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Analysis

Institutional solutions to market failure on the landscape scale [1]

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Abstract

This paper offers an ecologically-based view of land and land value, building upon the multiproduct nature of ecosystems and upon landscape ecology. The paper questions the ability of markets to create optimal landscapes, even when traditional methods of internalizing externalities are applied, and concludes that attempting a complete valuation of ecosystems is quixotic. Achieving sustainable landscapes requires both sufficient ecological knowledge and institutions capable of overcoming landscape-scale market failure. Accordingly, the paper examines forms of public and private ownership in the United States to assess how well particular institutional conditions might facilitate ecological adaptation there.

Keywords: Landscape ecology; Land value; Ecosystem management; Externalities

1. Landscape value and the market

Ecosystems resemble natural multiproduct factories.[2] Powered by the sun, they produce a variety of goods and services of use to humans. The goods and services, or 'functions', they provide vary according to the type of management, or lack thereof, they receive. For instance, a forest may produce plant and animal biomass, soil retention, nutrient uptake, groundwater recharge, and many other useful functions. Increasing some functions through management may imply declining or increasing levels of other functions over time. For instance, increased timber harvesting may imply less soil retention and changes in the species mix of animals and their populations.

The mix of goods and services provided by a particular piece of land, and their value, depends upon the scale of analysis one chooses. For example,

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[2] The authors are aware that, to a great extent, it is difficult to delineate the boundaries of an ecosystem because one natural system tends to blend from one to another. However, they use the term here to facilitate the examination of scale effects in valuing natural systems.

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to have a certain value based upon its output of economically significant goods and services. However, when considered within the context of a watershed, the same piece of land may have another value arising from its interrelationships with other components of the watershed. When spatial considerations within a broader landscape are considered, the land may have yet a different value. Ecological processes that operate at the landscape scale raise new questions about the ability of 'markets to allocate land adequately between various uses.

Landscape ecology views large land areas in terms of the distribution of energy, materials, and species as they relate to the sizes, shapes, numbers, kinds and configurations of component ecosystems. Landscapes may be considered any spatially heterogeneous area (Turner, 1989). Landscape ecology and island biogeography tell us that spatial patterns of vegetative cover' greatly affect ecological processes and, therefore, the mix of goods and services, provided by ecosystems (Ewel, 1986; For-man and Godron, 1986; Turner, 1989; Franklin, 1992; Lee et al.,' 1992; Stanford arid Ward, 1992; Naveh and Lieberman, 1993).

Consider, for example, an isolated patch of Douglas-fir forest surrounded by a clearcut. Recent studies show that the microclimate of the clearcut extends into old-growth forest. for 200 m or more in the case of relative humidity and wind, and up to 300 m in extreme cases. This affects biotic processes such as the rate of tree mortality. Attaining a significant amount of unmodified interior habitat requires forest patches of 50 ha or more. However, most forest managers of Douglas-fir use patch sizes of 10 to 15 ha (Franklin, 1992). Therefore, as a large share of a forested area is clearcut, it makes a great difference whether it is cut in one contiguous block or in numerous highly dispersed small compartments. The former leaves a large area of undisturbed interior habitat whereas the latter does not. Of course. large areas of contiguous clearcuts without residual forest offer their own problems.

To follow the above example further. clearcutting also affects other biological processes. Intensive. but highly dispersed, clearcutting in the Lake States has *created* greatly increased deer populations, heavily browsed understories of forest patches. reduced tree plant species of special interest. Concentrated harvest areas could have mitigated some of these negative effects. The impact of such practices on riparian habitats has received less study. Depending'upon the sizes of watersheds and extent of cutover, the cumulative effects of dispersed versus concentrated forest cuttings on hydrologic and geomorphic events can be great (Franklin, 1992).

Connections between patches of cover types also may have an important impact on maintaining species populations over time. Birds and small mammals, for instance, may travel along fencerows between woodlots to avoid crossing open fields. Therefore, gene pools may be more extensive and woody patches where small mammal populations have become extinct may become recolonized more readily when they are connected by fencerows than when they are isolated. Grizzly. bear use habitats within 100 m of roads far less than other similar habitats In a 274-km^2 area of grizzly habitat in the Rocky Mountains road development significantly reduced the area of bear habitat by 'affecting the 'spatial characteristics of the area (Turner, 1989). In similar fashion the shape of patch can affect species distribution, population stability, and dispersal (Forman and Godron, 1986).

Spatial patterns affect many other processes. For instance, the spatial pattern of landscapes affects the flow of. nutrients or sediment in surface waters. Grazing. animals transport nutrients . . . across landscapes and between, patches. Spatial, patterns may influence the flux of gases between the atmosphere and biota as well as the processes redistributing nutrients across the landscape (Turner, 1989).

Thus, in ways we only partly are beginning to understand human management affects ecological processes and the resulting goods and services received from a landscape. To explore the economic significance of spatial relationships, consider the case where a forest is connected by a watercourse to a downstream wetland. Building on Gottfried (1992) we can express the mix of goods and services provided by the forest with the following equation:

$$f = h(w, F, c_f) \quad (1)$$

$$c_f = i(F) \quad (2)$$

where f 'and w represent vectors of functions provided by the forest and the downstream wetland, respectively, and F represents a vector of human activities used to obtain benefits from the forest. As the composition of F varies (e.g.. more or less harvesting of trees, clearing for agriculture, fertilization, etc.), the values of each element of f change. The outputs from the wetland, w, affect those of the forest. Fish, for example, may migrate between the two ecosystems, so that the Production of fish depends on the system as a whole. Human land management decisions, as summarized by F, affect the spatial pattern of vegetative cover on the forested landscape, c_f, defined as a' vector of spatial cover attributes.[3]

Similarly, the following equations show that the mix of goods and services provided by the wetland'.' depends upon inputs from the forest, humans and the,' spatial patterns of the wetland:'

$$w = j(f, W, c_w) \quad (3)$$

$$c_w = k(W) \quad (4)$$

where' W and c_w represent, respectively, vectors of human inputs used' on the wetland and of spatial attributes of the wetland.

By varying the types of management, F and w, used in the ecosystems, the management regime(s) offering the mix of watershed goods and services of greatest value to society can be found. This involves calculating, for each management regime, the sum of the consumer surpluses of the goods and services provided by each ecosystem and by their interaction.[4] Because the forest and downstream wetland relate intimately with one another, the value of the entire watershed cannot be determined by evaluating individual components in isolation. Rather, the sizes and types of impacts of the two systems on one another differ, so that one cannot approach, watershed value merely by incorporating external effects of one component on another. Valuing one component in this manner also fails to consider the possibility that, because of these interrelationships. society 'could-be better off if the individual component were managed for less than its optimum value so that the entire watershed had a greater value. For these reasons it makes sense to value the watershed 'as a whole. This ' requires knowing not only the interrelationships between functions within an ecosystem, but "the 'in&relationships between ecosystems (Gottfried, 1992).

Boundaries also, make a difference when considering the impacts of spatial pattern on ecosystem outputs and value. Whereas the value of any one parcel or ecosystem takes as a given the spatial pattern of the surrounding landscape, all the land use decisions*. of resource managers on the landscape together determine the spatial pattern of all the landscape components. The production of neotropical birds, spotted owls and red-cockaded woodpeckers requires complex habitat conditions across large areas, even continents, so that the spatial cover patterns resulting from the decisions of all the land managers in these areas determine the birds' abundance and distribution. Thus, the product mix of an ecosystem depends greatly on the spatial pattern produced by all the decision-makers on the landscape in much the same way that the price taken by perfectly competitive firms and buyers is determined by their interactions. This effect of spatial pattern on landscape output mix might be termed 'economies of configuration' (Wear, 1992).

The vector of outputs from the landscape comprised of a forest and wetland will depend upon the ecological relationships between the two component ecosystems as well as the spatial pattern emerging from the land use decisions of the resource managers. The vector of landscape outputs, L, therefore, depends upon ecological relationships within and between the component ecosystems, the amounts and types of human inputs, and the spatial configuration of covers that emerge:

$$L = l(F, W, C)$$

$$L = l\left(h(w, F, c_f), j(f, W, c_w), C\right)$$

$$C = m(c_f, c_w)$$

The value of this landscape can be found using the same methodology as that for the component ecosys-

[3] For discussions of measurements of spatial pattern, see Turner (1989).

[4] For more detail on valuing ecosystems and watersheds as multiproduct and systems of linked multiproduct assets, see Gottfried (1992). For a discussion of optimal management of forest stands when interactions with neighboring stands are taken into account, see Swallow and Wear (1993).

tems. In either case, the natural system produces a mix of valued goods and services that depends upon management. By varying management practices on the landscape, the practice(s) offering the greatest value can be found.

In a market economy whose landowners make land-use decisions in a decentralized, unregulated manner, there are four reasons why the market cannot create an optimal landscape where all the societal values stemming from land use are taken into account. First, we know relatively little about the functions *i* through *m*. Even the function relating spatial pattern to ecological processes varies according to the scale of analysis (Turner, 1989; Turner et al.. 1989). Should* landowners attempt to compensate one another for all externalities, they lack sufficient information to do so.

Second, where-many landowners exist in a watershed, it *is* widely acknowledged that the optimal amount of pollution, sedimentation, etc. cannot be achieved, even with the existence of clearly defined property rights without some form of outside intervention.

Third, economies 'of configuration,, whose effects may be felt over large distances and, long periods of time distant from their causes, make intervention difficult. Not only is the information required difficult to attain, but because of the spatial dimensions involved in producing landscape goods and services, each landowner would have to receive individualized attention (different levels of incentives) in order to contribute optimally to the landscape.[5] This micromanagement of landowners via market-type incentives is far too costly to be practical.

Fourth, economies of configuration require working with landscapes as a whole, not with individual owners. The effects of landowners' contributions to landscape level ecological processes are not separable in their spatial dimension. The location of each landowner's parcel of land plays a critical role in determining the landscape's mix of goods and services. Aggregating landowners' contributions to ecological goods or bads, in order to determine some optimal landscape configuration via a damage or benefit function, loses this critical information. Because landowners jointly affect the landscape's ecological processes, scale problems emerge when taxes, subsidies, or other economic policy instruments attempt to internalize individual landowners' externalities. Instead, owners must be dealt with as a group, for it is at this scale that landscape level processes emerge. Because of these scale problems, individual owners acting alone cannot provide the socially optimal mix of ecologically-provided goods and services. Rather, this requires orchestrating human endeavors across a landscape and across landowner boundaries. In short, the presence of economies of configuration implies that the market will fail, even when traditional methods 'of internalizing externalities are applied.

Similarly, at least for the short to medium term, attempting to value ecosystems completely in the' face of substantial economies, of configuration may prove' next to impossible, or at least uneconomical, given the ecological complexities involved and the difficulty of placing values on different mixes of species. Rather, it may be better'to consider management of landscapes for sustainable production of socially valued goods and services., In doing so society must be clear *what* it wishes to sustain and whether the institutional requirements warrant doing so.

2. Institutions for landscape management

If the unaided market cannot provide the socially optimal mix of landscape goods and services, what institutions best might provide for ecological goods and services subject to economies of configuration?

The public land option relies on large blocks of strategically located public lands manipulated to achieve ecological goals. The shift of the US Forest Service's management objectives, for example, to 'ecosystem management' represents one such attempt. In this approach managers would adjust land uses on public lands to complement or compensate for land uses on adjoining parcels of private lands to attain landscape-level management goals. One rather easily can argue that, if plausible, society would rather use public lands to solve ecosystem problems

[5] "Incentives" includes both positive and negative incentives.

than regulate private lands. It is not as easy to argue that public lands have comparative advantage to solve these problems.

Ecosystem goals probably cannot always be achieved solely through ecosystem management on public lands either because (1) the existing condition of the landscape does not allow for the desired level of ecosystem benefits, or (2) the amount and distribution of public lands within the ecosystem is insufficient for achieving objectives. If we can identify where the first case holds, we can identify where ecosystem goals are infeasible, or where some types of restorative programs are required.

If the latter holds, then a different and far more complex situation emerges. One set of approaches to landscape management in this case-the central planner option--relies on central government action. If the government owns too little land to effect ecosystem/landscape scale societal goals, society can expand public ownership. However, land acquisition, particularly in a time of tight budgets, may not be feasible. Moreover, such acquisitions usurp private rights, something that using government land to provide environmental goods and services hoped to avoid.

Politics, of course, plays a significant role in determining the efficacy of public land management. In theory, the government could act as a central planner that dictates the activities of individual landowners within an ecosystem. However, and regardless of whether or not such centralized land planning is technically effective, today's ideological climate which tends to reject all central planning renders such an approach infeasible. Moreover, the very act of federal government managing large blocks of public land affects many groups who perceive that this threatens their rights or interests. While optimizing land use requires that managers fully take into account trade-offs between various user groups, the current highly politicized and emotional process of dealing with conflicting claims to public lands does not lend itself to rational, optimal land management. Public land management's vulnerability to sudden changes originating in the political process threatens the ability of the government to manage ecosystem processes and landscapes effectively. Given the above, centralized approaches to land management carry with them serious difficulties.

On the other hand, in the mixed public/private option various kinds of incentive programs combine with private ownership to provide promising institutional arrangements. Regional governmental or quasi-governmental institutions could be established to use incentives to coordinate landscape management in light of economies of configuration. Such institutions might establish a mechanism for exchanging harvesting rights among private landowners in a planning region. This would assure acceptable returns on investment and avoid taking of private property. However, such institutions, too, could fall prey to some of the difficulties of centralized management. Some people hold, of course, that both central and regional land management imply substantial waste of scarce resources due to their purported inefficiency.

Rather than work through some form of central or regional landscape-scale management, government policy could attempt to target critical areas whose locational attributes singled them out for importance (e.g., corridors connecting habitat patches that otherwise would be too small for certain species). Government could purchase such land (a smaller task than discussed previously), purchase development rights only, or provide tax incentives or subsidies to landowners to maintain the land as a corridor. Tax incentives, such as special capital gains treatment, could encourage landowners to defer harvesting of forests or protect riparian zones. Attempting to manage an entire landscape when only a small portion of the landscape ultimately may provide the necessary economies of configuration may impose unnecessary, and considerable, costs on all landowners. The targeting option may provide a spatial solution to a spatial problem.

An alternative approach—the cooperative option—may lie in encouraging the formation of voluntary coalitions or partnerships of user groups that share an interest in the use of the region's land. Such groups could include farmers, timber companies, government agencies, and environmental and other not-for-profit organizations. For instance, in Oregon a conservation group, 1000 Friends of Oregon, and the Homebuilders Association of Metropolitan Portland (HAMBP) joined forces on the drafting, revision, and adoption of city and county comprehensive plans. 1000 Friends of Oregon realized that preservsity urban development, a goal that they obtained through this process. HAMBP gained increased opportunities for housing construction, a shortened permit process, and less restrictive and exclusionary zoning practices (Long and Arnold, 1995). In the East and Upper Midwest of the US, watershed councils are widely used to bring together ail the stakeholders in a watershed, including government officiais at all levels (as participants or advisors), to develop and implement watershed restoration plans and to coordinate management policies along their rivers (Doppeit et al., 1993). In the Pacific coastal region of Costa Rica landowners are discussing joining their coastal mountain properties into a large private ecotoadsm reserve, while in Ecuador fishermen, shrimp pond operators, and other groups cooperate on improving the water quality of the river upon which they depend for their livelihoods. This involves agreements on refraining from cutting mangroves (personal observation)..

Lee (1992) has suggested several criteria for evaluating institutional arrangements. These criteria can be used to asses; the-ecological efficacy of -private and public land ownership. He suggests that two primary 'requirements for sustainability include the use of ecological, information, in decision-making and, assuming the. former, successful. control over human activities (effective institutions). People can adapt to ecological realities only if they perceive these realities accurately. Four conditions; or factors;. may result in poor perceptions of ecological realities in highly differentiated societies with complex public or private institutional arrangements for managing ecosystems. First, resource managers are socially and spatially removed from those producers who make resource decisions at the lowest level and who observe the environmental feedbacks of those decisions. Second, managers react too little and too late to unfavorable impacts, or take inappropriate actions. Third, resource managers perceive a potential environmental problem but. because they do not feel threatened. themselves;, take no action. Finally, unquestioned moral commitments to ideologies such as capitalism or environmentalism divert managers' attention from problems relating to specific ecological conditions.

Making decision-makers more responsive to local reside for long periods in the area they manage, can mitigate the first three factors. Increasing the authority. responsibility, and accountability of localized decision-makers, and improving integration of scientific learning with decision-making, can decrease the impact of the fourth factor. Small private ownership managed under a. system of incentives may ultimately do a better job of meeting all these criteria than large public, or other large-scale, ownerships.

Voluntary conformity with these ecological goals likely would work better if landowners see that it is in their. interest to adopt new land use practices. Firey (1960, 1963) concluded that individuals only are willing 'to sacrifice now in order to conserve resources for future generations if at least two conditions are met: (1) that individuals internalize values that stress future generations, and (2) that these values prove beneficial to the individual or group and maintain' self-esteem and group identification. Otherwise, farmers, for instance, will express an idealistic commitment to conservation, but fail to practice it, as Firey observed. When people habitually, or voluntarily; adhere to certain routines they believe are morally right, there is little need for coercion and formal social control;

Firey (1963) stated that ensuring stable institutions, such as private property, rights to protection, and basic human rights, is the most reliable way of eliciting commitments to future generations from those now living. Among various institutions, relatively small social organizations seem to be most adept at institutionalizing behaviors that affect ecological processes, whether positively or negatively. Getting private owners to cooperate in providing public goods such as environmental[6] benefits becomes increasingly difficult as the scale of ecological processes and the number of owners increases. Small-scale collective regulation can limit effectively most of the information pathologies described above, increase the likelihood that ecologically-informed behaviors will be institutionalized, and increase the probability that people will internalize future-oriented values. Therefore, small-scale organizations

[6] Putnam (1993) points out that voluntary associations build the trust necessary to overcome free rider behavior.

may limit information pathologies, and offer the most hope of incorporating ecologically-informed resource management into habitual, or voluntary, behavior. Lee (1992) cbhcludes that small-scale organizations may prove more effective than large-scale organizations in'overcoming information pathologies and that:

"a hierarchical system of regulation involving local communities -as the. primary collective governance units may be the most efficient and effective means for institutionalizing sustainable ecological processes, because an ecological identity and conscience are more likely to be products of community life than of regional or national collectivities." (p. 87)

However, small-scale organizations. may not always offer the'best solution. Given that long tenancy of small private owners may provide opportunities to gain knowledge that can be used to manage landscapes effectively, one still must ask how effectively older generations transmit this information to their youth. In many areas cultures are changing rapidly and old ways are being lost. In areas of high owner turnover, such as areas subject to second-home conversion or influxes of new residents from outside of the area, local ownership need not. carry with it substantial ecological knowledge. Achieving optimal land use via community organizations assumes that organizations 'and individuals will be able to work together. Where 'issues have become highly emotional, cooperation may prove difficult to obtain. In these cases society once again must assess which *types* of organizations offer the *best* hope of gaining and using ecological knowledge effectively.

Because economies of configuration give rise to externalities that cannot be addressed through the unaided market, the costs of achieving landscape goals are likely to be high. When information pathologies and interagency coordination difficulties can be overcome. using public hinds to provide ecosystem services. when ecologically feasible, may prove most cost-effective. This may require creative new ways of structuring public institutions. The avoided costs of regulating private lands may easily offset the foregone revenue flows from public lands. When public lands are. too small to provide the needed economics of configuration, either targeted policies and/or promotion of community-based groups as primary resource regulators may prove most effective.

In any case, society must ask whether the added costs of regulation or institution-building warrant the benefits obtained from more optimal land use patterns. In the Case of Community groups or partnerships, theory would suggest that they do so out of perceived self-interest—that the perceived benefits they receive exceed their costs. In the case of centralized decision-making,. it is difficult to gauge the benefits derived from ecosystems. Herein lies a substantial challenge for nonmarket valuation: defining values for alternative states that are complex and highly uncertain. However, while it may be difficult to place values on ecosystem conditions, ocher evidence may 'imply that benefits clearly outweigh the potential costs of regulation. The perceived value of ecosystem services reflected in the Endangered Species Act is very high. Some would argue that it places a practically infinite value on individual endangered species. As a result, the Act has justified very *costly* interventions. If improved ecosystem health prevents endangering species, this suggests substantial returns to ecosystem management, given the very real and substantial costs that could be avoided.

In assessing which institutional arrangements dest bring about maximum benefits at least cost, no one approach may prove suitable in. all cases. Optimal land use requires understanding the social dynamics that make possible, or obstruct, certain institutional solutions. One point is clear: dealing with economies of configuration will *require* flexibility and creativity on all levels of society.

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