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The Role and Value of Natural Capital in Regional Landscapes

John C. Bergstrom

Several developments in recent years related to the use, valuation, and management of natural resources provide the motivation for this paper. First, increased urbanization during the economic boom times of the 1990s has led to acceleration of the conversion of natural and undeveloped areas to unnatural and built-up areas in many regions of the nation. As a result people concerned about the loss of nature and various associated benefits in their communities are pushing for public action to protect remaining natural and undeveloped areas. The push for these protective actions sets the stage for conflicts with other people who support continued allocation of natural and undeveloped areas to various types of urban-related development. Insight into the resolution of such conflicts can be gained through a better understanding of how natural capital contributes to quality of life in different regions.

The second development motivating this paper is the identification and definition of different regions for the purpose of natural resource management assessment and decision-making. Within the various disciplines involved in natural resource management, including economics, ecology, environmental ethics, geography, and sociology, the importance of conducting resource assessment and decision-making at appropriate spatial and temporal scales is receiving increased attention. Within academia and public resource management agencies regional *landscapes*

such as urban or rural landscapes appear to be gaining some favor as an appropriate temporal and spatial scale of analysis for resource management and policy.

A third development motivating this paper is the reexamination of aggregate growth models to better account for the contribution and value of different forms of capital including natural capital and the recognition that improving individual and social welfare is more than a matter of only increasing GDP-type measures of growth. The focus of the paper is on the contribution of natural capital to quality of life growth in regional landscapes. This focus includes a discussion of the value and valuation of services provided by natural capital.

Quality of Life Growth and Natural Capital

England (2000) and Whitely (2000) provide very informative reviews of changes in economic growth models since J.M. Keynes pioneering work in the 1930s. Traditional neoclassical economic growth models, these authors point out, are based on later work by Solow (1956) and Swan (1956). The general stylized form of these models is as follows:

$$(1) \quad Y_t = f(K_t, L_t | A_t),$$

where Y_t represents aggregate output of commodities in year t , K_t represents physical capital in year t , L_t represents labor in year t , and A_t represents the state of technology in year t .

A limitation of the traditional neoclassical economic growth model illustrated in (1) is

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that it does not explicitly account for the role of different forms of capital. For example, since it only measures physical capital, K_t does not include human capital. Components of human capital include technical skills and training, managerial skills and training, unique individual gifts and talents, personal education level, personal health, personal values, and leadership abilities. With respect to (1), investment in human capital may increase the productivity of L_t resulting in an increase in Y_t (Manikiw, Romer and Weil, 1992; Castle, 1998; Whitely, 2000). K_t in (1) also does not include social capital. Social capital is the unique ability of different types of communities to provide the social interaction and mutual support and trust needed to mobilize individuals and groups to work together towards particular outcomes (Coleman, 1990; Castle, 1998; Flora and Flora, 1993; Woolcock, 1998; Wilson, 2000). One particular outcome that individuals and groups may work towards in a community or region is economic growth. In the context of (1), investment in social capital may also increase the productivity of L_t , leading to an increase in Y_t .

The growth model shown in (1) is also limited in that the K_t term does not generally include financial capital. Financial capital is the unique amount, type and availability of savings and credit that individuals in a community or the community as a whole can access to purchase or finance goods and services. Access to financial capital is an important component of regional economic growth development, often representing a major constraint to economic development in rural areas (RUPRI, 1997). In the context of (1), ready access to financial capital may increase an individual's or community's ability to invest in other forms of capital including physical, human, and social capital ultimately leading to an increase in Y_t .

Another limitation of (1), which brings us more to the central topic of this paper, is that the K_t term does not make a clear distinction between constructed capital and natural capital. *Constructed capital* is the unique combination of and connections between constructed elements that constitute the "built environ-

ment" found in a community or region. This built environment includes buildings, roads and bridges, power plants, water treatment plants, and various other components of the infrastructure and structure of a community or region that contribute to economic growth and development (Castle, 1998).

Natural capital is the unique combination of and interactions between biotic and abiotic elements of nature that constitute ecosystems and natural resources found in a community or region. Components of natural capital or capacity include ambient air, surface water, ground water, minerals, soil, rainfall, temperature, humidity, wind, vegetation, fish and wildlife, insects and microorganisms, and various types of natural ecosystems. Natural capital is a major but often overlooked contributor to economic growth and development in a community or region (Castle, 1998; England, 1998; England, 2000; Katz, 2000).

Recent authors have emphasized the contributions of the various types of capital mentioned above in the process of economic growth and development from temporal and spatial perspectives (Castle, 1998; Hite, 1991). Building from these conceptual frameworks, the growth model in (1) is modified in a landscape context as follows:

$$(2) \quad Y_{ij} = Y(C_{ij}, F_{ij}, H_{ij}, S_{ij}, N_{ij} | A_{ij}),$$

where Y_{ij} represents aggregate output of commodities in year t in landscape j , C_{ij} represent the aggregate level of constructed capital in year t in landscape j , F_{ij} represents the aggregate level of financial capital in year t in landscape j , H_{ij} represents the aggregate level of human capital in year t in landscape j (total labor pool plus job skills, training, etc.), S_{ij} represents the level of social capital in year t in landscape j , N_{ij} represents the level of natural capital in year t in landscape j , and A_{ij} represents the state of technology in year t in landscape j .

The traditional goal of economic growth and development has been to increase the aggregate output of marketed commodities such as manufactured goods. Thus traditional economic development measures of Y_{ij} in (2) in-

clude total gross output for a region or gross domestic product (GDP) for the nation as whole that reflect the market value of goods and services resulting from economic production. The implicit social welfare assumption behind the economic development goal of increasing gross output of marketed commodities is that as Y_{tj} increases in a region the aggregate well-being of people in the region increases as well.

Philosophers throughout recorded human history have debated what factors are most important in the determination of human well-being. The phrase from Judeo-Christian scriptures claiming that "man does not live by bread alone" summarizes the pluralistic sentiment shared by people from a broad array of cultural, philosophical, and religious backgrounds that individual and social well-being is not just a function of the material commodities we consume. Over the past three decades a small number of "out-of-the-mainstream" economists have gone on record challenging the assumption that increasing the level of gross output of marketed commodities in region always leads to social well-being improvements in the region (Easterlin, 1974; Huetting, 1980; Daly and Cobb, 1989; Daly, 1987; Ayres, 1996).

Even "mainstream" neoclassical economic theory recognizes that production and consumption of material goods is a means to an end and not the end itself. Neoclassical economic theory teaches us that material goods and services are produced to meet individual needs and wants generating individual utility or satisfaction. We then learn from standard welfare economics theory that community or social well-being is some function of the utility of individuals in the community. However, specification of a theoretically-sound social welfare function that is widely acceptable to people on ethical grounds has remained elusive.

An overarching problem of concern to individuals across all walks of life is how to enhance one's own *quality of life*. Various private and public agencies and organizations also express the desire to improve the quality of life of people in a particular community or

region as their major motivation for being interested and involved in community or regional development.

Because of the shared concern across diverse individuals and groups over one's own quality of life and the quality of life of others, a potential pluralistic end goal of individual and group action is to enhance the quality of life at individual and aggregate scales. There is no doubt that individual and aggregate quality of life is function of production and consumption of marketed goods and services. It is also a function, however, of many types of nonmarket goods and services that are not produced and sold in regular economic markets.

At the aggregate level let the overall quality of life in a regional landscape be specified as follows:

$$(3) \quad QOL_{tj} = f(Y_{tj}, Z_{tj}),$$

where QOL_{tj} represents the overall quality of life in year t in landscape j , Y_{tj} represents the aggregate level of marketed goods and services in year t in landscape j , and Z_{tj} represents the aggregate level of nonmarket goods and services in year t in landscape j . Y_{tj} in (3) includes all of the familiar goods and services that are bought and sold in the marketplace including food, houses, clothes, cars, books, movies, etc. Z_{tj} in (3) includes goods and services that are important determinants of quality of life, but that are not commonly bought and sold in the marketplace including environmental quality and amenities, noncommercial recreation and leisure activities, and personal health and safety.

As is the case with Y_{tj} , the various types of capital mentioned above influence the quantity and quality of nonmarket commodities that can be "produced" or generated in a region, or in equation form:

$$(4) \quad Z_{tj} = Z(C_{tj}, F_{tj}, H_{tj}, S_{tj}, N_{tj} | A_{tj}).$$

Substituting (2) and (4) into (3) results in the relationship:

$$(5) \quad QOL_{ij} = f(Y(C_{ij}, F_{ij}, H_{ij}, S_{ij}, N_{ij} | A_{ij}), \\ Z(C_{ij}, F_{ij}, H_{ij}, S_{ij}, N_{ij} | A_{ij})).$$

Equation (5) shows that quality of life in a regional landscape in a given year is a function of the levels of constructed capital, financial capital, human capital, social capital, natural capital, and state of technology in year t in the landscape. The different types of capital and state of technology influence quality of life through their interrelated effects on the levels of marketed and nonmarket commodities utilized by people in the regional landscape in a given period.

Functions and Values Supported by Natural Capital

Natural capital is conceptualized as an asset within a particular regional landscape during a given period. A regional landscape includes given levels of all of the different types of capital discussed in the previous section. Thus functions and values of natural capital within a particular regional landscape are subject to *ceteris paribus* conditions with respect to the quantity and quality of other types of capital.

Natural Capital Functions

As an asset, natural capital within a particular landscape has various *functions* that support goods and services of value to people. For example, functions of natural capital include soil development through the interaction of various chemical cycles that operate within ecosystems. In a regional landscape that includes agriculture, soils are used as commercial inputs in agricultural production processes. Natural capital provides commercial inputs into many other types of economic production found in regional landscapes. For instance, any commercial production processes requiring a water input are dependent on natural capital functions that support the availability of water quantity and quality in a regional landscape. For the most part regional development policy in the United States has histor-

ically emphasized the goal of maximizing the use of natural capital, especially in rural areas, as commercial inputs (Bromley and Hodge, 1990; Bergstrom, 1998).

Natural capital also functions to provide “places” within a regional landscape which support what philosophers and sociologists refer to as “values of place” (Norton, 1994). For residents of a particular region, natural capital supports places to live and work. In a rural landscape these residents include “long-time” residents who work locally in traditional jobs in the agricultural, natural resource extraction, and manufacturing sectors. In many rural areas of the U.S. there has also been an influx of “new” residents who work in local or non-local nontraditional jobs in the recreation and tourism, high technology, business service sectors, or are retired and living off of transfer payments from pension funds, retirement accounts, and other nonlocal sources of income (McGranahan, 1999).

Natural capital also supports places to visit. In many rural areas of the country where the natural capital within the landscape has high amenity value, recreation and tourism catering to nonresident visitors is a booming business. Most of this recreation and tourism is nature-based—e.g., hunting and fishing, camping, hiking, boating, lake and river swimming, water skiing, off-road touring, snow skiing, and snowmobiling. Another type of tourism supported by natural capital in rural areas is agricultural tourism, or agtourism. Agtourism including such activities as visiting dude ranches has been an established business activity in many parts of the country and is taking hold in other areas of the country (Bergstrom *et al.*, 1990; Duffy-Deno, 1997).

Another broad function of natural capital in a region is the provision of “space” within a particular regional landscape. Space here is defined from a human interaction perspective, as in the phrase “you’re in my space.” Specifically, space refers here to the physical distance between people as they engage in various life activities (e.g., work, play) and the interrelated frequency of interaction between people as they engage in these activities. The availability of more space between people

within rural landscapes characterized by abundant natural capital is one of the draws for people living in more crowded regions to visit and move to these rural areas.

The provision of flora and fauna habitat is often identified as an important function of natural capital by philosophers, ethicists, economists, ecologists, biologists, and other social and physical scientists. In recent years the preservation of natural capital within landscapes as habitat for endangered plant and animal species has been a contentious natural resource policy issue. Heated debate between and among residents and nonresidents of the Pacific Northwest over the preservation of "old growth" forest landscapes to provide habitat for the endangered spotted owl is a familiar and obvious example.

Another function of natural capital is provision of unique physical terrain within a landscape. Physical terrain includes mountains, rolling hills, gorges, valleys, plains, marshes, and beaches. Use and management of physical terrain features may also be a controversial area of natural resource policy at certain times and regions in the United States. Clashes may arise, for instance, between and among residents and nonresidents of rural areas over the preservation and management of unique physical terrain features of rural landscapes. Debates in both the eastern and western United States over mining practices (e.g., strip mining) that temporarily or permanently alter the appearance of physical terrain and the entire landscape are cases in point.

A major function of natural capital is provision of a natural water supply system. With respect to water quantity, natural capital supports surface and subsurface water supplies through watershed run-off into rivers and lakes, and the seepage of surface water into subsurface aquifers. With respect to water quality, natural capital elements (e.g., plants, soil) help to filter out chemicals in surface and subsurface water supplies which are potentially harmful to human, plant, and animal health. The function of natural capital as a natural water supply system within particular landscapes is an especially important issue from a regional economic development perspective.

Natural Capital Values

The conceptualization of elements of nature within a regional landscape as a type of *capital* focuses attention on the anthropocentric, instrumental value of the goods and services supported by natural capital. It is acknowledged here that elements of nature have value beyond their instrumental value to humans (Bergstrom, 1998). However, a discussion of these values is beyond the scope of the present paper. Thus the discussion of values in this section will be limited to values supported by natural capital in a regional landscape that directly or indirectly benefit people.

The commercial input function of natural capital, for example provision of water as a commercial input, primarily supports the value people derive from consuming commercial goods, or *material consumption value*. The "place to work" function also supports material consumption value as well as job satisfaction value and security and stability values derived from access to steady employment. The "place to live" function supports job satisfaction value, security and stability values, cultural values, historical values, recreation and leisure use values, aesthetic appreciation values, and mental, physical and spiritual health values. The "place to visit" function supports cultural values, historical values, recreation and leisure use values, aesthetic appreciation values, and mental, physical and spiritual health values. In addition to material consumption values the natural water supply function also supports recreation and leisure use values, aesthetic appreciation values, and mental, physical and spiritual health values.

The functions of natural capital to provide "space", flora and fauna habitat, and unique physical terrain support recreation and leisure use values, aesthetic appreciation values, mental, physical and spiritual health values, and existence values. *Existence value* is defined as the value people place on the mere existence of something regardless of current or future use. Existence value may be a large portion of the value placed on certain elements of natural capital within a particular regional landscape such as endangered animal and plant species.

Commodity and Amenity Values

For analysis and discussion purposes it is useful to categorize the various values of the goods and services provided by natural capital into two broad categories: commodity values and amenity values. In the arena of natural capital use and management, *commodities*, *commodity interests*, and *commodity values* are frequently used terms. In these cases *commodity* takes on a more specific meaning than the use of the term in economic theory to refer to goods and services in general. When government agencies such as the U.S.D.A. and land-grant university administrators talk about commodity values they are referring primarily to values associated with the production and consumption of "private good" commercial products using land as a commercial input including food and fiber products, timber products, and mineral products. Commodity values would include material consumption value and some portions of job satisfaction value and security and stability value.

Natural capital amenity values are defined here to be the direct benefits people receive from the sights, sounds, smells, and presence of functions and services around them which are supported by natural capital. A key part of this definition is that amenity benefits are derived directly from natural capital and not from consumption of commercial products produced using natural capital inputs. Through commercial inputs, natural capital provides indirect benefits to people through the consumption of final commercial products such as food, fiber, and timber products. Thus material consumption value would not generally fit the definition of natural capital amenity value. Cultural values, historical values, recreation use values, aesthetic appreciation values, existence values, job satisfaction values, security and stability values, mental health values, physical health values, and spiritual health values would all have significant amenity value components. Previous studies have been conducted to measure amenity values of natural capital in the form of agricultural and forest land (Beasley et al., 1986; Bergstrom et al., 1985; Bowker and Didychuk, 1994; Crosson,

1985; Halstead et al., 1984; Hite and Dillman, 1981; Kline and Wichelns, 1996; Rolston, 1985; Rosenberger and Walsh, 1997).

Market and Nonmarket Values and Valuation

Some natural capital amenity value components are captured in market prices and transactions while other components are not. For example, amenity values associated with recreation use may be captured at least partially in prices landowners charge people to lease natural capital in the form of rural land for consumptive and(or) nonconsumptive recreational activities. Also, amenity values associated with aesthetic appreciation may be captured at least partially in the price of rural land sold for residential purposes.

Many natural capital amenity values, however, are in the nature of nonmarket values, meaning that they are not reflected in market transactions and prices. The nonmarket nature of certain natural capital values results from characteristics of nonrivalry and(or) nonexclusiveness (Randall, 1983). The extent of nonrivalness in the consumption of natural capital values is dependent on congestion levels. Figure 1 classifies the natural capital values in a particular regional landscape according to the degree of rivalness and exclusiveness assuming relatively low human congestion. In this case the bulk of amenity values fall into the nonrival, nonexclusive cell and the nonrival, exclusive cell. Primarily because of the nonexclusive characteristic, values in the nonrival, nonexclusive cell are in the nature of nonmarket values. An example is the value people derive from viewing natural "open space" or "green space" from public, uncongested highways. Values or goods in the nonrival, nonexclusive cell are known commonly as *pure public values* or *goods*.

Because they can be made exclusive, the values in the nonrival, exclusive cell can potentially be privatized and captured in market trade and prices. For example, at least sections of a large farm, ranch, or natural area can be closed-off from public access or view. The aesthetic appreciation values derived from

	Rival	Nonrival
Exclusive	Material Consumption	Private Nonconsumptive Recreation Use
	Private Consumptive Recreation Use	Private Scenic Appreciation
	Individual Job Satisfaction	Private Cultural Value
		Private Historical Value
		Private Security and Stability
		Private Physical Health
		Private Mental Health
		Private Spiritual Health
Nonexclusive	Public Consumptive Recreation Use	Public Nonconsumptive Recreation Use
		Public Scenic Appreciation
		Public Cultural Value
		Public Historical Value
		Public Security and Stability
		Public Physical Health
		Public Mental Health
		Public Spiritual Health
		Existence Value

Figure 1. Natural capital value classifications

viewing these private areas becomes a type of private good or value. Specifically, as long as human congestion is low, values in the non-rival, exclusive cell may be classified as uncongested private goods. The benefits provided by uncongested private goods may be capitalized into the market value of the land sold for residential and(or) recreation and tourism purposes.

As more and more people access or use a good or value, congestion eventually sets in causing values in the nonrival, nonexclusive cell to move into the rival, nonexclusive or the rival, exclusive cell. For example, as greater numbers of people travel public highways or move into the countryside to enjoy open-access natural capital amenities such as aesthetic appreciation values, these values may move from being nonrival to rival in use and enjoyment. In the rival, nonexclusive cell, values are still available on a nonexclusive basis, but because of congestion people can no longer enjoy amenity values on a nonrival basis. In the same way, at a certain congestion level the values in the nonrival, exclusive cell that were formally available on a nonrival basis will become rival, shifting these values into the rival, exclusive cell. The rival, exclusive cell contains pure private goods or values. Examples include private, exclusive quail or pheasant

hunting preserves in the Southeastern U.S. The quantity and quality of quail or pheasant on these preserves available for hunting are carefully regulated. Access by a limited number of hunters is strictly enforced and is very expensive.

Figure 2 lists potential techniques for valuing different types of public and private goods. These techniques can be applied to measure natural capital amenity values categorized by degree of rivalness and exclusiveness. Natural capital values in the nature of pure private goods can be valued using traditional market price valuation techniques. The economic impacts of expenditures associated with these values can be measured using economic impact analysis techniques such as input-output analysis. The noneconomic social effects of these values can be assessed using various types of social effects or impact assessment. Natural capital values in the nature of uncongested private goods also can potentially be valued using market price valuation techniques. Economic impact analysis and social effects assessment can be used to assess economic and social impacts associated with uncongested private goods and values.

Because of the lack of market prices, non-market valuation techniques must be employed to measure the economic value of nat-

	Rival	Nonrival
	Pure Private Goods	Uncongested Private Goods
Exclusive	Market Price Valuation Techniques	Market Price Valuation Techniques
	Economic Impact Analysis (e.g., CGE, Input-Output)	Economic Impact Analysis (e.g., CGE, Input-Output)
	Social Effects Assessment	Social Effects Assessment
	Congested Public Goods	Pure Public Goods
Nonexclusive	Revealed-Preference Extramarket Valuation Techniques (e.g., travel cost method, hedonic price method)	Revealed-Preference Extramarket Valuation Techniques (e.g., travel cost method, hedonic price method)
	Stated-Preference Extramarket Valuation Techniques (e.g., contingent valuation method)	Stated-Preference Extramarket Valuation Techniques (e.g., contingent valuation method)
	Economic Impact Analysis	Economic Impact Analysis
	Social Effects Assessment	Social Effects Assessment

Figure 2. Valuation techniques for values associated with different types of public and private goods

ural capital values in the pure public good cell. The travel cost method may potentially be used, for example, to quantify public nonconsumptive recreation use values derived from countryside landscapes. It may be possible to use the hedonic price method to quantify nonrival, nonexclusive aesthetic appreciation values which are capitalized into the value of natural capital in the form of land sold for residential and(or) recreation and tourism purposes. The contingent valuation method can potentially be used to quantify the commensurable portions of all natural capital values in the nature of pure public goods. To the extent enjoyment of pure public good values involves actual expenditures, the economic impacts of these expenditures can be measured using economic impact analysis. Noneconomic social benefits derived from enjoying pure public good land values can be assessed using social effects or impact assessment.

Congested public goods in the rival, nonexclusive cell will not generally have market prices. Natural capital values in the nature of

congested public goods must therefore be measured using nonmarket valuation techniques. For example, the travel cost method may be used to measure the economic value of nonexclusive recreational use in a congested National Forest. If congested public good values are capitalized into the value of natural capital in the form of land, the hedonic price method can potentially be used to quantify these amenity values. The contingent valuation method can potentially be used to measure all congested public good values. As with pure public good values, if actual expenditures are associated with congested public good natural capital values, the economic impacts of these expenditures can be measured using economic impact analysis. Noneconomic social effects can be measured using social effects or impact assessment techniques (Bartik, 1988; Cheshire and Sheppard, 1995; Correll et al., 1978; Garrod and Willis, 1992; Lee and Fujita, 1997; Lee and Linneman, 1998; Rosenberger and Walsh, 1997; Young and Allen, 1986).

Aggregate Values by Landscape Type

The aggregate natural capital value for a particular landscape is the sum of the different natural capital values for that landscape. The magnitude of aggregate natural capital value and the portion of aggregate natural capital value represented by different types of amenity and nonamenity values will vary across different landscapes. Consider first an urbanized landscape characterized by high human development and congestion. In this landscape aggregate natural capital (including land) value is dominated by pure private good values and congested public good values. Amenity values in the form of pure public goods and uncongested private goods are relatively sparse in this landscape.

Aggregate natural capital value in a suburban landscape is also dominated by pure private goods and congested public good values. Although more of the pure private goods values may be in form of private amenity values, most of the pure private good value is made up of material consumption value. Congested public good values include, for instance, the use of congested public parks and other natural areas for recreation. These areas will not likely be as congested as similar areas in the urbanized landscape, but are congested nonetheless. Natural capital values in the form of uncongested private goods and pure public goods are still relatively low on average. Suburbs on the rural fringe will likely have higher levels of amenity values in the form of pure public goods and uncongested private goods as compared to suburbs on the urban fringe.

On the other extreme from an urbanized landscape, consider a frontier/natural landscape with relatively little human development. In this type of landscape natural capital amenity values in the form of pure public goods will be relatively abundant. Because of the lack of human development, pure private good values, amenity or otherwise, will be sparse. Natural capital amenity values in the form of uncongested private goods will also be relatively abundant. There will be few congested public goods in this type of landscape.

In a traditional agrarian economy landscape

human development is evident mainly through the presence of farming and natural-resource extraction operations such as fishing, timber harvesting, and mining. Because land and other natural resources are still relatively abundant in relation to human use and congestion, amenity values in the form of pure public goods and uncongested private goods are relatively abundant. The higher levels of commercial economic activity and human activity lead to higher levels of pure private goods and congested public goods.

A relatively new type of landscape emerging in the United States is the *exurban* landscape. The exurban landscape is an agrarian economy landscape or a frontier/natural landscape experiencing an influx of new residents from urban areas who have skipped over the suburbs to move to an area where they can enjoy the relative abundance of natural capital amenity values in the form of pure public goods and uncongested private goods, while continuing to work in jobs closely related to their urban careers. In fact, many of these people may continue to physically commute or "telecommute" to jobs headquartered in urban areas. Some may start new careers in their new rural landscape home, but in nontraditional areas such as the recreation and leisure industry, arts and crafts industry, cottage industries, or the high-tech industry. The increased economic activity spurred on by exurban residents increases the level of pure private goods and congested public goods in the landscape. Natural capital amenity values in the form of pure public goods and uncongested private goods are still relatively abundant.

Figure 3 summarizes the mix of commodity values and amenity values supported by natural capital typically found in different landscapes. Moving from an urbanized landscape to a frontier/natural landscape, public good values and amenity values typically rise, and private good values and material consumption values typically fall. The magnitude of aggregate natural capital values will rise and fall across landscapes according to how the sum of the different types of material consumption values and amenity values change across landscapes. Empirical assessment of

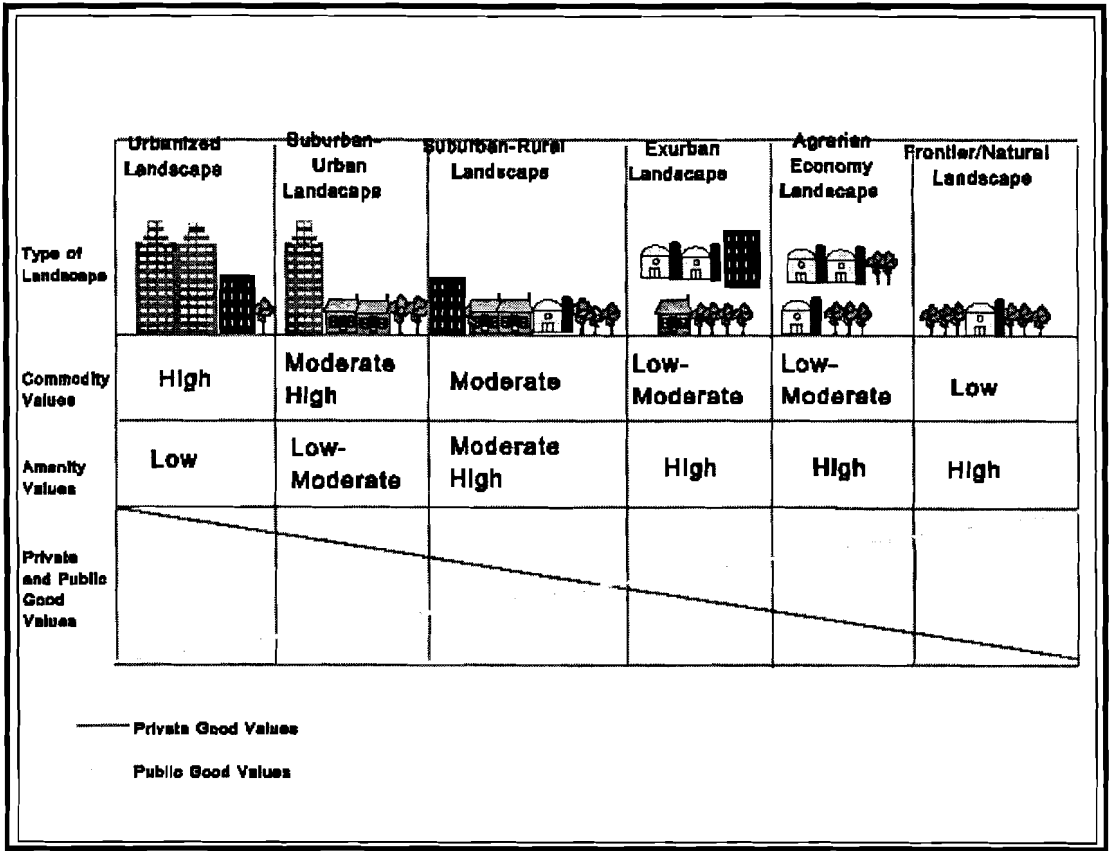


Figure 3. Landscape values spectrum

different values would be needed to determine how aggregate natural capital values change across landscapes.

Moving to a larger scale, an *interregional landscape* is made up of a mix of various types of landscapes. Aggregate natural capital value for an interregional landscape is the sum of commodity values and amenity values associated with each individual type of landscape within the broader interregional landscape. Comparison of aggregate natural capital value across different interregional landscapes would also require empirical assessment of commodity and amenity values.

Natural Capital Values and Quality of Life in Different Landscapes

Natural capital contributes to individual and group quality of life in a regional landscape through the values discussed in the previous

section. As shown in equation (5), however, quality of life is a function of all types of capital present in a regional landscape, not just natural capital. How does the quantity of quality of other types of capital affect the contribution of natural capital to quality of life in a regional landscape?

It should first be recognized that within a particular regional landscape, the mix of different types of capital will differ. For example, in a frontier/natural landscape, natural capital will be relatively abundant compared to other forms of capital. In this type of landscape the marginal value of natural capital in the generation of nonmarket commodities will be relatively low whereas the marginal value of natural capital in the generation of market commodities will be relatively high. Therefore, to increase quality of life in the frontier/natural landscape there will likely be strong incentive to allocate relatively more natural

capital into the mix of capital needed to produce market commodities with high commodity values.

As a region moves from a frontier/natural landscape to a more developed landscape, natural capital becomes relatively more scarce compared to other forms of capital. For example, in an urbanized landscape the total mix of different types of capital present in the landscape contains relatively little undeveloped natural capital. In this type of landscape the marginal value of undeveloped natural capital in the generation of nonmarket commodities will likely be relatively high and the marginal value of natural capital in the production of market commodities will likely be relatively low. Therefore, in an urbanized landscape there would likely be strong incentives to allocate relatively more of the remaining undeveloped natural capital into the mix of capital needed to generate nonmarket commodities with high amenity values.

Incentives and pressures to allocate natural capital to support commodity or amenity values in different landscapes will also be influenced by substitute and complement relationships between the different types of capital shown in equation (5) in the generation of quality of life. In the production of market commodities natural capital and other forms of capital are generally considered substitutes according to neoclassical economic theory. In the case of nonmarket commodities with relatively high amenity values, natural capital and other forms of capital appear to be more in the nature of complements than substitutes. In order to enhance quality of life in a more urbanized landscape this complementary relationship would provide additional incentive and pressure to allocate scarce natural capital to the support nonmarket commodities and amenity values.

Summary and Conclusions

Natural capital can be thought of as an asset with a number of major functions. These functions include provision of commercial inputs, a natural water supply system, unique physical terrain, flora and fauna habitat, space, and a

place in which to live, work, and visit. The functions of natural capital support economic and noneconomic values ranging from material consumption value to nonuse values including existence value.

Two general categories of natural capital values are commodity values and amenity values. Commodity values are derived from commercial commodities produced using natural capital inputs. These commercial commodities include food and fiber products, timber products, mineral products, and manufactured goods. Amenity values are derived directly from natural capital and have large nonconsumptive or passive-use components. Natural capital amenity values include recreational use value, scenic appreciation value, existence value, and certain types of cultural, historical, and health values.

The classification of natural capital values into private or public values is an important distinction to be made for empirical valuation, natural resource use and management, and regional development policy. A major determinant of the private or public good nature of natural capital values is their degree of exclusiveness and rivalness. *Rival and exclusive* values such as material consumption value are in the nature of pure private goods. *Nonrival and nonexclusive* values such as existence value are in the nature of pure public goods. In-between classifications include *nonexclusive, rival* values and *exclusive, nonrival* values. An example of a nonexclusive, rival value is public consumptive recreation use such as public fishing. An example of an exclusive, nonrival value is private nonconsumptive recreation use, such as private bird watching under low human congestion.

Natural capital commodity values fall primarily into the rival, exclusive category. Market price valuation techniques can therefore be used to quantify these values. Under conditions of high human congestion some natural capital amenity values may fall into the rival, exclusive category. However, because of the lack of established markets for these values market valuation techniques may not be readily applicable to these values.

Most natural capital amenity values fall

into the exclusive, nonrival category, nonexclusive, rival category, or nonrival, nonexclusive category. Revealed or stated preference nonmarket valuation techniques must be used to quantify values associated with pure public goods in the nonrival, nonexclusive category. Values in the rival, nonexclusive category are typically associated with congested public goods. Because of the nonexclusive nature of these values, revealed or stated preference nonmarket valuation techniques must be used to quantify these values. Values in the exclusive, nonrival category are typically associated with uncongested private goods. Because markets may exist for uncongested private goods, values associated with these goods perhaps can be quantified using market valuation techniques.

The economic impacts of values associated with pure private goods such as commodity values can be measured using economic impact analysis techniques. To the extent that actual market expenditures are incurred to enjoy values associated with pure public goods, congested public goods, and uncongested private goods, economic impact analysis techniques can also be used to measure the impacts of these values on local and regional economies. The enjoyment of amenity values of different types often involves actual market expenditures. Thus economic impact analysis can and has been used to measure the economic impacts of amenity value expenditures on local and regional economies. Social effects assessment can be used to assess the noneconomic effects of all types of natural capital values on individuals and communities.

The distribution of natural capital values associated with different types of private and public goods varies across regional landscapes. A highly urbanized landscape typically provides a high proportion of pure private good values such as commodity values and a low proportion of pure public good values including amenity values. On the other extreme, a frontier/natural landscape provides a low proportion of pure private good values such as commodity values and a high proportion of public good values such as amenity values. Landscapes in between these extremes includ-

ing suburban, agrarian economy, and exurban landscapes provide more balanced mixes of private and public good values and commodity and amenity values. The aggregate value of each type of landscape must be determined on a case-by-case basis through empirical valuation.

An interregional landscape is made of different mixes of specific landscapes including urbanized, suburban, agrarian economy, exurban, and frontier/natural landscapes. The aggregate value of natural capital in each regional landscape is a function of the natural capital values provided by each landscape and the interaction of values between landscapes in the region (e.g., substitute and complement effects). Holistic empirical valuation studies which account for value interactions between different landscapes must be conducted to determine the aggregate value of a particular interregional landscape.

The contribution of natural capital to quality of life in a regional or interregional landscape is dependent upon the level of natural capital in a landscape relative to the levels of other forms of capital in a landscape. In more urbanized landscapes where undeveloped natural capital is relatively scarce there is likely to be strong incentive and pressure to allocate remaining undeveloped natural capital to the support of nonmarket commodities with high amenity values. In agrarian or frontier/natural landscapes where undeveloped natural capital is relatively abundant there is likely to be strong incentive and pressure to emphasize allocation of undeveloped natural capital to the production of market commodities with high commodity values. Because quality of life is ultimately something that is subjectively determined in the "eye of the beholder", all individuals and groups will not agree on how natural capital should be used and managed in a particular landscape. Thus better knowledge of the role and value of natural capital in regional landscapes can help inform natural capital use and management decisions. However, better knowledge alone will not resolve what may turn into bitter natural capital use and management disputes between people whose primary interests are market commodities and

commodity values and other people whose primary interests are nonmarket commodities and amenity values.

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