur mainly on private ranches and more rarely on public lands managed as natural areas for native plants and animals. In a study of the reproductive success of these birds, breeding pairs on ranches exhibited greater reproductive success and breeding area occupancy on ranches than on other land uses, and home ranges occurred more frequently on improved pasture than woodland scrub or marsh habitat (Morrison and Humphrey, 2001). Although not all threatened or other native species are likely to respond favorably to ranching practices, these findings for the Caracara indicate that ranchlands have an important role in conservation of some of the rare species native to the historic rangelands and prairies of this region.

In addition to species of special concern, such as the Caracara, ranches provide habitat for a host of common native species, many of which depend upon the converted grasslands and wetlands on ranches (Main et al., 2004). More than 400 bird species have been documented in Florida and many of these use ranch habitats for foraging or breeding habitat. These birds included year round residents as well as seasonal visitors that include the Sandhill Crane, the American Kestral, Eastern Phoebe and other common species. Despite dependency of conservation on private lands, there is a lack of information on how different land management practices on ranches influence the distribution and abundance of native species, making it difficult to develop strategic approaches for species conservation in this region.

Regulatory ecosystem services of Florida's grazing lands

The conservation and maintenance of soil and water resources is critical to the sustainability of rangelands and grazing lands

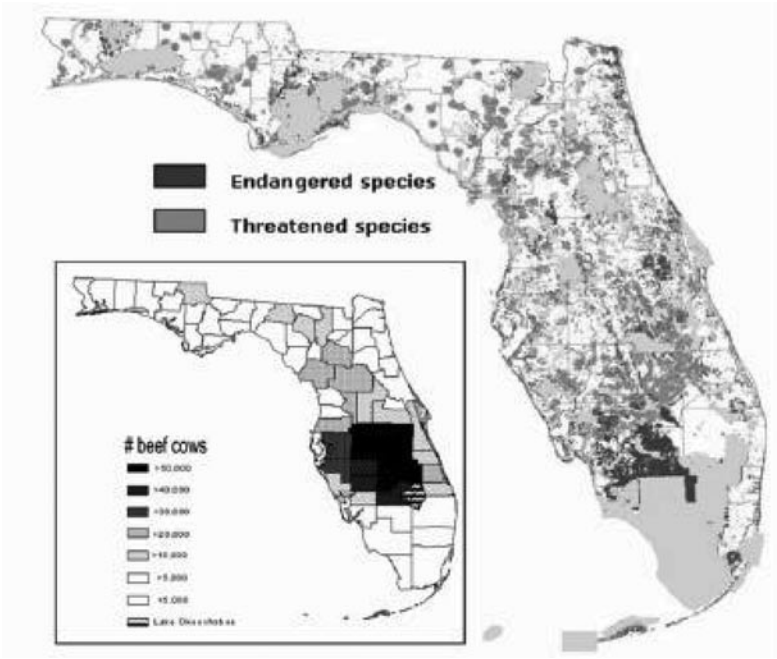

Figure 1. The distribution of endangered and threatened species on private lands in Florida (light gray shading shows federal and state owned lands). Data provided by Florida Natural Areas Inventory. Inset map shows the distribution of beef cows in Florida, indicating distribution of private grazing lands.

(Council for Agricultural Science and Technology, 2002; Maezko et al., 2004), and the regulatory ecosystem services they can provide. Regulatory ecosystem services on Florida grazing lands might include water storage, abatement of flooding, maintenance of fire regimes through prescribed burning, water treatment or cleansing, maintenance of soil fertility, and carbon sequestration in wetland soils. We concentrate here on the regulatory services revolving around water that are a major environmental concern in South Florida. These are the driving force behind major state and federal efforts to improve water quality and restore natural hydrologic function, from the headwater systems in the cattle country north of Lake Okeechobee to the Everglades in extreme south Florida.

South central Florida faces huge challenges in protecting water quality and wetland ecosystems in the face of encroaching development and significant agricultural production (Harwell, 1998; SFWMD, 2004). Historically, wetlands comprised nearly 25% of the land area in the watershed north of Lake Okeechobee, the heart of Florida's grazing lands, but have since been reduced to about 15% of the landscape due to a drainage system that was imposed starting in the 1950's to reduce flooding and increase the suitability of the land for agricultural production (Steinman et al., 2001).

There is now a tremendous emphasis on water supply in this region. The Comprehensive Everglades Restoration Plan, the major state and federal partnership to restore the Everglades and its watershed, requires "getting the water right," includes the quality, quantity, timing, spatial distribution and flow characteristics of water in the region (NAS 2006). The Everglades restoration plan currently focuses on water storage and conservation on publicly acquired lands, but the need for conservation easements and other incentives to help create ecological buffers between natural systems and developed land are also key to the project's success (NAS 2003). Privately owned grazing lands are obvious candidates for inclusion in this effort, especially in the watershed north of Lake Okeechobee where ranches are the dominant land use (Hiscock et al., 2003). Ranchers could benefit economically from managing water or wetland systems in ways that benefit the regional goals for ecosystem restoration.

There may be some economic advantages of complementing these goals on private lands, because the public cannot afford to purchase and manage all the lands necessary for a geographically well-distributed hydrologic restoration, especially with escalating land costs in the rapidly developing region (Fig. 2). Furthermore, private land managers can tackle management issues that plague public land managers, such as invasive species control, and operations and maintenance of restoration infrastructure.

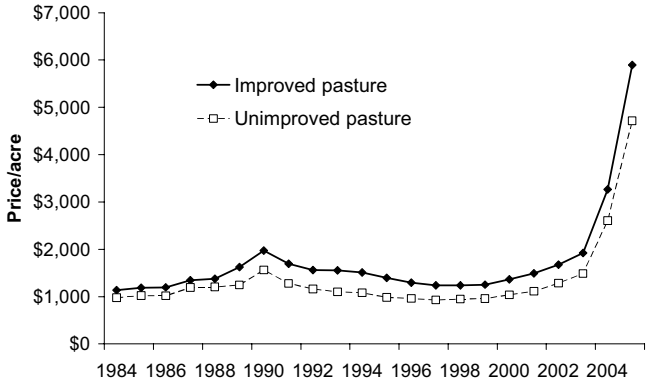

Figure 2. Land values in the south and central Florida region. Data compiled from annual land values surveys conducted by Reynolds (2006).

In addition to meeting water supply needs Florida faces daunting challenges improving water quality. Land use changes and practices within this region dramatically changed the habitat characteristics and ecological functions of uplands, marshes and lakes resulting in increasing nutrient loads into Lake Okeechobee. Since the 1970s phosphorus concentrations in the Lake have more than doubled, causing increased algal blooms and eutrophic conditions (Steinman et al. 1999). Despite considerable efforts on the part of the legislature and state agencies, the P inputs into the lake are well above the targeted level of 140 $Mg \cdot y^{-1}$ based on TMDL limits established by the Florida Department of Environmental Protection.

Regulators have targeted beef cattle ranches in the Lake Okeechobee watershed to achieve a portion of the desired P load reductions, because of the large area of ranches, even though the per area contribution of ranches is low (Hiscock et al. 2003). The cattle ranching community has identified a variety of cattle Best Management Practices (BMPs) for water quality improvements, including, for example, protection of wetlands and reduction of cattle impacts on drainage canals and ditches (Florida Cattlemen's Association FCA, 1999). Implementation of water quality BMPs on ranches is expected to achieve up to 25% of the targeted load reduction, but few data are available to support the effectiveness of these BMPs, and the role of wetland protection in meeting these needs. Several research projects are underway to quantify several water quality BMPs in the region, such as pasture water management and wetland restoration.

An initial study on stocking density, which ran from 1996–2003, showed that cattle stocking density had no effect on nutrient concentrations or loads on in pasture runoff, indicating that grazing animals to not contribute substantially to nutrient loads in the region (Capece et al. 2007). However, the accumulation of phosphorus in the soil of improved pastures, due to past fertilizer use, increased nutrient loads 7-fold over unimproved pastures that had never been fertilized. Thus, management of ranches in the region to protect water quality will have to deal with this legacy of accumulated phosphorus in pasture soils (Swain et al., 2007).

The value and importance of wetlands on Florida's grazing lands for water cleansing and treatment is clearly nuanced. These wetlands, include open lakes, marshes, seasonal wetlands, seepage slopes, streams and rivers, as well as extensive canals and ditches. In general maintaining wetlands in Florida's grazing lands is critical to the provision of regional regulatory ecosystem services. Wetlands are a central feature of the south Florida landscape. Although drainage and habitat modification means that Florida grazing lands no longer support the extensive wetlands that once occupied this region, they do encompass much of the remaining wetland habitat. Further wetland habitat loss or degradation will reduce provision of regional ecosystem services. A recent analysis suggests that conversion from wetlands to agricultural cropland affects regional climate, allowing for colder temperatures and more extended freezes in south Florida (Marshall, et al., 2003).

Maintaining wetlands on ranches means supporting wetland species and the ecological processes that control wetland ecosystem function. We need to understand the drivers in these functions. For example the drainage conditions of wetlands, characteristics of the surrounding landscape, and variation in seasonal and annual rainfall, all influence the distribution, community composition and abundance of amphibian communities in ranch wetlands, an important base for the wetland-based foodwebs in the region (Babbitt and Tanner, 2000; Babbitt et al., 2006). Maintenance and enhancement of wetland functions on grazing lands raises interesting questions as to where the boundary between meeting regulatory requirements imposed by the public (e.g. nutrient abatement) and providing broader ecosystem services in the public interest (maintaining wetlands) might lie.

In addition to water provision and flood control, wetlands and associated uplands in Florida may provide opportunities for carbon sequestration. The potential of U.S. grazing lands to sequester carbon and mitigate the greenhouse effect has been widely discussed in the literature (e.g. Follett et al., 2001). There are only limited data on carbon storage in wetlands and soil in Florida. Whether conversion of rangeland and unimproved pasture to more intensively managed improved pastures with high yield forage grasses, the introduction of invasive plant species and higher stocking rates, is accompanied by changes in carbon sequestration or reduction in other ecosystem services is not known adequately.

One of the most challenging questions when determining trade-offs among ecosystem services is to what degree the goals for these services are aligned both spatially and temporally. For example a practice that enhances food production may be incompatible with maintaining flood protection. Fire regimes that are best for forage productivity may reduce carbon sequestration. Best management practices that favor wetland hydroperiods generating the normal length of flooding and the timing of drawdown events, critical for species such as Wood Storks and other wading birds thatspecialize on feeding in the shallow water and concentrated prey that characterize drawdowns, may or may not be compatible with water storage ecosystem services. Chan et al (2006) discuss the challenges and a methodology for aligning the goals of protecting biodiversity diversity, and enhancing ecosystem services, and discusses how these may be in conflict with the role of provisioning services.

MAKING ECOSYSTEM SERVICES PAY

Grazing lands have a great potential to contribute an array of ecosystem services, but sustaining these services will require economic incentives that make it possible for ranches to remain profitable. The nature of the ecosystem service provided will depend upon the management practices implemented on individual ranches, macro-level changes in land use, and economic and social factors. Economic factors, such as prices received for cattle and alternative products, and economic incentives for implementing conservation or other environmental practices, will continue to be a major driver of management decisions. If market forces necessitate increased intensification of the landscape, then ranches may continue to provide food and other products, but this provision will come at the expense of other supporting and regulating services, such as and biodiversity conservation and water quality and supply. If conservation incentives are not economically attractive to land owners, then participation will be low and the conservation payoff will be sub-optimal.

Ecological-economic models typically show a direct trade off between intensification and ecological services, in which greater intensification erodes the "natural capital" necessary for sustaining ecological services (Aronson et al., 2006; Farley and Daly, 2006). Non-marketed ecosystem services such as water regulation, water quality, or biodiversity support have no current price in the market place and therefore provide no market feedback to signal their scarcity, and no market incentive to produce them. Markets may not be the best way of allocating these scarce resources, but economic incentives, whether through markets or non-market

mechanisms, are essential for sustaining the supporting multiple ecosystem service on private lands.

Managing for multiple ecosystem services can reduce negative environmental impacts of agriculture, but requires production incentives to encourage and reward environmental stewardship Robertson and Swinton (2005). If consumer demand generated a sufficient market to increase financial premiums for livestock produced from certified environmentally sustainable grazing lands, then this would favor retention of other ecosystem services on these lands. A model for this is the sustainable forestry initiative (Sustainable Forestry Initiative, 2006), a 3rd party certification program for wood products that generates increased revenues for certified producers because of consumer demand for wood products from forests managed in a sustainable manner. This type of reward requires that consumers are sufficiently educated about the environmental role of grazing lands to be willing to pay a premium. Another way for the market to trade in ecosystem services is "cap and trade", allocating the waste disposal capacity of nature in a market structure that is used to trade, for example, toxic emissions rights in the United States, such as SO_2. This purchasing is in effect a "negative ecosystem service," purchasing the right to pollute. Another emerging example is the Kyoto Protocol where, by capping emissions of global greenhouse gas, the treaty creates incentives for a global market in carbon trading. One could envisage a market where the regional or national capacity for a certain amount of ecosystem services (say water storage coupled with biodiversity benefits) is assessed, divided into units, and traded amongst various market players including grazing lands. Those who require ecosystem services must pay those who generate them. The research needed determine regional criteria and levels for ecosystem services, and how these could contribute to national scale aggregate indicators of ecosystem services (Meyerson et al. 2005) will be challenging.

There are conservation options for private landowners in Florida, as elsewhere, which provide incentives for maintaining a variety of ecosystem services. Each of these programs has advantages and disadvantages for the land owner and varying level of impact on conservation. These traditional approaches remain essential tools for conserving grazing lands and maintaining less intensive land uses or buffers in the landscape. Non-market incentives for sustaining grazing lands fall into two categories. First, there are easements, land donations, or charitable sales programs that typically involve less than fee sales, usually sale of development rights (Main et al. 2006). In Florida conservation easements are an increasing component of Florida state acquisition programs (FL DEP 2005) and also part of the USDA programs such as the Wetlands Reserve Program, and the Grasslands Reserve Program. The second type of non-market incentive is the Byzantine array of cost share programs available to encourage favorable conservation practices on ranches. Private landowners of grazing lands in Florida are eligible, at present, for 18 federal, 5 state, and additional NGO cost share conservation programs. For example US Fish and Wildlife Service provides funding for endangered and threatened species that targets private landowners, although these programs offer very limited dollars given the need (Swain, 2005). Federal USDA cost share is used extensively to support ecosystem services, although a search of the Farm Bill database suggests that Florida's total conservation payments over the last 10 years — $75,017,857 — is low in comparison with most other states, and overall Florida ranked 34th, only receiving 0.5% of total US government farm subsidies over this period (Environmental Working Group, 2006).

Conservation cost share programs are symbolic, but with limited funds it is not surprising that they hardly begin to meet the need. Government private lands programs are still relatively small, generally reactive, lack focus on lands with the highest overall ecosystem value, and are thus not strategically targeted. Furthermore, they are not particularly financially attractive to landowners since they require landowner financial commitment, and do not improve revenues. In terms of public accountability, the effectiveness of these programs is hard to evaluate, since they are all based on paying for practices, rather than pay for performance.

In contrast to the limited funds available for conservation programs, the financial pressure to get out of grazing land management is extreme. In south central Florida, escalating land values for pastureland (Fig. 1) puts tremendous pressure on ranchers to sell their land, and increases the likelihood that the land will be converted to more intensive use, resulting in a more fragmented landscape. These increasing land values also decrease the attractiveness of available conservation programs that reward conservation based on outdated land values. This introduces a major challenge to traditional conservation programs because the economic incentives they provide have not kept up with escalating land values, making them less attractive to land owners. Some conservation programs, such as the USDA Wetland Reserve Program, have recently increased the value of their easement purchases to try to make up some of the difference, but have not kept up with increased land values. Finding a way out of this dilemma will require coordinated collaborative efforts in which private landowners work with state and federal agencies and conservation organizations to develop long-term strategies for sustaining privately owned grazing lands in the landscape.

Innovative planning programs in Florida, yet unproven, offer the potential to maintain grazing and other conservation lands, and the ecosystems they provide, by linking development in one area to conservation in another. The Florida Rural Land Stewardship Program is an incentive-based approach that "protects vulnerable ecological resources, promotes economic vitality, and affords continued opportunity for agriculture and conservation of the rural lands heritage through the voluntary stewardship of area landowners" (Wilson Miller, 2006). Stewardship conservation programs such as these have great promise for conserving rural lands in perpetuity, but their effectiveness depends on how well they assign and distribute stewardship credits, and how well they target areas that have the greatest potential to provide particular services.

Other programs emerging worldwide signifying that the concept of paying for environmental services is becoming embraced widely (Daily and Ellison, 2002; FAO, 2004). Adequately compensating owners of grazing lands for the multiple ecosystem services their land provides will require better quantification of those services and increased fine-scaled knowledge of their spatial distribution in the landscape. One of the compelling arguments for sustaining grazing ecosystems in a low to moderate intensity of use is because of the escalating cost of maintaining the ecosystem services that grazing lands provide once they become degraded or are lost all together. The cost of restoring natural capital increases as ecosystem goods and services decline (Aronson et al., 2006, Farley and Daly 2006). In Florida a new pilot project called Florida's Ranchland and Environmental Stewardship Program, funded by the USDA, the South Florida Water Management District and FL Department of Agriculture, is being instigated to evaluate a pay for performance program, providing water storage and water treatment on Florida grazing lands (Swain and Bohlen 2005, Lynch this

volume). The goal is that paying ranchers will provide needed ecosystem services, and will sustain ranches economically, increasing the probability of maintaining natural capital at a moderate level of use, and continuing to provide a broad array of ecosystem goods and services at lower cost to society than would be incurred by the alternatives.

The resilience of grazing lands to provide multiple and diverse ecosystem services will depend upon sustaining landscape continuity and a diverse mosaic of natural systems and communities over a wide spatial scale. As more and more grazing lands are lost or intensified in vulnerable regions, it will be more costly and difficult to sustain the diverse ecosystems services these systems provide. Further intensification may lead to irreversible change. Environmental sustainability of ranches in south Florida will hinge largely on their role in regional efforts to manage the supply and quality of water, and their conservation benefits for wildlife habitat and biodiversity. Additional ecosystem services might be more important in other areas of the world where historic rangelands are being converted to more intensive land use. Regardless of which ecosystem services might be most important for grazing lands in a given region, developing tools for analyzing these services at a variety of scales, and incorporating this understanding into innovative policies and programs that compensate landowners for providing these services, are essential ingredients for developing sustainable grazing systems.

REFERENCES

Akerman, J.A. (1976) Florida Cowman, a History of Florida Cattle Raising. Florida Cattlemen's Association, Kissimmee, Florida. pp

Aronson, J., Blignaut, J., Milton, S. and Clewell, A. (2006) "Natural capital: the limiting factor." Ecological Engineering 28:1–5.

Babbitt, K.J. and Tanner, G.W. (2000) "Use of wetland by amphibians in a hydrologically modified landscape." Wetlands 20: 313–322.

Babbitt, K.J., Baber, M.J. Brandt, L.A. (2006) "The effect of woodland proximity and wetland characteristics on larval anuran assemblages in an agricultural landscape." Canadian Journal of Zoology 84:510–519.

Capece, J.C., Campbell, K.L., Bohlen, P.J., Graetz D.A. and Portier, K. (2007) "Water quality impacts of beef cattle ranches in the Lake Okeechobee Basin." Rangeland Ecology and Management (in press).

Carpenter, S.R. and Turner, M. (2000) "Opening the black boxes: Ecosystem services and economic valuation." Ecosystems 3: 1–3.

Carpenter, S.R., Bennett, E.M. and Peterson, G.D. (2006). "Scenarios for ecosystem services: an overview." Ecology and Society 11(1): 29. Available at http://www.ecologyandsociety.org/vol11/iss1/art29/. Accessed October 31, 2006.

Chan, K.M.A., Shaw, M.R., Cameron, D.R., Underwood, E.C. and Daily, G.C. (2006) "Conservation planning for ecosystem services." Public Library of Science (PLoS) Biology 4(e379): 1–15. Available at www.plosbiology.org. Accessed November 1, 2006.

Council for Agricultural Science and Technology. (2002) "Environmental impacts of livestock on U.S. grazing lands. Council for Agricultural Science and Technology, Washington, DC. Issue paper No. 22.

Costanza, R., d'Arge, R., De Groot, R., Farver, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P. and van den Belt, M. (1997) "The values of the world's ecosystem services and natural capital." Nature 387:253–260.

Daily, G.C. and Ellison, K. (2002) The new economy of nature: the quest to make conservation profitable. Island Press, Washington, DC.

Daily, G.C., Alexander, S., Ehrlich, P.R., Goulder, L., Lubchenco, J., Matson, P.A., Mooney, H. A., Postel, S., Schneider, S.H., Tilman, D.G. and Woodwell, G.M. (1997) "Ecosystem services: benefits supplied to human societies by natural ecosystems." Issues in Ecology 2:1–16.

Environmental Working Group (2006). Farm Subsidy Database. http://www.ewg.org:16080/farm/region.php?fips=12000. Accessed November 1, 2006.

Farley, J. and Daly, H. (2006) "Natural capital: the limiting factor, a reply to Aronson, Blignaut, Milton and Clewell." Ecological Engineering 28:6–10.

Florida Cattlemen's Association. (1999) Water quality best management practices for cow/calf operations in Florida. Florida Cattlemen's Association, Kissimmee, FL. 64 pages.

Florida Dept. Environmental Protection. (2005) Florida Forever Status Report — February 2005. Tallahassee, FL, USA.

Follett, R.F., Kimble, J.M. and Lal, R. (2001) The Potential of U.S. Grazing Lands to Sequester Carbon and Mitigate the Greenhouse Effect. CRC Press, Boca Raton, FL. 442 pages.

Food and Agriculture Organization (FAO) (2004) Payment schemes for environmental services in watersheds. Food and Agricultural Organization, Rome. 88 pages.

Harwell, M. A. (1998) "Science and environmental decision making in South Florida." Ecological Applications 8:580–590.

Hiscock, J.G., Thourot, C.S. and Zhang, J. (2003) "Phosphorus budget analysis relating to land use for the northern Lake Okeechobee watershed, Florida." Environmental Engineering 21: 63–74.

Hogue, P., Jennings, E., Kunkle, B., Pate, F., Richey, E., Ward, R., and West, R. (1999) Florida First — Beef Cattle. Florida First Base Papers, University of Florida/IFAS, Gainesville, FL. Pages 181–192.

Lynch, S. and. Batie, S.S. (2005) Building the Scientific Basis for Green Payments. Report on a workshop sponsored by the U.S. Department of Agriculture, CSREES, World Wildlife Fund, and The Elton R. Smith Endowment at Michigan State University. World Wildlife Fund, Washington DC. 41 pages.

Maezko, K.A., Bryant, L.D., Thompson, D.W., Borchard, S.J. (2004) "Putting the pieces together: assessing social, ecological, and economic rangeland sustainability." Rangelands 26:3–14.

Main, M.B., Swisher, M.E., Mullahey, J., DeBusk, W., Avrum J.S., Tanner, G.W., Selph, J., Hogue, P., Bohlen, P. and Allen G.M.

(2004) The ecology and economics of Florida's ranches. Document WEC 187 of the Wildlife Ecology and Conservation Department, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL. 6 pages. Available at http://edis.ifas.ufl.edu/UW202. Accessed October 30, 2006.

Main, M.B., Karim, A. and Hostetler, M.E. (2006) Conservation options for private landowners in Florida. Document CIR1441 of the Department of Wildlife Ecology and Conservation, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL. 37 pages. Available at http://edis.ifas.ufl.edu/UW194. Accessed October 31, 2006.

Marshall, C.H., Pielke, R.A. and Steyaert, L.T. (2003). "Wetlands: Crop freezes and land-use change in Florida." Nature: 426: 29–30.

Meyerson, L.A., Baron,J. Melillo, J.M., Naiman, R.J., O'Malley,R. I., Orians,G., Palmer,M.A., Pfaff, A. SP., Running, S., Sala, O. E. 2005. Aggregate measures of ecosystem services: can we take the pulse of nature? Frontiers in Ecology and the Environment. 3:56–59.

Millennium Ecosystem Assessment. (2005) Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. 137 pages. Available at http://www.maweb.org//en/index.aspx. Accessed October 28, 2006.

Morrison, J.L. and Humphrey, S.R. (2001) "Conservation value of private lands for Crested Caracaras in Florida. Conservation Biology 15: 675–684.

NAS. (2003) Re-Engineering water storage in the Everglades: risks and opportunities (2005). National Academy of Sciences, National Academies Press, Washington, D.C.

NAS. (2006) Progress toward restoring the Everglades: the first biennial review 2006. National Academy of Sciences, National Academies Press, Washington, D.C.

Reynolds, J.E. (2006) Florida land value reports. Available at http://www.agbuscenter.ifas.ufl.edu/landuse/. Accessed Oct. 29, 2006.

Robertson,G.P., Swinton, S.M. 2005. Reconciling agricultural productivity and environmental integrity: a grand challenge for agriculture Frontiers in Ecology and the Environment:.3 (1): 38–46.

SFWMD. (2004) Comprehensive Everglades restoration program annual report. West Palm Beach, FL: South Florida Water Management District and Florida Department of Environmental Protection. 108 pages.

Steinman, A.D., Havens, K.E., Carrick, H.J. and VanZee, R. (2001) The past, present, and future hydrology and ecology of Lake Okeechobee and its watersheds. In Porter, J. and Porter, K., editors. The Everglades, Florida Bay, and Coral Reefs of the Florida Keys. An Ecosystem Handbook. CRC Press, Boca Raton, FL. P. pages 19–37.

Steinman, A.D, Havens, K.E., Aumen, N., James, R.T., Jin, K., Zhang, J. and Rosen, B. (1999) Phosphorus in Lake Okeechobee: sources, sinks and strategies. In Phosphorus biogeochemistry of subtropical ecosystems: Florida as a case example, Reddy, K., O'Connor, G. and Schelske C., editors. CRC Press, Boca Raton, FL. pages 527–544.

Sustainable Forestry Initiative. SFI Labeling Program. Available at http://www.aboutsfi.com/sfilabel_use.asp. Accessed October 31 2006.

Swain, H.M. (1998). "Archbold Biological Station and The MacArthur Agro-Ecology Research Center." Bulletin of the Ecological Society of America 79:114–120.

Swain, H.M. 2005. A Reality Check from Florida. The Endangered Species Act at Thirty, Renewing the Conservation Promise, Volume 1. D.D. Goble, J.M. Scott, and F.W. Davis, editors. Island Press. Pages 137–140

Swain, H.M. and Bohlen, P.J. 2005. Incentives for Encouraging Innovation in Generating Environment Services on Cattle Ranches: The Ecologist's Perspective. In Lynch, S. and Batie, S., editors. Building the Scientific Basis for Green Payments. World Wildlife Fund, Washington, DC. Pages 15–17.

Swain, H.M., Bohlen, P.J., Campbell, K.L., Lollis, L.O. and Steinman, A.D. (2007) "Integrated ecological and economic analysis of ranch management systems." Rangeland Ecology and Management (in press).

USDA-NASS. (2006) Cattle inventory, January 1, 2006: Cows that calved — beef. Washington, D.C.: National Agricultural Statistics Service, Agricultural Statistics Board, United States Department of Agriculture. Available at http://www.nass.usda.gov:8080/QuickStats/PullData_US.jsp. Accessed October 5, 2006.

USDA-NRCS. (2001) Total rangeland in 1997 and percent change in areas, 1992–1997. United States Department of Agriculture, Natural Resources Conservation Service, Resource Assessment Division Washington, DC. Map 4977. http://www.nrcs.usda.gov/technical/land/lgif/m4977l.gif. Accessed October 27, 2006.

USDA-NRCS. (2006) Natural resources inventory: 2003 NRI: Land Use. United States Departement of Agriculture, Natural Resources Conservation Service. Washington, DC. Available at http://www.nrcs.usda.gov/TECHNICAL/land/nri03/Landuse-mrb.pdf. Accessed Oct. 27, 2006.

Wilson Miller. Rural Lands Stewardship overview. http://www.wilsonmiller.com Accessed November 1, 2006.