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ECONOMIC VALUATION OF ECOSYSTEM SERVICES IN THE SAVANNAH RIVER BASIN: CONCEPTUAL STUDY PLAN

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Economic Valuation of Ecosystem Services in the Savannah River Basin

1. Introduction

The Savannah River Basin (SRB) stretches from the mountains of Georgia, North Carolina and South Carolina, through the piedmont and coastal plain regions of Georgia and South Carolina, eventually ending at the Atlantic Ocean along the Georgia and South Carolina coastal border (see Figure 1). The SRB includes several major U.S. Army Corps of Engineers (USACE) water resource management projects including the Hartwell Dam and Reservoir Project, the Russell Dam and Reservoir Project, and the Thurmond Dam and Reservoir Project (Figure 2). These projects regulate the flow of water for almost the entire length of the SRB, roughly from about Interstate 85 in Upstate South Carolina and Northeast Georgia to Savannah, GA. Thus, the SRB represents a managed ecosystem. This managed ecosystem provides a variety of ecosystem services to people living within and outside of the SRB.

The primary purpose of this paper is to present an overall framework for defining and estimating the total economic value of ecosystem services in the SRB. We begin by discussing some important background ecologic concepts. We then discuss broad values associated with ecosystems from a societal perspective to put economic valuation in context by summarizing concepts used for comprehensive valuation of ecosystems. The final section of the paper is devoted to discussing specific classifications of ecosystem services, and how these services might be valued in monetary terms for input into policy and management decisions.

2. Background Ecologic Concepts

Effective measurement of the economic benefits of SRB ecosystem services requires an interface between the ecologic sciences and the economic sciences. To develop such an interface, a common "language" which can be used by various parties involved and interested in valuing ecosystem services is needed. We use terms and definitions for ecologic and economic concepts which may help form the core of such a common language. In this section, we discuss background ecologic concepts drawing from Bergstrom and Randall (2010) and Bergstrom and Loomis (1999).

Ecosystem processes are defined as the broad physical purposes of ecosystems at the scale of the universe. When viewed from a general perspective, ecosystems appear to have two major processes: energy transfer and matter recycling. Energy transfer involves absorbing and utilizing low-entropy solar energy and then emitting high-entropy energy back into the atmosphere. Organic matter recycling (which is fueled by solar energy) involves the storage and flow of life-supporting chemicals through ecosystem processes.

These broad ecosystem processes of energy transfer and organic matter recycling support ecosystem functions. Ecosystem functions are defined as major environmental tasks performed by natural ecosystems at the scale of a specific ecosystem type (e.g., wetlands area, upland forest, river, lake, reservoir or estuary). An example of an ecosystem function is natural development. Following Bergstrom and Loomis (1999), we define natural development generally as natural changes in the quantity and (or) quality of biotic and abiotic components of ecosystems (e.g., habitat and community succession over time).

Natural development can occur at different temporal scales. For example, natural development includes short-term primary (plant) production such as growth of a single plant from a seed to a mature individual. It also includes short-term secondary (animal) production such as growth of a minnow to a full-grown adult fish. Short-term primary (plant) and secondary (animal) production could vary in rates of development from weeks and months to years. Natural development also occurs over a wide range of spatial scales. Both temporal and spatial scales reflect generation times (periods) of the dominant species within the ecosystem that process most of the energy in the system.

The longer-term development of an entire lake or reservoir from a newly formed "young" lake to an "old" lake occurs over time scales of decades to centuries. The last stages of this development or succession are termed “morphometric eutrophication.” Rates of development can be accelerated by inputs of nutrients from changing land uses (e.g., wastewater treatment plants, feed lots) and is considered “cultural eutrophication.” The rates of natural development are important parameters in measures of ecosystem productivity resulting from energy flow and nutrient cycling.

Having defined natural development, we identify two major biotic functions of ecosystems, and three major abiotic functions. The biotic functions are: 1) natural plant development, and 2) natural development of fish and wildlife. The abiotic functions are: 1) natural development of water supplies, 2) natural development of air supplies, and 3) natural development of rocks and minerals (Bergstrom and Loomis 1999). The biotic and abiotic functions of ecosystems are dynamic, making measurement of the direct biotic and abiotic outputs of these functions (e.g., fish and wildlife populations, water quality) in a particular watershed difficult.

In the SRB, an example of the natural plant development function is “tree growth” which results in changes in the quantity and quality of trees in the watershed, including evergreen and deciduous forests (see Figure 3 for distribution of different forest cover types in the SRB). An example of natural development of fish and wildlife in the SRB is “fish growth” which results in changes in the quantity and quality of fish in the streams and lakes of the watershed including bass, crappie, bluegill, sunfish, catfish, shad, and sturgeon. Examples of natural development of water supplies in the SRB are the nutrient cycling and storage functions in SRB streams and lakes which help to purify water in those streams and lakes. The absorption of CO_2 and emission of O_2 by plants in the SRB helps to improve air quality in the SRB and is an example of natural development of air supplies. An example of natural development of rocks and minerals in the SRB is the long-term ecological and geological processes which generated kaolin clay deposits in areas of the SRB along the “fall line” near Augusta, GA

In practice, scientists typically make a series of discrete measurements of the direct biotic and abiotic outputs of ecosystem functions during a given developmental phase. Following Bergstrom and Loomis (1999), we define a developmental phase as the state of natural development during a specific period of time at a specific place (e.g., the abiotic and biotic state of a specific reservoir in the SRB in 2011 relative to its origin). During a particular developmental phase, the biotic and abiotic outputs of ecosystem functions have specific quantity and quality dimensions. Quantitative measures of these dimensions give a "snapshot" of the quantity and quality of biotic and abiotic components of an ecosystem at a given time and place (e.g., quantity and quality of water in a particular SRB reservoir in a given year, a given day, or even a given hour in the case of instream river flows and reservoir water levels.).

Ecosystem functions during a developmental phase generate ecosystem goods and services with given quantity and quality dimensions. Following Brown et al. (2007), ecosystem goods are defined as generally tangible materials generated by ecosystem processes and functions such as plants, fish and wildlife and minerals which are useful and valuable to humans. For example, ecosystem goods associated with the natural development of fish and wildlife function include fish and wildlife species in the SRB (e.g., striped bass, white-tail deer, and bald eagles) available for recreational fishing and hunting and on-site wildlife observation and photography. Ecosystem goods associated with the natural development of plants function include evergreen species harvested for timber products. Ecosystem goods associated with the natural development of rocks and minerals include kaolin clay deposits which are mined and used for various purposes including paper, paint and cosmetics (Bergstrom and Loomis 1999; Bergstrom and Randall 2010).

Also following Brown et al. (2007), ecosystem services are defined as changes in the condition or location of things which are useful and valuable to people. Thus, for example, the ecosystem service of water quality improvement through nutrient cycling and storage contributes to improvements in game fish quality and drinking water quality in the SRB. The ecosystem service of air quality improvement through CO_2 absorption and O_2 emission by plants contributes to improvements in air for breathing by humans and perhaps some regulation of climate (e.g., some mitigation of rising temperatures which may be induced by global climate change).

Another example of an ecosystem service is how the natural development of plants can function to contribute to the protection of the red-cockaded woodpecker (which is a Federally-designated endangered species under the Endangered Species Act) in the SRB by providing pine tree habitat of a certain quality (e.g., old-growth) needed by the woodpecker.

3. Ecosystem Valuation Context: A Broad Perspective

Before discussing the economic values of ecosystem goods and services, we believe it is important to set the context by first discussing ecosystem values within a broader perspective. Establishing this context requires us to consider briefly some broad societal (e.g., philosophical/ethical notions) of value. In the context of natural resource management, *intrinsic value* is defined as the value of a natural resource separate from its usefulness (or utility) to humans. For example, one may argue that bald eagles in the SRB have intrinsic value as part of the SRB ecosystem which is not dependent on human uses and values (e.g., biocentric view). *Instrumental value* is defined as the value of a natural resource as an "input" into human uses and values (e.g., anthropocentric, utilitarian view). For example, bald eagles in the SRB provide instrumental values to people as “inputs” into wildlife observation and photography or even the enjoyment a person receives from contemplating the existence of bald eagles in the SRB (whether they see one or not).

Ecosystem processes and functions in the SRB contribute to both intrinsic and instrumental values as defined above. For example, instrumental values of bald eagles for wildlife observation and photography are dependent on the provision of water of sufficient quantity and quality to sustain bald eagles and the fish they eat. Abiotic and biotic ecosystem components can have both positive and negative instrumental values. There is evidence that in the SRB bald eagles are getting sick (and perhaps dying) by eating certain non-native aquatic plants (*Hydrilla* associated with toxic cyanobacteria). Thus, these non-native aquatic plants have negative instrumental values to people because they are damaging bald eagles and diminishing bald eagle viewing and photography opportunities.

Ecosystem processes and functions in the SRB contribute to the intrinsic value of natural resources in SRB by providing the means for the continued existence of these natural resources outside of human management, use and values. For example, even if humans did not manage fish and wildlife in the SRB, ecosystem processes and functions would continue to support fish and wildlife populations in the basin. If people had no use or value for these fish and wildlife, these functions would not have anthropocentric instrumental value. However, these fish and wildlife populations would still have intrinsic value.

Because natural resources can have both biocentric (or ecocentric) intrinsic value and anthropocentric instrumental value, the question of "which values count" in resource management decisions arises. This question is generally answered by federal or state legislatures or the specific agency in direct charge of managing an ecosystem. For example, the U.S. Army Corps of Engineers wildlife habitat restoration actions under National Ecosystem Restoration (NER) goal appear to “count” both intrinsic value and instrumental values.[1] Anthropocentric, instrumental values to humans include both non-economic and economic values. Examples of non-economic values of ecosystems include spiritual or cultural values.

Some federal legislation such as the Endangered Species Act (ESA) provides a more biocentric answer to the question of which values count. The ESA, for example tends to give greater weight to intrinsic values of sustainable survival among certified rare or threatened fish and wildlife species as compared to their instrumental values to people. This biocentric weighting may be due to the higher values of endangered plants and animals arising from their extreme scarcity or perceived risk of extinction (Bergstrom and Loomis 1999; Ferre 1988).

In summary, there is a broad set of economic and non-economic values which are associated with ecosystems. Economic valuation of ecosystem goods and services therefore represents a partial accounting of the full range of ecosystem values. The task of the economist is not to attempt to measure all ecosystem values. Rather, the economist's primary role is to do the best job possible measuring as many of the economic benefits of ecosystems as possible. The assessment of the non-economic benefits of ecosystems is the primary duty of some other discipline (e.g., ecology, environmental ethics, theology, etc.). Given the broader context for economic valuation discussed in this section, we next consider the need for identifying goods and ecosystem services of interest in the SRB and measuring the economic value of these goods and services.

4. Identification of SRB Ecosystem Services

The following discussion in based upon a recent summary of ecosystem goods and services identification and valuation concepts provided by Bergstrom and Randall (2010). A key feature of the definition of ecosystem goods and services provided in the previous section and others (e.g., Boyd and Banzhaf 2007; Brown et al. 2007) is the emphasis on materials and things generated by ecosystems which are useful and valuable to people. Thus, the definition of ecosystem goods and services used in this study plan is anthropocentric or human-centered.

Anthropocentrism is in keeping with an economic perspective on the environment because, as a social science, the focus of economics is on human actions and values. Although the anthropocentric focus is inherent in economic studies of the environment, other less human-centered perspectives or ethics are also important as indicated by the discussion of ecosystem values from a broader perspective in the previous section.

Ecosystem goods and services are often confused with ecosystem processes and functions. In this study plan, ecosystem processes refer to the flow of energy through an ecosystem and the chemical cycles discussed previously. Ecosystem functions refer to natural development of plants, fish and wildlife, rocks and minerals, and air and water. Ecosystem processes and functions involve complex physical and biological relationships and interactions that work together for a particular ecological purpose such as nutrient cycling.

Ecosystem goods and services are the specific results of ecosystem processes and functions that either directly or indirectly contribute to human well-being. For example, solar energy and nutrient cycling promote aquatic plant and fish growth in lakes and rivers – aquatic plants and fish can then be harvested and consumed by people for food (an ecosystem good) or can help to store carbon contributing to global climate regulation (an ecosystem service). As another example, solar energy and the hydrologic cycle contribute to rainfall. Some of the rainfall flows into rivers and lakes resulting in natural surface water supplies (an ecosystem good). In a river or lake, living organisms such as shellfish and other consumer species act as filters to remove and internally store or breakdown contaminants, thus naturally purifying the water they live in (an ecosystem service).

To some scientists and resource managers, the difference between ecosystem processes and functions and ecosystem goods and services may seem mainly semantic. Indeed this need for precise definitions may especially seem unnecessary when the terms used to define an ecosystem good or service and ecosystem processes and functions sound very similar. The important conceptual difference to keep in mind is that ecosystem goods and services are defined as goods and services which are useful and valuable to people (e.g., an economic perspective) whereas ecosystem processes and functions are useful and valuable to plants, animals and the ecosystem itself (e.g., an ecologic perspective).

From an ecologic perspective, ecosystem process and functions may be viewed as ends in themselves (e.g., the ends would include maintaining ecosystem health and integrity or as a means to compare distinctly different or similar ecosystems in studies of biogeography). However, from an economic perspective, ecosystem processes and functions are viewed as means to ends – the ends of interest are goods and services or "outputs" or "endpoints" which are useful and valuable to people. Thus, within the economic perspective, ecosystem processes and functions have instrumental value as inputs into the generation of outputs (ecosystem goods and services) which impact human utility or well-being (Bergstrom and Randall 2010).

Table 1 lists ecosystem goods and services of interest in the SRB based on classification schemes presented by Bergstrom and Randall (2010), Boyd and Banzhaf (2007), Brown et al. 2007), Farber et al. (2006), Heal et al. (2005), MEA (2005) and Wallace (2007). Ecosystem goods are grouped in two broad categories: renewable and non-renewable. With continual use, the supply of non-renewable ecosystem goods will eventually be used up over time, but with some potential for reuse through recycling (e.g., metal recycling). The supply of renewable ecosystem goods can be maintained at predictable levels over time, even with continual use, provided the stock is managed in a sustained yield fashion (i.e., fish harvest equals fish population growth) with a margin of safety regarding risks from disease outbreaks or other environmental uncertainty.

The ecosystem goods listed in Table 1 are generally well-known to people who study or use SRB resources; for example, fishery resources in the SRB are generally well-known to biologists, resource managers and anglers. However, the ecosystem services listed in Table 1 include life and quality-of-life services provided by SRB resources that are less well-known to scientists, resource managers and the general public. For example, it is difficult for most people who swim in SRB reservoirs to be aware of how different living organisms purify the reservoir water and help to make it safe for swimming. The general public may also be generally unaware of how bees and other pollinators interact with different plants in the SRB ecosystem to pollinate the many plants we enjoy looking at (e.g., flowers) or the fruits and nuts of which we enjoy eating (e.g., apples, pecans, blueberries). Yet, these ecosystem services provided by pollinators have well-documented economic values that are subject to changes in land uses and other variables (e.g., Galai et al. 2009; Potts et al. 2010). In the remainder of this document, we use the term "ecosystem service" as a short-hand for ecosystem goods and services. The conceptual distinction between ecosystem goods and ecosystem services, however, should be kept in mind.

5. Total Economic Value Concepts

5.1. Expenditures vs. Consumers Surplus

From a consumer's standpoint, the gross economic value of a good or service is the consumer's gross willingness-to-pay for a good or service which is equal to expenditures plus consumers surplus. For example, suppose the most a person would be willing to pay for a recreational fishing trip to a SRB reservoir is equal to $100, but he or she only pays $60 for the trip in travel costs (e.g., gasoline, food and beverages) and fees (e.g., boat ramp launching and parking fees). In this case, the gross economic value of the trip is $100, expenditures are $60, and consumers surplus is $40 ($100 minus $60). Thus, consumers surplus is a measure of net economic value, net benefits, or net willingness-to-pay (often referred to as just as willingness-to-pay or WTP) of a good or service to an individual consumer. From an economic standpoint it is important to distinguish between the gross and net economic values, but for many ecosystem services, the expenditure is zero so the two are the same.

Consumers surplus, as a measure of net economic value or net benefits, is the appropriate measure of economic value for the U.S. Army Corps of Engineers National Economic Development (NED) account. This account focuses on the question: "What is the best or most efficient use of natural resources for the benefit of the U.S. as a whole?" For instance, consumers surplus is the appropriate measure of economic value for benefit-cost analysis of policies and projects. Benefit-cost analysis is sometimes referred to as a test for efficiency since it eliminates projects for which the economic benefits are less than the economic costs (Bergstrom and Randall 2010).

In general, expenditures (e.g., market cash-flow) only reflect financial value (Stoll, Loomis, and Bergstrom 1987). Financial value is important for measuring the impacts of ecosystem-based economic activities (e.g., on-site recreation) on the economies surrounding a particular ecosystem (e.g., impacts on jobs and income). Financial value is the appropriate measure of economic impacts for the U.S. Army Corps of Engineers Regional Economic Development (RED) account. The RED account focuses on the question: "How does a policy or project impact a regional economy in terms of economic impact measures such as jobs and income?" Financial value is not appropriate for benefit-cost analysis of policies and projects because it does not capture the full range of economic benefits supported by ecosystems, and it does not measure net benefits.

In this conceptual study plan, our focus is upon the National Economic Development account and therefore the net benefits (net economic value) of ecosystem services measured by consumers surplus. The overall goal of the economic valuation of ecosystem services for the National Economic Development account is to measure net benefits associated with all components of the total economic value of natural resources affected by management actions.[2]

Natural resources can be defined in a number of ways. The standard economic definition of a natural resource is something that is useful and valuable in the condition in which it is found in nature (Bergstrom and Randall 2010). The "useful and valuable" part of this definition means that the resource provides at least some agents with improved well-being through a direct or indirect pathway, and the resource is considered scarce in that agents desire more of it than is currently available. Examples of natural resources going from relatively small to larger scales include: 1) an individual fish or deer, 2) a population of deer or birds, 3) a community of fish, deer, and bird populations, and 4) an entire ecosystem such as a lake or forest. Irrespective of the scale of analysis, the total economic value of natural resources can be divided into two broad categories; active use value and passive use value.

5.2. Active Use Value

Active use value (AUV) is the value derived from actively using a natural resource. AUV can be subdivided based on whether activities which generate value occur on or off site, and whether these activities are consumptive or non-consumptive. Suppose that the "site" we are interested in valuing is a particular SRB reservoir managed ecosystem. On-site, consumptive AUV would be derived from consumptive activities which occur at the reservoir such as recreational fishing. On-site, non-consumptive AUV would be derived from non-consumptive activities which occur at the reservoir such as wildlife photography.

Off-site, consumptive AUV would be derived from consuming natural resources provided by the reservoir at an off-site location; for example, drinking water withdrawn from the reservoir at one's home away from the reservoir. Off-site, non-consumptive AUV would be derived from non-consumptive activities which directly use a natural resource provided by the reservoir at an off-site location; for example, using fish from the reservoir to stock an aquarium rather than eat the fish or using rocks or driftwood collected along the reservoir shoreline as decorations at one’s home. Off-site, non-consumptive AUV would also include viewing personal or commercial photos or videos of SRB plants, fish and wildlife or rocks and minerals at home.

5.3. Passive Use Value

Passive use value (PUV) is the value derived from passively using a resource. This category of value always occurs off-site and is always non-consumptive because use is passive, not active. Suppose again that we are interested in valuing a particular SRB reservoir managed ecosystem. Vicarious PUV would be derived from imagining the reservoir-related experiences of other human and nonhuman agents. One type of Vicarious PUV is bequest value, which for example, would be the value a person places on knowing that natural resources at the reservoir (e.g., unique rock formations, bald eagles) will be preserved for other people to enjoy (actively or passively) within the same generation or across generations (Randall and Stoll 1980). Existence value would be derived, for example, from the satisfaction a person receives from merely thinking about natural resources (such as rare plants and endangered or threatened wildlife species) existing within the reservoir ecosystem for their own sake, or a value for posterity even if not actively used or consumed.

Passive use value (PUV), as indicated by its definition, can be experienced by members of the general public who never visit a particular place or ecosystem. For example, a sizable number of people across the entire U.S. may derive value from simply knowing that endangered red cockaded woodpeckers continue to exist for their own sake in the SRB. While this PUV per person may be relatively small, the aggregate PUV could be very large when aggregated over the proportion of the U.S. population who experience this value. Thus, an important question for ecosystem service valuation is; how wide is an ecosystem's impact or drawing power; that is, what is the geographic extent over which people care about the ecosystem considering both active and passive use values? One major factor influencing this drawing power or geographic extent is the uniqueness of the ecosystem of interest. For example, the Grand Canyon has a geographic extent of all of North American and possibly worldwide. Whereas the bulk of value for a common lake or reservoir might only accrue locally or regionally as similar lakes or reservoirs exist nearby in other regions or states.

Passive use values are one type of what economists refer to as public goods. Enjoyment from thinking about a free-flowing river ecosystem does not alter or “use up” the water flows; i.e., it is “non-rival” in the sense that one person's passive use value does not preclude someone else from obtaining enjoyment from thinking about the same ecosystem. In addition, no one can be denied the opportunity to think about or obtaining satisfaction from knowing that a particular ecosystems or ecosystem component such as a bald eagle or red cockaded woodpecker exists (i.e., economists consider these passive use values to be non-exclusive and non-rival).

Public goods are contrasted by private goods which generate rival and exclusive values. Private goods include many types of agricultural and forest products supported by ecosystems; for example, food and lumber. Economic values generated by food and lumber are considered “rival” as consumption by one person typically reduces the amount of commodity left over for someone else to consume. Also, economic values generated by food and lumber are considered exclusive as people must typically pay for these commodities in order to consume or use them.

5.4. Economic Valuation and Resource Interdependency

When attempting to measure active and passive use values associated with natural resources, people may express a preference for high-profile resources such as “charismatic megavertebrates" (e.g., bald eagles). Values expressed for these high-profile resources imply an indirect valuation for the components of the ecosystem that supports these species. For example, humans may value watching bald eagles flying over a lake and are unaware or indifferent towards fish in the lake. But if the fish in the lake are a critical part of the eagle's food supply, then humans have a derived value for the fish and their habitat. Thus, while an anthropocentric valuation paradigm might on the surface seem to ignore many underlying and important ecological functions, this apparent gap may often not be the case. The ecological linkages necessary to support many of the high profile species may mean that the entire ecosystem must be protected for a multitude of lesser known species.

6. Ecologic/Economic Linkages and Valuation Steps

Measurement of economic values for input into ecosystem management decisions involves the major steps and linkages outlined in Figure 4. First, the management action under consideration must be defined completely and precisely. Second, changes in ecosystem functions brought about by management actions must be measured. Third, changes in ecosystem services resulting from the changes in ecosystem functions must be measured. Finally, the change in total economic value resulting from these changes in services must be identified and quantified.

As an illustration of the steps and linkages shown in Figure 4, suppose that the management action of interest is a change in quantity of water released from a SRB reservoir to support downstream fish and wildlife habitat. We would first need to define the exact changes in management under consideration and the subsequent effects on ecosystem functions (e.g., change in plant development, change in fish and wildlife development). The change in ecosystem services resulting from changes in ecosystem functions would then be measured (e.g., change in quantity or quality of recreational hunting and fishing at the reservoir and downstream; change in wildlife observation and photography at the reservoir and downstream; change in quantity of hydropower generation at the reservoir and change in salinity or water depth in the estuary and harbor).

The final step is to measure the change in total economic value brought about by these changes in services: e.g., changes in off-site, consumptive active use value (AUV) to electricity consumers; changes in off-site, consumptive AUV to drinking water consumers; changes in on-site, consumptive AUV to recreational hunters and anglers; changes in on-site, non-consumptive AUV to birdwatchers; changes in existence values of fish and wildlife species affected by the changes in reservoir water releases). Changes in economic values may result from changes in service quantity, service quality, production costs, and commodity prices, (e.g., changes in the cost or price of electricity; changes in the cost or price of off-site drinking water; changes in the cost or satisfaction derived from recreational hunting, fishing or bird watching).

Economic services and values associated with ecosystem services generated by the four major ecosystem functions discussed previously are shown in Tables 2-6. Comprehensive ecosystem service valuation would require the linkages illustrated in Figure 4 to be assessed for each service row shown in Tables 2-6. After all linkages have been assessed and it is determined which economic values in column 2 will change as a result of the management action under consideration, a valuation technique(s) for developing a monetary estimate for each relevant change in economic value must be selected and implemented. In many cases, only the most important ecosystem services are valuated because of limited data or time.

7. Economic Value Measures

To compare tradeoffs between different ecosystem management actions, it is important for ecosystem services to be valued in identical or commensurate terms. For assessing economic tradeoffs, money (the "money metric") is the preferred commensurate measure of value. For economic efficiency analysis, theoretically appropriate monetary measures of changes in individual and community "well-being" include net willingness-to-pay and willingness-to-accept compensation (Bergstrom and Randall 2010; Freeman 2003).

Although there are often ethical objections to using money as a common measure of ecosystem values, using money as the currency or unit of measures meets the important criteria for being a policy relevant measure of value. Monetary values bring commensurability between commodity valuation, opportunity costs, budget requests and the values of nonmarket goods and services including many ecosystem services. Any proposed approach for measuring the economic value of non-market ecosystem services must be evaluated by whether it produces estimates that are conceptually comparable to the type of monetary values people place on lumber, food, hydropower, and other commodities commonly traded in economic markets via market prices.

Choosing between willingness-to-pay (WTP) and willingness-to-accept compensation (WTA) as legitimate measures of economic value involves legal distinctions regarding property rights as well as consideration of measurement techniques. In situations where the public has a right to an ecosystem service that is proposed to be reduced, WTA compensation to allow the reduction may be more appropriate than WTP to avoid the reduction. However, in the case of U.S. Army Corps of Engineers reservoir management for example, no user group has any specific *de jure* property rights to a particular ecosystem service whether it be electricity, fishing or water skiing. Thus, in a wide variety of decision making contexts, WTP may be the appropriate measure and is easier to measure (Bergstrom and Randall 2010).

8. Economic Valuation Techniques

There are two general classes of techniques for measuring willingness-to-pay (WTP) and willingness-to-accept compensation (WTA); revealed preference methods and stated preference methods (Bergstrom and Randall 2010). Revealed preference methods use data on actual observed behavior to estimate WTP or WTA. For example, suppose we want to estimate consumers' WTP for hydropower electricity generated at a particular SRB reservoir. This WTP, which is a type of off-site, consumptive active use value (AUV), can be estimated using observed market prices for electricity minus the generation and delivery costs to arrive at a net value which reflects net benefits in the form of willingness-to-pay over and above the power generation costs.

Another example of a revealed preference method is the travel cost method which uses observations of the quantity of recreational trips taken at different costs to estimate a recreational demand function. This demand function can then be used to estimate WTP over and above travel costs for recreational activities, say which occur at a particular SRB reservoir or river reach. In the case of an activity such as recreational fishing or hunting, this willingness-to-pay represents a type of on-site, consumptive AUV. For an activity such as bird watching or wildlife photography, this willingness-to-pay represents a type of on-site, non-consumptive AUV.

The hedonic price method represents a revealed preference method which uses property value data to estimate the value of environmental amenities. The general concept underlying this method is that the variable prices people pay for spatially-different property reflects their willingness-to-pay for attributes of the property including environmental amenities. For example, views of, access to, and frontage on SRB reservoirs have been found to positively influence residential property values in the SRB (Espey et al. 2007).

Stated preference methods use data on intended or planned behavior (as stated by a person) to estimate willingness-to-pay (WTP) or willingness-to-accept compensation (WTA). The most widely applied stated preference method in the natural resource management arena is the contingent valuation method. The contingent valuation method was originally developed to value recreation use, but since has been used to measure a broad range of economic values associated with a variety of natural resources (Bergstrom and Randall 2010).

The contingent valuation method involves confronting survey respondents with realistic valuation scenarios and acceptable valuation questions. For example, suppose we want to measure a group of citizens' willingness-to-pay to reduce invasive aquatic plants such as *Hydrilla* in a SRB reservoir. The contingent valuation survey instrument would describe the proposed program for reducing *Hydrilla* in detail and how it would be financed (e.g., increase in boat ramp launch and parking fees and/or taxes). The following valuation question might then be posed: "If the proposed *Hydrilla* reduction program cost your household $X per year because of an increase in fees or taxes, would you vote to approve the program?" “Yes” or “No” responses to this question across respondents for various values of X can be statistically analyzed to estimate mean willingness-to-pay for the program.

An interesting aspect of the above *Hydrilla* reduction example is that some reservoir uses may have a negative willingness-to-pay (WTP) for Hydrilla reduction. We would expect recreational boaters, water skiers and swimmers to have a positive WTP for reducing *Hydrilla* since these plants can foul boat props and interfere with water skiing and swimming. However, at least some anglers may have a negative WTP for reducing Hydrilla since these plants provide cover for game fish. Note that saying someone has negative WTP for reducing *Hydrilla* is the same as saying they have a positive willingness-to-accept compensation (WTA) for accepting a reduction in these plants and the possible associated reduction in fishing quality (e.g., fish catch).

Revealed and stated preference methods have relative strengths and weaknesses for valuing ecosystem services. The primary strength of revealed preference methods is that value estimates are based on *actual behavior and tradeoffs*. The primary weakness of these methods is related to this strength. Because values are based on actual behavior and tradeoffs observed in economic markets, revealed preference methods can only be applied to value ecosystem services which are associated with some type of actual market expenditures. Thus, if data on existing market expenditures cannot be linked to the specific ecosystem service of interest, revealed preference methods cannot be used to value the ecosystem service. Revealed preference methods are most amenable to measuring active use values because these values are often associated with some type of market expenditures (e.g., expenditures on commercial electricity, expenditures on gasoline and supplies incurred on recreational trips to a reservoir).

The primary strength of stated preference methods is flexibility. A well-designed contingent valuation survey, for example, can be effective in measuring willingness-to-pay for ecosystem services for which no market expenditure data exist (thereby ruling out revealed preference methods). The primary weakness of stated preference methods is also related to its primary strength.

The flexibility of stated preference methods comes from the fact that artificial or hypothetical valuation scenarios and questions are used to collect valuation data. Thus, estimated values are not based on actual behavior and tradeoffs, which may lead to concerns about the validity of stated preference method results. A number of validation studies have been conducted which compare economic values estimated from contingent valuation responses to economic values estimated from actual market behavior. These studies suggest that well-designed contingent valuation studies are capable of generating economic value estimates which reflect actual preferences, especially for active use value (Bergstrom and Randall 2010).

9. Holistic vs. Piecewise Ecosystem Service Valuation

9.1. Holistic Valuation

As indicated previously, the overall goal of ecosystem service valuation from an economic perspective is to measure the total economic value of the ecosystem services affected by management actions. One approach to measuring this total economic value is to conduct separate studies to measure each of the components of total economic value. There is a key concept in economic valuation, however, which parallels a key concept in ecology – the sum of the parts does not necessarily equal the whole. In ecology, this phrase means that the complex physical and biological interrelationships between the biotic and abiotic components of an ecosystem when viewed as a whole are not accurately reflected by the mere "sum total" of the roles these components play in an ecosystem at a smaller scale such as an individual organism or community. Under the proper set of assumptions, the sum of these interacting components can be greater than the parts when viewed as a functional ecosystem (Odum 1989).

In economics, the phrase “the sum of the parts does not necessarily equal the whole” refers to the fact that sum of values of the components of total economic value measured in separate studies will not generally equal the total economic value measured in a single, holistic study. If the different parts of the total economic value “whole” are substitutes (e.g., people view different ecosystem services as substitutes with respect to the total economic value they place on a SRB reservoir), the sum of ecosystem service values measured in separate studies will likely exceed the total economic value measured holistically. However, if the different parts of the total economic value “whole” are complements (e.g., people view different ecosystem services as complements with respect to the total economic value they place on a SRB reservoir), the sum of ecosystem service values measured in separate studies will likely be smaller than the total economic value measured holistically (Hoehn and Randall 1986).

Natural resources associated with U.S. Army Corps of Engineers water resource projects in the SRB are managed at relatively large, interrelated and complex scales (e.g., landscape ecology, entire watersheds and regional economy scales). Resource management at large, interrelated and complex scales suggests the need to conduct economic valuation in a more holistic manner. In general, there is a need to move away from conducting separate studies aimed at measuring a few components of total economic value to more comprehensive studies aimed at measuring total economic value in a holistic manner. The need for holistic valuation points to another disadvantage of revealed preference methods such as the travel cost method. These methods are limited to valuation of total economic value components or parts. Thus, the sum of estimates of the components of total economic value measured in separate studies using revealed preference methods will not generally equal the total economic value of an ecosystem measured holistically.

An advantage of stated preference methods is the ability to measure total economic value holistically. For example, the contingent valuation method can in principle be used to measure the total economic value of a natural resource directly. Once total economic value is measured holistically, it is then possible to derive conceptually valid measures of the components of total economic value (Hoehn and Randall 1986). In sum, conceptually valid measures of the components of the total economic value of ecosystem management can be derived from holistic estimates of total economic value. However, conceptually valid measures of the total economic value of ecosystem management cannot be derived from the sum of the components of total economic value measured in separate studies.

A possible overall direction for measuring the total economic value of ecosystem management in a conceptually valid and policy-relevant manner is landscape ecosystem service valuation which is similar to the spatially-explicit ecosystem service valuation approach (Liu et al. 2010). The first step in this valuation process would be to conduct a participatory planning process where ecosystem management "experts" and "stakeholders" cooperatively define alternative ecologically-sound landscapes, say for the SRB. These landscapes could be illustrated using GIS-type maps that display the various components of the landscape.

Ecological modeling would be required to define the ecosystem functions associated with each landscape. The "outputs" of these functions (e.g., quantity and quality of plant and animal life; quantity and quality of minerals) would need to be translated into ecosystem services of benefit to humans using a variety of modeling techniques involving multiple disciplines. All of this information related to ecosystem functions and services would need to be included in the GIS-type map for a particular landscape. Once each landscape has been adequately defined, a representative sample of the public that visit and know about the SRB could then be asked to provide willingness-to-pay responses for the landscapes using a holistic valuation technique such as the contingent valuation method.

Estimates of the economic value of ecosystem services could then be input into the landscape GIS-type maps as a separate layer, the valuation layer. Then, as different land use changes or management activities are planned, the total economic value of these different alternatives could be calculated. It is important to emphasize two points to avoid abuse of such a system. First, only landscape alternatives that pass some type of ecological integrity test or threshold should be considered. Second, the various components of economic value should be displayed in as transparent a way as possible.

Economic value information contained in the GIS-type maps would be very helpful for evaluating trade-offs and choices between alternative landscapes. The GIS-type maps envisioned for describing an ecologically-sound landscape would also facilitate the consideration of noneconomic factors when assessing alternative ecosystem management strategies. This flexibility is important because the final decision on which landscapes to manage for in a particular area (e.g., USACE water resource project) will be based on both economic and noneconomic factors.

9.2. A "Second Best" Piecewise Approach

Time, money and logistical constraints may hinder development and implementation of the holistic, landscape ecosystem service valuation approach proposed above. In this case, a "second best" approach is to measure SRB ecosystem services following a piecewise approach. This approach would involve conducting separate studies at different times and/or places to value particular SRB ecosystem services. If this approach is taken, it would be preferable to conduct primary data studies for each ecosystem service for each time and place combination. For example, at each place and time combination, a revealed or stated preference primary data study would be conducted to measure each main ecosystem service.

If it is not possible because of time, money or logistical constraints to conduct a primary data study for each main ecosystem service for each time/place combination, benefit transfer is the next best option. Benefit transfer involves using secondary data from a existing studies (termed study site values) to estimate economic values for another site of policy or management interest for which primary valuation data do not exist (termed the policy site). Benefit transfer has commonly been applied by natural resource management agencies to transfer outdoor recreation values (e.g., see Rosenberger and Loomis 2001). It has been applied to a much smaller degree in studies using transfer values of other ecosystem services.

One of the primary reasons for the widespread use of benefits transfer to transfer outdoor recreation values is the abundance of primary data nonmarket economic valuation studies focusing on outdoor recreation which have been conducted in the past. Thus, there is a large library of secondary data on outdoor recreation values. For example, Rosenberger and Loomis (2001) identified 163 previous outdoor recreation valuation studies. For other ecosystem services, the library of secondary valuation data is much smaller because measurements of these additional ecosystem values have begun within the last decade.

Second to outdoor recreation, probably the most previous studies exist for ecosystem services supported by wetlands. For example, recent meta-analysis studies have identified over 30 previous studies which estimated economic value of ecosystem services supported by wetlands including nursery grounds for commercial fish species, water purification, nutrient storage, carbon sequestration and flood control (Brander et al. 2006; Brouwer et al. 1999; Woodward and Wui 2001). However, for other types of ecosystem services including those supported by other types of ecosystems (other than wetlands), only a few or perhaps no previous valuation studies exist, especially over particular types of ecosystems in different geographic regions. Thus, the scope of SRB ecosystem service valuation studies relying on benefit transfer will necessarily be limited by available economic valuation data.

In addition to available economic valuation data, the scope of SRB ecosystem service valuation studies relying on benefit transfer will also be limited by available ecologic data. Estimating the effects of environmental factors (e.g., quantity and quality of water in a SRB reservoir) and policy factors (e.g., reservoir management actions) on the economic value of ecosystem services requires linking changes in ecosystem functions to changes in economic values. A major ecosystem function in a reservoir managed ecosystem, for example, is natural development of water supplies through nutrient cycling and storage. Nutrient cycling and storage supports the ecosystem service of water purification, which supports other ecosystem services including recreational fishing, non-consumptive wildlife observation and clean drinking water. Without a clear understanding and data describing nutrient cycling and storage in a reservoir managed ecosystem, we cannot estimate, say, how a change in reservoir water quantity and quality will affect ecosystem service values even if we have reliable economic valuation data (such as we have, for instance, in the case of recreational hunting and fishing).

Thus, given both ecologic biophysical data and economic valuation data constraints, combined with time, money, and logistical constraints, a SRB ecosystem service valuation plan following a piecemeal approach will likely be limited to a relatively small, select subset of ecosystem services, especially if the piecemeal approach relies on benefit transfer. Ideally, separate valuation studies, whether based on primary data or benefit transfer data, would be conducted within a nested, holistic design which attempts to account for landscape-scale interdependencies between ecosystem processes/functions, services, and values.

It may also be prudent for valuation studies and application of values to management to follow the "safe minimum standard (SMS)" conservation approach to account for uncertainty. When faced with uncertain information regarding ecosystem processes/functions and economic values, the SMS approach states that we should maintain a minimally-viable population of say, fish and wildlife species, unless the costs of doing so are "unreasonably high" (see Bergstrom and Randall 2010, Chapter 19).

The SMS approach, for example, may suggest maintain a certain minimum "environmental flow" threshold in SRB rivers and streams adequate for keeping certain fish species from going extinct. Implementing the SMS is complicated by the difficulty of determining what are "minimally-viable" fish and wildlife population levels from an ecological perspective and what are "unreasonably high" costs from an economic perspective. Ultimately, implementation of the SMS approach would likely involve both science-based problem solving, public input and best-professional judgment and management.

10. Summary and Conclusions

Ecosystem management will require a decision support structure that is somewhat different from past natural resource planning models. While understanding the relationship among multiple inputs and outputs is still useful, the outputs of interest are more than board feet of timber, number of game fish and visitor days of recreation. For example, outputs or endpoints of interest also include measures of species diversity, carbon sequestration and water quantity and quality in different ecosystem types. Thus, both ecological and economic modeling will have to be more comprehensive and integrated than in the past.

The focus of economic valuation of ecosystem services should be on estimating total economic value in terms of net willingness-to-pay, not just financial value or cash-flow. To estimate changes in total economic value, changes in management action must first be specifically defined and then linked to changes in ecosystem functions and services. Changes in ecosystem services of benefit to humans must then be valued using an appropriate economic valuation technique. Management of ecosystems as a whole implies the need for more use of holistic economic valuation methods which capture both active and passive use values. An example of holistic valuation is estimation of the total economic value of an entire ecosystem landscape such as the SRB watershed (or sections of the watershed) using the contingent valuation method.

Obtaining total economic value estimates specific to each ecosystem or ecosystem landscape in different geographical regions across various time horizons is a substantial challenge. Economic value estimates can be integrated into a GIS mapping approach to be considered along with other factors. However, while economic value estimates are important to making ecosystem service provision and management responsive to public desires, they should be treated as one among many inputs to a broad, collaborative decision-making process involving many disciplines.

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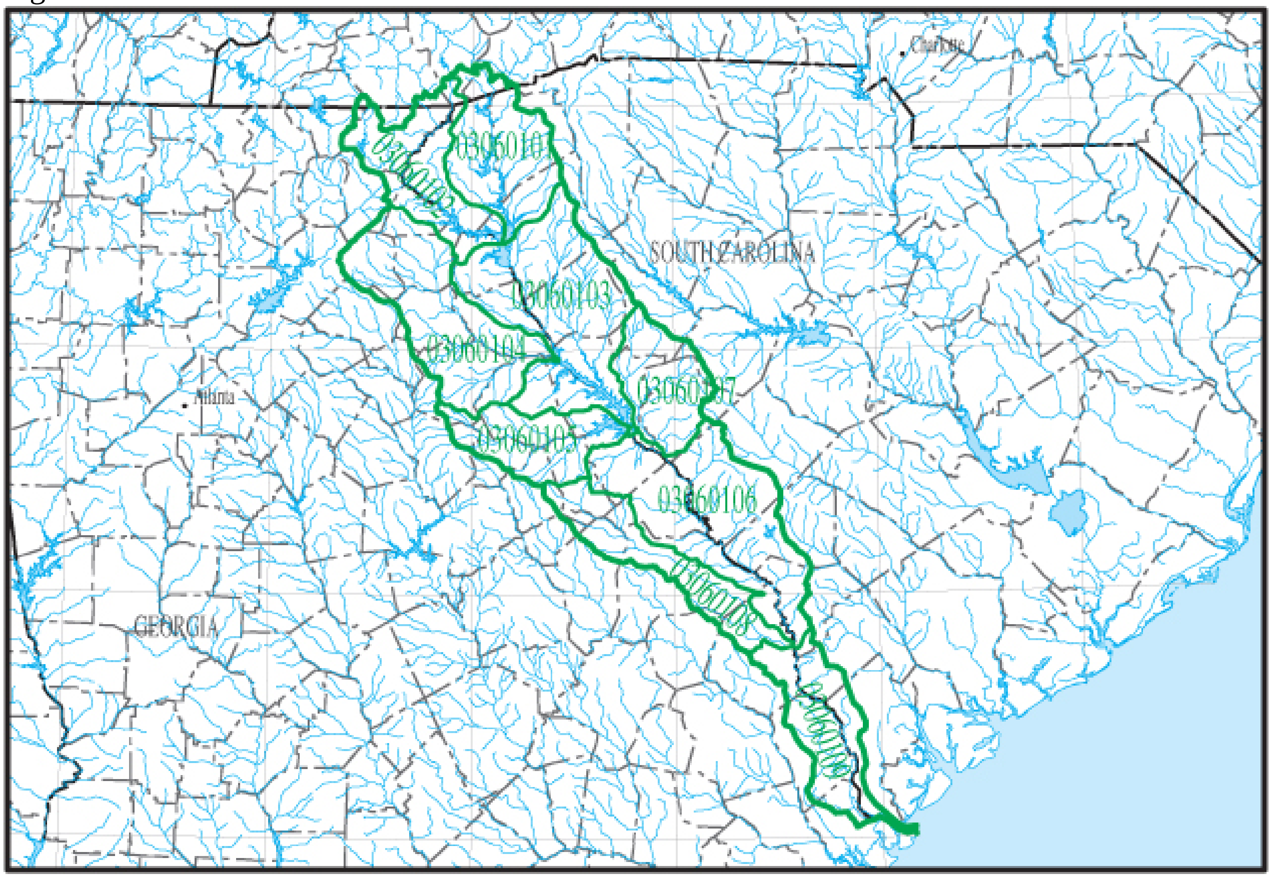
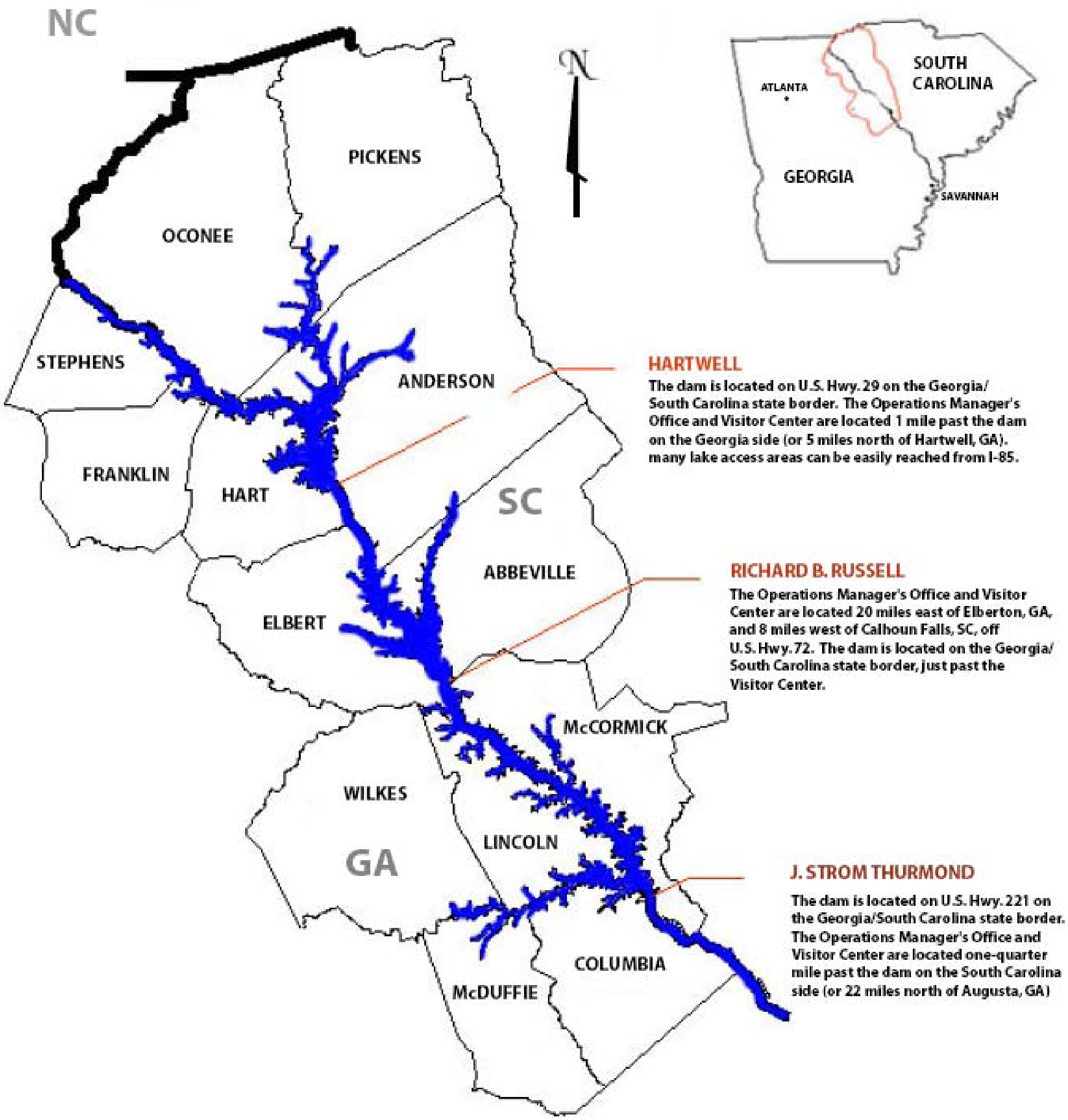
Figure 1: Savannah River Basin



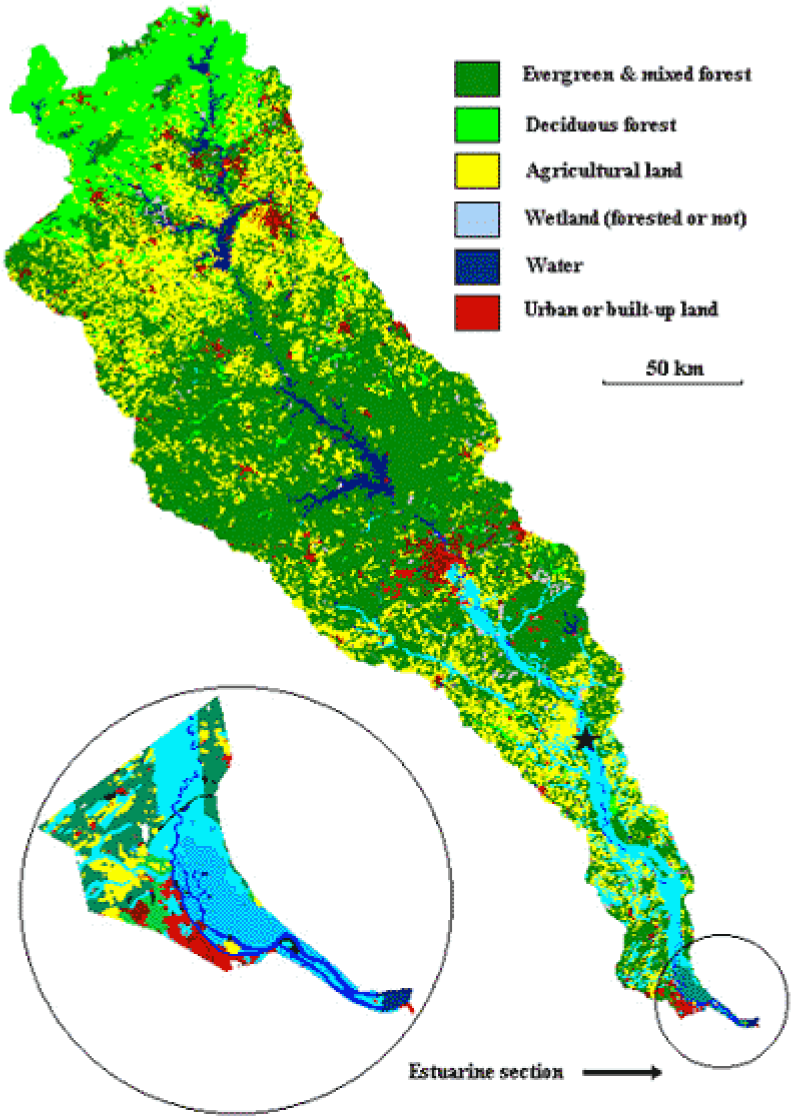
Source: Science in Your Watershed, US Geological Survey (http://water.usgs.gov/wsc/)

Figure 2. Major USACE SRB Water Resource Management Projects



Source: Draft Environmental Assessment and Finding of No Significant Impact: Temporary Deviation Drought Contingency Plan, Savannah River Basin. U.S. Army Corps of Engineers, Savannah District, October, 2008.

Figure 3. Land Cover and Land Use in the Savannah River Basin



Source: Georgia Rivers LMER (http://lmer.marsci.uga.edu/savannah.html)

Figure 4: Conceptual Linkages Between Management Actions, Ecosystem Structure, Ecosystem Functions/Processes, Ecosystem Goods and Services and Ecosystem Values

Valuation Linkages	Examples
Management Actions	Reservoir water-level management (e.g., normal guide curve releases; drought contingency plans)
Ecosystem Structure	Water quantity and quality in a reservoir and downstream from the reservoir; river and reservoir nutrient levels; river and reservoir fish and wildlife populations, salinity of lower reaches
Ecosystem Functions/Processes	Primary production, secondary production, food chain/web, nutrient cycling, hydrologic cycle (surface and ground water flows)
Ecosystem Goods and Services	Recreational fishing and hunting (days and catch), wildlife observation, carbon sequestration, nutrient storage, flood control
Ecosystem Values	WTP for fishing or hunting day WTP for wildlife observation day WTP for carbon sequestration Avoidance of flood damage and salt-water intrusion

Planning/ Engineering

Ecology

Economics

Table 1. Ecosystem goods and services

Ecosystem goods	*Ecosystem services*
Nonrenewable	Purification of air and water
Rocks and minerals	Translocation of nutrients
Fossil fuels	Maintenance & renewal of soil fertility
Renewable	Pollination of crops & natural veg.
Wildlife & fish (food, furs, viewing)	Dispersal of seeds
Plants (food, fiber, fuel, med. herbs)	Maintenance of precipitation patterns
Water	Erosion control
Air	Control of pests of plants or animals
Soil	Maintenance of biodiversity
Recreation opportunities	Protection from the sun's UV rays
	Partial stabilization of climate
	Moderation of temp., winds & waves
	Mitigation of floods and droughts
	Water transportation and navigation

Based on classifications developed by Boyd, J., and S. Banzhaf. "What are Ecosystem Services?" The Need for Standardized Environmental Accounting Units." Ecological Economics 63 (2007): 616-626; Brown, T.C., J.C. Bergstrom and J.B. Loomis. "Defining, Valuing and Providing Ecosystem Goods and Services." Natural Resources Journal 47, 2 (2007): 329-376; and Wallace, K. J. 2007. "Classification of Ecosystem Services: Problems and Solutions." Biological Conservation 139: 235-246.

Table 2: Ecosystem Goods and Services and Economic Values Associated with Natural Plant Development Function	
Ecosystem Good or Service	Economic Value
Change in quantity and(or) quality of on-site commercial plant harvest	Change in off-site, consumptive active use value to producers (e.g., producers surplus from commercial timber products) Change in off-site, consumptive active use value to consumers (e.g., consumers surplus from commercial timber products)
Change in quantity and(or) quality of on-site recreational plant harvest	Change in on-site, consumptive active use value to consumers (e.g., consumers surplus from edible wild plants)
Change in quantity and(or) quality of plants available for observation and photography	Change in on-site, non-consumptive active use value to consumers (e.g., consumers surplus from observing rare plants in their natural habitat) Change in off-site, non-consumptive active use value to producers (e.g., producers surplus from commercial photos or videos featuring natural plants) Change in off-site, non-consumptive active use value to consumers (e.g., consumers surplus from viewing personal or commercial photos or videos featuring natural plants at home).
Change in quantity and(or) quality of plants available for vicarious use	Change in vicarious, passive use value to consumers (e.g., existence value).

Table 3: Ecosytem Goods and Services and Economic Values Associated with Fish and Wildlife (F&W) Development Function	
Ecosystem Good or Service	Economic Value
Change in quantity and(or) quality of on-site commercial F&W harvest	Change in off-site, consumptive active use value to producers (e.g., producers surplus from commercial fish and wildlife products) Change in off-site, consumptive active use value to consumers (e.g., consumers surplus from commercial fish and wildlife products)
Change in quantity and(or) quality of on-site recreational F&W harvest	Change in on-site, consumptive active use value to consumers (e.g., consumers surplus from recreational hunting and fishing)
Change in quantity and(or) quality of F&W available for on-site observation and photography	Change in on-site, non-consumptive active use value to consumers (e.g., consumers surplus from viewing F&W in their natural habitat) Change in off-site, non-consumptive active use value to producers (e.g., producers surplus from commercial photos and videos of F&W) Change in off-site, non-consumptive active use value to consumers (e.g., consumers surplus from personal or commercial photos and videos of F&W)
Change in quantity and(or) quality of F&W available for vicarious use	Change in vicarious passive use value to consumers (e.g., existence value)

Table 4: Ecosystem Goods and Services and Economic Values Associated with Rock and Mineral (R&M) Development Function	
Ecosystem Good or Service	Economic Value
Change in quantity and(or) quality of on-site commercial R&M extraction	Change in off-site, consumptive, active use value to producers (e.g., producers surplus from commercial mineral products) Change in off-site, consumptive, active use value to consumers (e.g., consumers surplus from commercial mineral products)
Change in quantity and(or) quality of on-site recreational R&M use and extraction	Change in on-site, consumptive active use value to consumers (e.g., consumers surplus from finding and extracting minerals) Change in on-site, non-consumptive active use value to consumers (e.g., consumers surplus from rock climbing) Change in off-site, non-consumptive active use value to consumers (e.g., consumers surplus from viewing rocks and minerals at home)
Change in quantity and(or) quality of R&M available for on-site observation and photography	Change in on-site, non-consumptive active use value to consumers (e.g., consumers surplus from viewing rocks and minerals in their natural surroundings) Change in off-site, non-consumptive active use value to producers (e.g., producers surplus from commercial photos or videos featuring natural rocks and minerals) Change in off-site, non-consumptive active use value to consumers (e.g., consumers surplus from viewing personal or commercial photos or videos featuring natural rocks and minerals)

Table 5: Ecosystem Goods and Services and Economic Values associated with Natural Development of Water Supplies Function	
Ecosystem Good or Service	Economic Value
Change in quantity and(or) quality of on-site and off-site commercial water transportation services/navigation	Change in on-site and off-site, non-consumptive active use value to producers (e.g., producers surplus from on-site and off-site commercial transportation services/navigation) Change in on-site and off-site, non-consumptive active use value to consumers (e.g., consumers surplus from on-site and off-site commercial transportation services/navigation)
Change in quantity and(or) quality of on-site or off-site, water-dependent commercial production	Change in on-site and off-site, consumptive active use value to producers (e.g., producers surplus from on-site hydropower production, and producers surplus from withdrawing water for off-site manufacturing) Change in off-site, consumptive active use value to consumers (e.g., consumers surplus from off-site electricity consumption)
Change in quantity and(or) quality of on-site or off-site recreation	Change in on-site, non-consumptive active use value to consumers (e.g., consumers surplus from change in quality of swimming SRB lakes and rivers) Change in off-site, non-consumptive active use value to consumers (e.g., consumers surplus from change in quality of swimming in on non-SRB lakes and rivers fed by SRB lakes and rivers)
Change in quantity and(or) quality of on-site or off-site drinking water	Change in on-site or off-site, consumptive active use value to producers (e.g., producers surplus from commercial drinking water) Change in on-site or off-site, consumptive active use value to consumers (e.g., consumers surplus from personal or commercial drinking water)
Change in quantity and(or) quality of water for off-site vicarious use	Change in vicarious passive use value to consumers (e.g., existence value)

Table 6: Ecosystem Goods and Services and Economic Values associated with Natural Development of Air Supplies Function	
Ecosystem Good or Service	Economic Value
Change in quantity and(or) quality of on-site and off-site air for human breathing	Change in on-site or off-site, non-consumptive active use value to consumers (e.g., consumers surplus from on-site and off-site air breathing)
Change in quantity and(or) quality of on-site or off-site, air for human viewing	Change in on-site or off-site, non-consumptive active use value to consumers (e.g., consumers surplus from clear atmospheric visibility)
Change in quantity and(or) quality of on-site or off-site climate regulation (e.g., temperature moderation)	Change in on-site or off-site, non-consumptive active use value to consumers (e.g., consumers surplus from on-site or off-site enjoyment of more moderate temperatures)
Change in quantity and(or) quality of air for off-site vicarious use	Change in vicarious passive use value to consumers (e.g., existence value)

Endnotes

[1] Under Section 206 of the Water Resources Development Act of 1996 "National Ecosystem Restoration" goal, the U.S. Army Corps of Engineers may plan, design and build projects to restore aquatic ecosystems for fish and wildlife.

[2] Economic valuation of benefits is not required for projects that fall under the Section 206 "National Ecosystem Restoration" goal (see Endnote 1), which is different from the "National Economic Development" goal which does require consideration of monetary benefits (e.g., see U.S. Water Resources Council. 1983. Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. Washington, D.C.: U.S. Water Resources Council, March 10).