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# Exploring the Use of Ecosystem Services Conceptual Models to Account for the Benefits of Public Lands: An Example from National Forest Planning in the United States

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**Abstract:** A shared understanding of the benefits and tradeoffs to people from alternative land management strategies is critical to successful decision-making for managing public lands and fostering shared stewardship. This study describes an approach for identifying and monitoring the types of resource benefits and tradeoffs considered in National Forest planning in the United States under the 2012 Planning Rule and demonstrates the use of tools for conceptualizing the production of ecosystem services and benefits from alternative land management strategies. Efforts to apply these tools through workshops and engagement exercises provide opportunities to explore and highlight measures, indicators, and data sources for characterizing benefits and tradeoffs in collaborative environments involving interdisciplinary planning teams. Conceptual modeling tools are applied to a case study examining the social and economic benefits of recreation on the Ashley National Forest. The case study illustrates how these types of tools facilitate dialog for planning teams to discuss alternatives and key ecosystem service outcomes, create easy to interpret visuals that map details in plans, and provide a basis for selecting ecosystem service (socio-economic) metrics. These metrics can be used to enhance environmental impact analysis, and help satisfy the goals of the National Environmental Policy Act (NEPA), the 2012 Planning Rule, and shared stewardship initiatives. The systematic consideration of ecosystem services outcomes and metrics supported by this approach enhanced dialog between members of the Forest planning team, allowed for a more transparent process in identification of key linkages and outcomes, and identified impacts and outcomes that may not have been apparent to the sociologist who is lacking the resource specific expertise of these participants. As a result, the use of the Ecosystem Service Conceptual Model (ESCM) process may result in reduced time for internal reviews and greater comprehension of anticipated outcomes and impacts of proposed management in the plan revision Environmental Impact Statement amongst the planning team.

**Keywords:** nature's benefits; socio-ecological systems; recreation planning



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## 1. Introduction

Ecosystem services, broadly defined, are the benefits people receive from nature. Integration of ecosystem services into management gained global prevalence following the release of the Millennium Ecosystem Assessment (MA) [1]. The MA was a response to

challenges identified in the International Convention on Biological Diversity, the United Nations Convention to Combat Desertification, the Ramsar Convention on Wetlands, and the Convention on Migratory Species. These conventions and the governments supporting them saw a need to better define ecosystem services and develop a scientific agenda to guide policy and management.

Implementation of the MA ideals have gained momentum in the European Union following the development of the Common International Classification of Ecosystem Services (CICES) [2] and the Mapping and Assessment of Ecosystem Services (MAES) [3]. Both efforts standardized descriptions of ecosystem services aligned with the MA and aided more consistent monitoring of ecosystem services. A review of the EU policies shows moderate integration of the ecosystem services concept, in general, with strong integration in environmental and energy policies [4].

In the United States, natural capital and ecosystem services featured prominently in a 1998 report and a 2011 follow-up report from the President's Council of Advisors on Science and Technology (PCAST) [5,6]. The reports provided specific recommendations for building capacity within the federal government to address ecosystem services. With subsequent direction from the White House, the U.S. Forest Service became one of the first U.S. land management agencies to require ecosystem services be addressed in planning documents via the 2012 Forest Service Planning Rule [7]. The U.S. Forest Service manages 193 million acres of public lands, including 154 national forests and 20 national grasslands.

The inclusion of ecosystem services in the 2012 Forest Service Planning Rule [8] was based in part on the Millennium Ecosystem Assessment and relies on sustainability objectives consistent with the Montréal Process (officially known as the Montréal Process Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests—it is a voluntary agreement on sustainable forest management) and other international indicators, criteria, and metrics for measuring performance [9]. The Planning Rule expanded the discussion of forest values beyond the categories required by the Multiple-Use Sustained-Yield Act of 1960 [10], which requires national forests to be managed for outdoor recreation, range, timber, watershed, wildlife, and fish (i.e., multiple-uses). It requires forests to address key ecosystem services, defined as ecosystem services that are: (1) important to people in the broader landscape or beyond the plan area itself, and (2) likely to be affected by the management plan under revision.

The 2012 Planning Rule gives broad discretion to planners in addressing ecosystem services, but it does not recommend procedures for addressing ecosystem services during assessments, planning, or monitoring. The Rule does not require forests to maintain specific levels of ecosystem services, nor does it require forests to use language specific to ecosystem services as long as they address forest benefits. The flexibility in addressing ecosystem services in forest plans recognizes the inherent difficulty associated with planning for ecosystem services, but in some cases, has led planners to rely heavily on traditional methods and data for analyzing multiple uses and on narrative discussions of other ecosystem services. The integrity of the forest planning processes thus depends on planning teams developing effective ways of identifying, communicating, and evaluating ecosystem service benefits in ways that policymakers and the public both understand and trust. Jaworski et. al. provide a five-step process that National Forest planning teams, with public and stakeholder input, can use to describe how people benefit from a National Forest and how those benefits might change under plan revision [11]. However, the five-step process does not provide details about tools for engagement and encourages planning teams to consider augmenting the five-step process with engagement methods or tools to better identify and evaluate key ecosystem services as well as feasible indicators representing benefit perspectives of the public and forest staff.

The 2012 Planning Rule further requires that key ecosystem services be tracked throughout the planning process and that management plans include standards, guidelines, and objectives that "guide the (forest) plan area's contribution to social and economic sustainability, taking into account: ecosystem services". Social and economic sustainability is

defined as the capability to meet the needs of the present generation without compromising the ability of future generations to meet their needs, including the capability of society (i) to produce and consume or otherwise benefit from goods and services including contributions to jobs and market and nonmarket benefits and (ii) to support vibrant communities including the network of relationships, traditions, culture, and activities that connect people to the land and to one another. Indicators of economic sustainability typically consist of a combination of environmental, social, and economic performance measures. The Montréal Process [9], including MP Criterion 6 and associated indicators for "socio-economic benefits to meet the needs of societies", provides an international framework to report on the status of sustainable forest management. These criteria and indicators are tracked in the United States through the Forest Service's National Reports on Sustainable Forests (e.g., [12]), and many indicators are tracked as part of the National Forest planning and monitoring process [13]. Examples of MP6 indicators used to assess sustainable National Forest management in the context of recreation benefits include: area of forest available for public recreation and tourism; area of forest managed primarily to protect cultural, social and spiritual values; and number, type, and geographic distribution of visits attributed to recreation and tourism. The Montréal Process and other international sets of sustainability criteria and indicators (e.g., United Nations - Inclusive Wealth Index) serve as reliable and consistent foundations for representing forest benefits; however, those sources are expected to require modification and augmentation to reliably address ecosystem service benefits at a more localized (e.g., National Forest) level.

A review of four national forest planning processes in the U.S. under the new rule found an emphasis on ecological rather than social and cultural resources, and little information on benefits to people (ecosystem services) [14]. They suggested that additional resources may be needed to help planners incorporate new ideas around ecosystem services into the planning process.

Over the same time period that the USFS was moving forward on ecosystem services, the National Ecosystem Services Partnership (NESP) [15], a community of practice led by Duke University's Nicholas Institute for Environmental Policy Solutions, has brought together academic experts and federal agency researchers and practitioners in the U.S., including the Forest Service, to move ecosystem services from a concept to an on the ground practice used by resource managers. The approach co-developed by NESP with academic experts and agency partners addresses the needs of agency decision makers in a number of ways. (1) It helps resource managers push beyond traditional concepts of ecosystem services, which are often ecological concepts like sediment levels in streams or miles of recreational trails, to the social and economic outcomes that people value, like impacts of sediment on water treatment costs for downstream communities or number of people using recreational trails each day. (2) It prioritizes measurement over monetization. Recognizing the difficulty of monetizing services in many cases, the focus is on measures that incorporate the connection to people; measuring something that people value or care about [16]. (3) It also emphasizes inclusion of all services, not just those that can be monetized or quantified so that trade-offs and co-benefits can be fully considered. (4) Furthermore, it lays the groundwork for consideration of who will be affected and how; which is particularly important if there are trade-offs across communities [17,18].

NESP work has focused on building a credible, feasible, consistent, transparent, and flexible set of tools to support implementation [19,20].

- Credible: aligned with the latest science and acceptable methods and reviewed by experts. Not the best available science, because that is often not feasible—requiring expertise, capacity, resources and time that managers do not have.
- Feasible: uses methods that require little or no specialized training in ecosystem services for a first order consideration or assessment of alternatives and development of metrics for monitoring. Can integrate easily with a second order, more quantitative or complex methodology run by specialists.

- Consistent: uses a common approach, terminology, set of interventions, outcomes, and metrics; and lays the ground for a common set of methods for predictive models and monitoring.
- Transparent: emphasizes use of a common framework—an ecosystem services conceptual/logic model—which forces a clear illustration of what ecosystem services are being considered, how they are connected to resource management and to wellbeing (social and economic impacts).
- Flexible: the primary framework—the ecosystem services models—are designed to be adaptable to specific contexts and uses. They are the basis for a series of different applications depending on resource manager's needs: team understanding; stakeholder engagement; educational materials; beneficiary and equity consideration; selection of metrics for monitoring, scaffold for evidence assessment and identification of research needs; and a framework for development of predictive models.

At the center of the NESP approach is a set of general ecosystem service conceptual models or templates that provide a common starting place for applications. Ecosystem services conceptual models (ESCMs) can help to simplify and streamline consideration of ecosystem services in decisions [21–28]. These conceptual models link changes in biophysical systems (like a forest) caused by an intervention (like wildfire risk mitigation) to changes in socio-economic and human well-being outcomes (like fire related property damage, respiratory health, and sediment triggered water treatment costs) and can also include direct, not environmentally mediated, changes in human well-being (like forest management jobs created) (Figure 1) [23,29]. They are built for common habitat types and common interventions or stressors that can be applied and adapted by resource managers to meet their specific needs [29]. Given a constrained set of ways in which managers manipulate the natural environment and a fixed number of effects such management can have on the environment and people, it appears possible for most natural resource management activities to establish a reference set of evidence-based conceptual models that can provide efficiency and consistency in application.

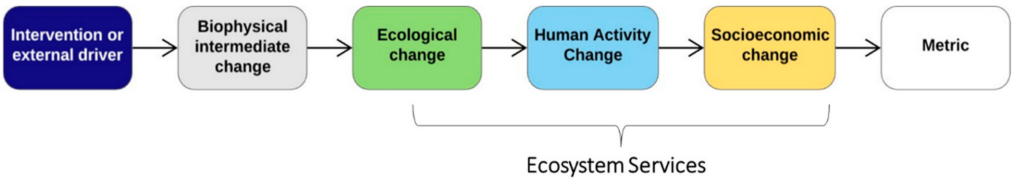



**Figure 1.** Ecosystem Services Conceptual Models show how a management intervention or external stressor or driver cascades through a natural system to have impacts on human activities and their social and economic wellbeing. The linkages between ecological change and socio-economic changes are the ecosystem services.

Based on our experience in multiple management contexts and that of colleagues, adapting generic ESCMs to specific management contexts is an excellent way to conduct an effective and transparent dialog among experts, researchers, managers, and engaged stakeholders to understand impacts on the ecological system and the social and economic outcomes. The result is a transparent, systematic, and hopefully complete picture of expected changes, not just targeted outcomes, allowing identification and consideration of co-benefits and trade-offs.

By transparently and credibly identifying social and economic impacts that are strongly linked to management choices or stressors, ESCMs provide a useful starting point for identifying socio-economic metrics that can be added to monitoring plans [30]. These social and economic metrics can be benefit relevant, linking ecological and social factors (provision and use; supply and demand), or values based on costs (e.g., loss of property) or people's willingness to pay [16,29,31]. Ideally metrics are developed for the socioeconomic impacts (yellow boxes) but when that is not feasible given data or methods, metrics for human activities (light blue boxes) can be a reasonable plan B.

In this paper, we describe a case study that explored how the methods and tools developed by NESP can be adapted by the USFS in its forest planning process, including in the identification of metrics to analyze and communicate the outcomes and tradeoffs associated with forest plan alternatives.

## 2. Materials and Methods

Foundational work to understand the primary management activities of the Forest Service and how these may alter the provision of ecosystem services was conducted through a series of conversations and interviews of experts and practitioners at the Forest Service. These resulted in the development of general or template ESCMs for some of the main management priorities for the Forest Service: timber management, fire management, and recreational management. Fire management has so many variations that we developed three models and still did not capture all of the management variables or how they interact. They include managing forests: (1) before fire to reduce risk, (2) during fire to perform suppression or not, and (3) short-term post fire management (seeding, mulching, closures, etc.) [32].

To explore the application of these ESCMs to a forest planning context, we worked with the Ashley National Forest (the Ashley) in northeastern Utah and southwestern Wyoming. The forest is over 1.38 million acres of forest, lakes, and mountains with elevation ranging from 6000–13,500 feet. Lands within the Ashley National Forest support a diverse range of vegetation, wildlife, geology, uses, and activities. Some key resources and resource uses on the Ashley include land and water-based recreation, wildlife habitat, livestock grazing, timber, and wildfire mitigation [33].

The Ashley is currently undergoing a forest planning process to update its 1986 Forest Land Management Plan to address current ecological, economic, and social conditions and trends. An Environmental Impact Statement (EIS) is a necessary part of forest plan revision in order to comply with the National Environmental Protection Act (NEPA). The EIS for plan revision includes a comparison of the environmental impacts, including socioeconomic and public benefit effects (e.g., ecosystem services), across forest plan alternatives. Effects can be described qualitatively if quantitative measures are not feasible), As a part of this planning process, the Ashley was interested in exploring a new way to (1) document the consideration of ecosystem services, (2) develop methods for communicating impacts to, and benefits from, ecosystem services with stakeholders, (3) identify ecosystem services metrics to support analysis of proposed management and alternatives in the plan revision Environmental Impact Statement (EIS) as required under the National Environmental Policy Act (NEPA), and (4) monitor progress toward ecosystem service (social and economic) goals after plan implementation. Forest plans provide broad guidance for forest management. Plans do not describe or address outcomes of specific projects or activities, although any proposed projects must be consistent with the forest plan. Forest plans establish multiple-use and ecosystem services goals and objectives, and establish management areas that inform the selection and design of future projects. Given the importance of recreation in the Forest plan, the Ashley wanted to start the process by looking at implications of recreational management on ecosystem services.

We conducted two meetings with the forest management planning team (economist, forest recreation program manager, soil and water program manager, civil engineer, wildlife biologist, collaboration specialist, archeologist, regional recreation and landscape planner, and regional planner) and the contractor for the EIS. The first was a 1-h virtual meeting where the Duke University team facilitated a dialog about adapting a generic project scale recreational forest management ESCM to the forest plan alternatives for the Ashley. A background document with the generic ESCM and the list of discussion questions were sent to all participants so that they could prepare and were able to read along (Supplementary Materials, Document S1). This virtual meeting started with a review of the generic project scale recreational management model built by the Duke team, and was followed by a facilitated discussion to adapt the model to the context and needs of the

Ashley. The discussion walked through how the management actions, human activity outcomes and socioeconomic outcomes, as described in the generic template model, should change to better reflect potential forest resource and recreation conditions and planning decisions on the Ashley. We also discussed whether there were specific species management issues (e.g., birding, hunting, listed species) that needed to be added, and whether there were any significant relationships between management and outcomes (arrows in the model) that were missing.

With some back and forth between the research team and the Ashley planning leads to answer remaining questions, a revised Ashley National Forest model was developed. The forest planning team was then asked to identify which social and economic outcomes were (1) most likely to be affected significantly by the plan, and (2) most important for them to quantify and monitor. These outcomes were separated into two categories – most important and less important.

During the second virtual meeting (4 h) we reviewed possible metrics for the outcomes identified in the new ESCM. Before this meeting, the Forest Service research leads built a spreadsheet that included a preliminary starter list of metrics and how they could be measured for each of these outcomes as a resource for this meeting. Metrics and methods on the spreadsheet came from:

- metrics addressed by other national forests that had completed their plans under the 2012 Planning Rule, listed on the USFS planning website https://www.fs.usda.gov/planningrule (accessed on 1 December 2020);
- items identified in the USFS Resource Planning Act (RPA)–Land Management Plan Data Catalogue that links RPA data products with Plan directives [34], and
- familiar products from Forest Service scientists working on recreation, including data from the National Visitor Use Monitoring Program [35,36] and studies on equity and recreation on national forests [37].

Before the meeting proposed metrics for each outcome were provided (Supplementary Materials, Document S2). We shared a Google sheet spreadsheet live during the virtual meeting that included the outcome category (grazing, recreation), the outcome group (economic activity, cultural value), the metric type (human activity or socioeconomic), outcome importance (more or less), suggested metric, data source or method for measurement, and notes (see final version of metrics spreadsheet in Supplementary Materials, Table S1). We took notes and updated the database in real time during the call.

This initial set of example metrics and measurement approaches provided the basis for a discussion of (1) whether these were the right metrics, (2) whether they were measurable, and (3) if additional ones were needed. We asked the forest planning team to consider the following characteristics of the metrics:

- Attribution: Would you expect to see a change in this metric due to the management alternatives? Is the signal greater than the noise?
- Scale: On what spatial and temporal scales would it make sense to measure the metric? Would this work for an individual forest project or would it work better for an aggregate measure of multiple projects (cumulative effects) for the forest or watershed or region?
- Equity: Can the metric show how the outcome is distributed across different communities, including underrepresented communities or tribes?
- Data sources: Is there existing data collection to support this metric, or would new data need to be collected?
- Feasibility: Is this a realistic metric, given the available data and additional work that would be required to measure it?
- SMART: Is it a SMART metric—specific, measurable and repeatable, attainable, relevant, time bound, and at the right spatial scale [38].

The planning team provided input on the metrics list, removing, adding, and suggesting alternative metrics. The research team then responded to these suggestions and

prepared a revised spreadsheet of metrics and shared that back with the forest planning team. We conducted a call with the planning team lead, planning consultant, and Forest Archaeologist to review the revised metrics and get additional input on metrics related to tribal and cultural resources. The planning consultant, assigned the task of writing the EIS and serving as the socioeconomic specialist, identified which metrics would be useful for the EIS, and which would be useful for monitoring, where those were different. During both meetings we also explored the idea of using simplified versions of the ESCM for communicating with forest service stakeholders during the planning process.

Following the meetings with the Ashley Forest planning team, we conducted a survey to find out how well the process worked and how the team had used or was planning to use the ecosystem service conceptual model and ecosystem service metrics (survey questions, Supplementary Materials, Document S3). The online survey was sent to all members of the planning team who participated in at least one workshop or call.

## 3. Results

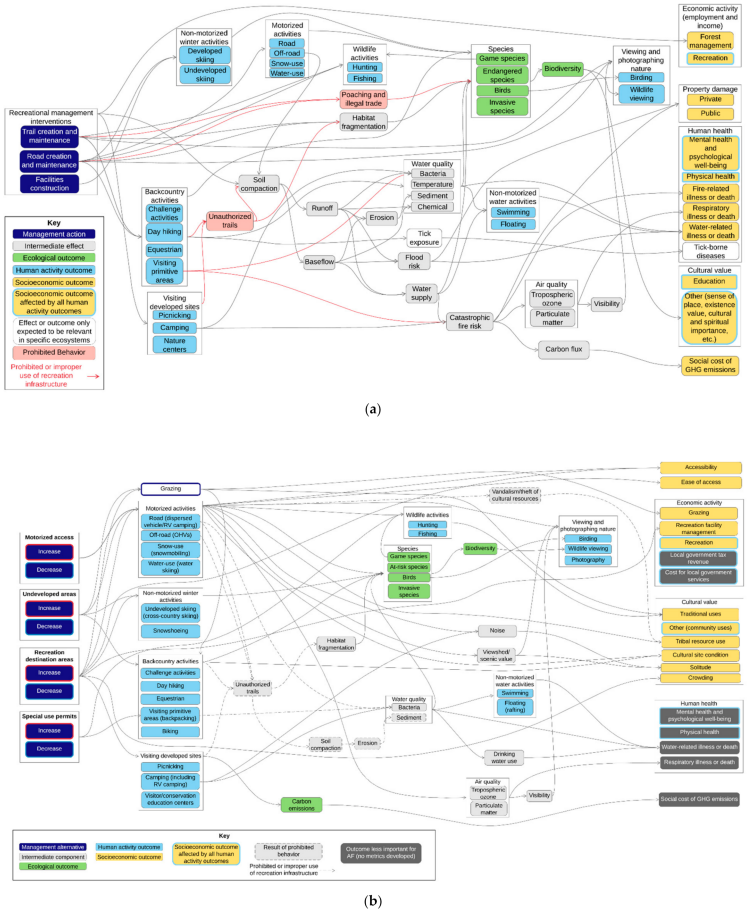
### *3.1. Adapting and Specifiying an Ecosystem Services Concetual Model for Forest Planning*

In general, engagement between the research team (i.e., Duke University and Forest Service Research staff) and the Ashley planning team revealed a number of productive collaboration opportunities and challenges in considering ecosystem service benefits through the use of the ESCM tool and methodology.

#### 3.1.1. Translating a Project Planning and Management Model into a Forest Plan Model

The base ESCM, which is designed for project scale recreational management (Figure 2a) [39], provided a useful starting place for dialog focused on adjusting and adapting the model for planning and the Ashley National Forest context. The resulting forest plan scale model (Figure 2b) is significantly different from the project scale model as follows:

- Spatial and temporal scale: The project scale model is based on management for a particular place and time, likely one forest type with common management goals, whereas a forest plan covers many different habitats (upland forest, wetlands, remote vs. high visitation sites) and multiple recreational management goals (hunting, camping, grazing, carbon storage, access) across a forest. Normally a project scale model, once applied to a specific site, would have details on key species, recreational activities, and outcomes (yellow boxes) that would be affected by the management action under consideration. Because the planning model has to apply more broadly it tends to maintain more generic categories for all of these.
- Management actions (dark blue boxes): The recreational management actions in the project scale model are very specific—trail creation and maintenance, road creation and maintenance, and facilities construction. In contrast, the forest plan mostly focuses on broader objectives and desired conditions across the Forest such as changes in access—motorized access and special use permits—and the extent of different types of recreation opportunities to be offered, e.g., undeveloped areas and recreational destination areas.
- Alternatives (dark blue boxes): For the project scale model, management actions are either included, e.g., a trail is being created or maintained, or it is not and would be dropped from the model. In contrast, for the forest plan model, broader strategy options (alternatives) are considered to increase or decrease access and extent of different types of recreational activity opportunities offered. These are not yet formulated into specific on-the-ground projects.
- Level of detail: While the project scale model includes significant detail on the biophysical and ecological changes (shown in light gray) linking the management and the socio-economic outcomes. These were viewed as less important to include in the planning models where we were focused on identifying social and economic outcomes.




(**a**)




(**b**)

**Figure 2.** This figure shows the (**a**) original recreational management ESCM built for project scale planning and management; and (**b**) the adapted recreational management ESCM built for the Ashley planning process. In both models, socio-economic outcomes (yellow boxes) with blue outlines indicate that every human activity outcome (blue) would have an arrow going to that outcome. This was done to reduce the number of arrows.

The other big difference between the models—where outcomes that are typically yellow boxes are shown in gray in the planning model—was for communication purposes. The outcomes in the gray boxes were left in the planning model because the planning team thought they might be important to stakeholders and wanted to show that they had been considered, even though the team thinks they are unlikely to change substantially due to the proposed alternative recreational strategies offered by the Forest plan. The forest planning team was able to adjust the project-level model into something that represented alternative recreation management for their forest planning process (changes summarized in Table 1).

**Table 1.** Changes in ecosystem services outcomes between the generic, project-scale recreational model, and the Ashley National Forest Plan scale model. The X indicates whether the outcomes was not changed, dropped or added in the transition from a project scale to a planning scale model.

| Outcomes | No Change | Dropped | Added | Specified/Clarified |
|---|---|---|---|---|
| Economic Activity–Management | | | | Recreation facility management |
| Economic Activity–Recreation | X | | | |
| Economic Activity–Grazing | | | X | |
| Accessibility | | | X | |
| Ease of access | | | X | |
| Cultural value–Traditional uses | | | X | |
| Cultural value–Other | | | | Cultural value–other (community uses) |
| Cultural value—Tribal resource use, cultural site condition, solitude, crowding | | | X | |
| Cultural value–Education | | X | | |
| Property damage | | X | | |
| Human health–Mental health and psychological well-being, physical health, water-related illness or death, respiratory illness or death | X | | | |
| Human health–Fire-related illness or death, tick-borne disease | | X | | |
| Social cost of greenhouse gas emissions | X | | | |

#### 3.1.2. Specifying Ecosystem Service Outcomes for the Ashley National Forest Plan ESCM

Specifying the outcomes—the human activities and socio-economic outcomes—in the conceptual model to the context of the Ashley National Forest resulted in significant changes from the generic project scale recreational management model (Figure 2a,b; Table 1). This process included dropping or "graying out" categories that are not relevant. For example, all of the potential human health outcomes, such as respiratory related illness related to smoke inhalation from fire, were considered either unlikely to occur in the Ashley National Forest or not likely to change due to the recreational plan components being considered in plan revision. Similarly, recreational plan components are not expected to significantly change carbon storage and sequestration and the contribution of this forest to mitigating climate change. New categories were also added during the discussion of metrics. Ease of access was added given it is a primary objective of the Ashley's management plan. And accessibility was added given that two priority recreational objectives (motorized activities and destination recreation areas) can have significant effects on the accessibility of recreational activities for families, young, elderly and disabled communities. The ESCM and metrics processes tend to be iterative and build upon one another.

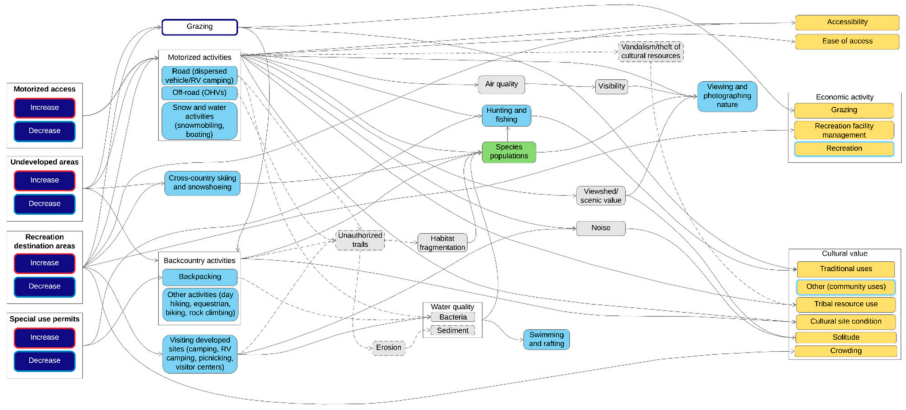
In addition to dropping and adding categories, we also specified outcomes to the Ashley context. For example, numerous specific outcomes were added to the category of cultural values, such as traditional uses (e.g., hunting), other community uses (e.g., use of wilderness areas for backpacking), tribal resource use, cultural site condition, solitude, and crowding. Given the local context of cultural values, it is expected that these will be added and changed for any application, at the project or planning scale.

#### 3.1.3. Facilitating a Common Understanding of Management Impacts for the ESCM

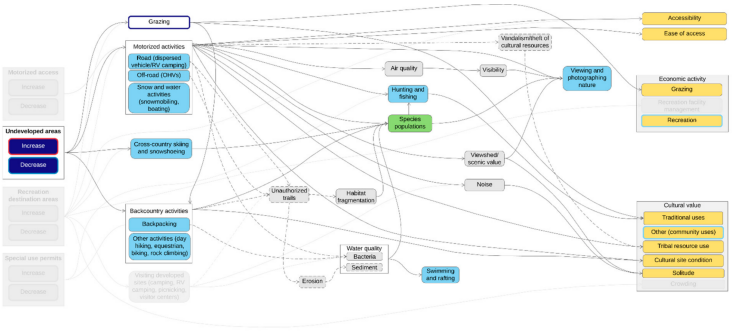
In the traditional plan revision workflow process, the relationships between proposed management and human benefit outcomes are developed independently by the USFS specialists or contractor, and reviewed once incorporated into the EIS analysis. Use of the ESCM model and the dialog between participating members of the Forest planning team to develop this model allowed for a more transparent process in identification of key linkages and outcomes. In addition, participation of Forest resource specialists allowed opportunity for identification of impacts and outcomes that may have not been apparent to the person writing the EIS, who might lack the resource specific expertise of these participants. As a result, the use of the ESCM model process may result in reduced time for internal reviews and greater comprehension of anticipated outcomes and impacts of proposed management in the plan revision EIS amongst the planning team.

#### 3.1.4. Exploring the Use of a Simplified ESCM for Stakeholder Communication

The Duke team proposed several simplified versions of the ESCM for possible communications tools. These included a version with many intermediate nodes removed (Figure 3a), a version showing the impacts for each management category separately (Figure 3b), and a version showing how different management activities connected to a single outcome (Figure 3c). We also discussed how the models could be used to show expected positive or negative relationships from a specific management choice (e.g., increase motorized access), indicated by color coding the arrows in a model. The Ashley team decided not to move forward with any of these, but recognized the potential use of these simplified models for communication of linkages between proposed management and socioeconomic outcomes for internal or external audiences.




(**a**)



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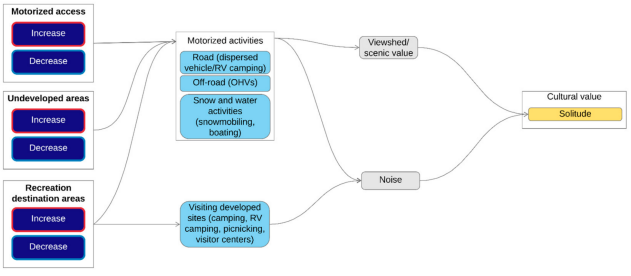


(**c**)

**Figure 3.** Simplified visualizations of the ESCMs explored for communication purposed include one (**a**) with fewer intermediate nodes, (**b**) one showing pathways and outcomes for a single management category, and (**c**) one showing what management categories and pathways lead to single outcomes.

### *3.2. Selection of Ecosystem Service Metrics*

Qualitative and quantitative metrics for ecosystem services outcomes in the Ashley National Forest ESCM were identified for two purposes: (1) clarifying differences in benefits and contributions to social and economic sustainability across plan alternatives, consistent

with efforts to provide an environmental impact statement for NEPA compliance [40,41], and (2) as metrics for monitoring human activity and social and economic impacts at plan implementation to demonstrate progress toward achieving or maintaining forest plan objectives and desired conditions, consistent with 2012 Planning rule requirements [8].

The initial list of metrics and measures provided an effective starting point for discussing appropriate metrics for the planning process. The group was able to jump right into discussing the details. The initial list included 40 metrics, including possible metrics for the outcomes in gray in the ESCM (Figure 2b) that were considered difficult to attribute to a change in forest management strategy and less important to the Ashley National Forest. All of these less important metrics were dropped. The final list included 30 metrics. Example metrics can be found in Table 2. (To see the final metrics table, see supplementary Table S1. To see the difference between the initial list of metrics and the final list see supplementary Table S2.) For economic activity we were able to find existing data sets and models such as market prices, Census of Agriculture, IMPLAN, and the USFS's Benefits to People at a Glance Reports (https://www.fs.fed.us/emc/economics/at-a-glance/index.shtml (accessed on 1 December 2020)) that allowed us to develop socio-economic metrics like grazing value, grazing community jobs, relative importance of grazing compared to other resources to Ashley National Forest users, number of people with livelihoods supported, recreational jobs, and income. (IMPLAN (IMpact analysis for PLANning) is an input–output economic modeling tool and dataset commonly used for economic impact analysis. IMPLAN was originally developed by the U.S. Forest Service and has since been privatized and managed by the IMPLAN Group LLC. IMPLAN is used by the agency to carry out economic impact studies of the agency's decisions and proposed actions. The Benefits to People at a Glance reports use IMPLAN data, supplemented with other agency data. These reports are available for each national forest and describe benefits associated with jobs and economic activity attributable to that national forest. The reports are available at (https://www.fs.fed.us/emc/economics/at-a-glance/benefits-to-people.shtml (accessed on 1 December 2020).). For cultural values, qualitative metrics or human activity metrics were proposed such as number of cultural sites, number of people visiting the sites, variety of site types, area of habitat supporting culturally important species, ranking of potential for use conflicts around tribal or cultural resources, ranking of potential negative impacts to sites, and mapping how management actions could impact tribal resources, solitude, and crowding.

For many different outcomes, metrics around quality of experience and ease of access were of interest to the planning team, including outcomes like solitude, crowding, access to recreation, and experience of use for different user groups (e.g., solitude seekers, large groups, hunters, mobility impaired visitors, off highway vehicle (OHV) users, etc.). To address this, we developed what we called an access and quality of experience matrix (Figure 4) that maps user groups to the areas and amenities they prioritize. It can be filled in for different plan alternatives, showing predicted increases, decreases, or no change in access and quality of experience, enabling visualization and transparency around potential differences in user group benefits. The Forest Planning team found these tables helpful. The tables shown here are examples, that are likely to be further refined by the Ashley National Forest.

Some metrics were not feasible to measure (e.g., youth participation in hunting and fishing). When data for selected metrics were not readily available and/or not feasible to collect in a timeframe consistent with the EIS schedule, the team explored other metrics or options for measurement for these outcomes, such as the access and quality of experience matrix described above. The 2012 Planning Rule emphasizes that Forests should rely on existing and readily available information/data—implying there is no need to pursue collection of new data. Other metrics were refined, like utilization rates of sites for solitude or crowding that specified changes in the forest in those geographies most relevant, for example, in undeveloped vs. developed sites. Other metrics were dropped either because they were viewed as not useful (e.g., revenues to ven-

dors or site fees) or were unlikely to change given the forest plan (e.g., length of time grazing leases held). Many new metrics were developed for the new outcomes identified during the metrics discussions, such as accessibility (ABA, Architectural Barriers Act; https://www.gsa.gov/real-estate/design-construction/accessible-facility-design (accessed on 1 December 2020)) and ease of access (for different uses). Most of the accessibility metrics included are typical for forest planning (e.g., number of accessible parking spaces, toilets, etc.). The ease of access metrics mostly use the access/quality of experience matrix developed during this project (Figure 4). A number of new metrics were also developed for cultural outcomes around the number and variety of cultural and heritage opportunities and visitation to them. And in addition to metrics for traditional uses, metrics specific to tribal uses were added. A number of outcomes have multiple suggested metrics that measure different aspects of the outcome and offer complementary information. For example, as seen in Table 2, cultural site condition metrics are included for both conflicts in use and for damages.

**Table 2.** Example ecosystem services metrics related to recreation for the Ashley National Forest Plan. ABA is an abbreviation for Architectural Barriers Act, which is a U.S. law requiring federal facilities be accessible to all people (e.g., wheelchair and stroller accessible).

| Outcome Group | Outcome | Metric | Planning or Implementation Level? |
|---|---|---|---|
| Economic activity | Recreation facility management | Total direct expenditures on management to implement the Forest Plan alternative. May be monetary or categorical method (increase, no change, decrease) | Planning |
| | | Deferred maintenance costs and change in deferred maintenance backlog. Monetary method. | Implementation |
| Cultural value | Cultural site condition | Potential for conflict/competition between authorized uses and cultural site use. Categorical (increased risk, no change, decrease risk) | Planning |
| | | Potential for damage/degradation to archaeological sites and heritage resources caused by authorized uses (recreational use, infrastructure construction, timber harvest) - this includes both above ground and below ground heritage resources. Categorical method. | Planning |
| Accessibility | Accessibility (ABA facilities) | Number of accessible parking spaces, toilets. | Implementation |
| | | Change in accessibility of facilities for forest plan alternatives using access/quality of experience matrix. Categorical method. | Planning |
| Ease of access | Ease of access (to recreational opportunities) | Change in access to recreation opportunities (hunting, fishing, hiking, etc.) for forest plan alternatives. Categorical (access/quality of experience matrix) | Planning |
| | | Change in access to recreation opportunities (hunting, fishing, hiking, etc.) realized. Surveys. | Implementation |

| | Area Type | | | | | Specific amenities | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **User group** | Wilderness areas | Destination Recreation Areas | Backcounty Recreation Areas | General Recreation Areas | Remote areas with low utilization | Disability-accessible trails, restrooms, parking areas | Developed receration sites such as camp grounds, picnic areas, interpretive sites | High-quality game species habitat | High-quality fishable waterways | Trails with mechanized access | Trails with motorized access |
| Boy Scouts | | | - | | + | | | | | | |
| Solitude-seekers | + | | | | + | | | | | | |
| Large groups | | - | | - | | | = | | | | |
| Mobility impaired visitors [1] | | - | | - | | = | = | | | | - |
| Hunters | + | | - | - | | | | + | | | - |
| Anglers | + | | | - | | | | | + | | - |
| Commercial outfitters (boat trips) | | - | | - | | | | | + | | |
| Mountain bikers | | | | - | | | | | | - | |
| OHV users | | - | | - | | | | | | | - |
| Cultural/historic site visitors | | - | | - | | | = | | | | |
| Tribal populations | + | | - | - | + | | | + | + | | |
| EJ populations | | - | | - | | | = | | | | |

**Figure 4.** The access and quality of experience matrix can be used to visualize impacts to different forest user groups. Shaded cells at the intersection of a user group (rows) and area or amenity types (columns) indicate that the user group cares about that area or amenity. The colors indicate the direction of the effect that the Forest Plan alternative is expected to have on each type of use area and amenity, and therefore on interested user groups. This is a hypothetical example for the conservation focused planning alternative, with a focus on non-motorized recreation in backcountry, proposed wilderness areas and other undeveloped areas and reduced emphasis on recreation infrastructure development, compared to the no-action alternative. [1] Including those with mobility disabilities and elderly visitors.

Discussion of specific metrics involved a smaller group of planning team specialists than that of the ESCM model development. This is due to the fact that the selection of these metrics was less dependent on interdisciplinary discussion and more focused on knowledge of data availability and relevancy. Based on the management actions and outcomes to be measured, participants in this process included the recreation and cultural specialist as well as the contractor involved in the EIS and acting as the Forest plan revision sociologist. While there may be similarities in metrics used across forests, the metrics selected for the Ashley plan revision impacts analysis are specific to this planning process. Metrics would likely vary for other plan revision processes based on the key management decisions, range of alternatives, and available data for each forest. The Ashley National Forest team reviewed the metrics, considered whether they were appropriate for the EIS phase of the planning process or would be important in the later plan implementation phase, and determined how to pull together the data for the planning process.

### *3.3. Feedback from the Ashley Forest Planning Team*

We received survey responses from three members of the Ashley Forest planning team. All of the respondents participated in the ESCM workshop and found it useful for thinking through the likely effects of the forest plan alternatives on ecosystem services provided by the Forest. While only one participant had tried to use the ESCM, participants saw a variety of potential uses, including documenting how ecosystem services were considered in the planning process and communicating about ecosystem services both within and outside of the Forest Service. The ESCM will be included in the Environmental Impact Statement for the Forest Plan Revision to illustrate the high-level programmatic impacts of the plan. One respondent noted that the ESCM is a helpful conceptual tool to guide discussion within the planning team, but is too theoretical to inform the process of writing the plan.

Two of the respondents participated in the metrics workshop. While one respondent found the exercise to be a good combination of on-the-ground experience with conceptual ideas, another found the workshop discussion interesting, but thought the metrics were too conceptual to be used in forest planning. They may incorporate some of the metrics into monitoring of forest plan outcomes. Respondents thought the metrics would be helpful in communicating the effects of forest management within the Forest Service and with external partners as well as describing forest plan alternatives' effects on ecosystem services.

## 4. Discussion

### *4.1. Ecosystem Services Conceptual Models Provide a Visual Tool for Facilitating a Common Understanding of Management Impacts*

These models provide a way to reduce confusion and avoid talking past one another; common problems when terms have different meanings to people. Use of these models as shared visualization tools also avoids leaps of faith, where people are making general connections (e.g., increased motorized access will improve hunting). They force explicit conversations and clarification of assumptions about how a management action leads to an outcome (e.g., it could improve access to hunting areas, but it also might reduce wildlife populations in these areas). The models provide a common starting place where the system and linkages are clearly laid out, and a platform for structured dialog. In addition, development of the ESCM model provides a record of the decisions made related to anticipated outcomes from proposed management. This information can then be included in the project record to support agency decision making processes. In addition, the Ashley National Forest model and associated documentation can be provided to other forest plan revision teams to allow for greater consistency in approach.

Despite the usefulness of the ESCM for the planning team, the interdisciplinary planning team (ID team) and the Forest leadership team (line officers) thought the full ESCM was too complicated to be useful in communications about the plan with stakeholders.

However, the simplified models might be of use earlier in the plan process—the assessment phase—to inform resource-specific discussions with the public and cooperators.

### 4.2. Ecosystem Service Metrics Identificaiton Process Expands Ideas for Relevant Measures

One of the intents of revising the forest planning rule was to help expedite the process of forest planning. Forest plans are expected to be updated every 15 years. In practice, some forest plans revisions have taken up to 8 years to complete, making updates every 15 years unlikely. It can be a long, complex process, often subject to objections and legal challenges. Due to the complexity of planning, lack of capacity in the Forest Service for economic and social analysis, and the need to define and address ecosystem services, planning teams often default to the traditional metrics for multiple use or qualitative discussions of ecosystem services.

The Forest Service has considered developing "strike teams" to coordinate planning across multiple forests or within a region that could complete much of the work. A specialized team might make the process more efficient. It might also allow for a broader look at ecosystem services; such a group might have the capacity to track new research and spread the cost of innovation across multiple forest plans. In such a model, the ecosystem service metrics identification process used here has the potential to expand ideas for engaging with forest staff, developing relevant measures, and provide a more rigorous approach to account for ecosystem service planning.

## 5. Conclusions

National Forests in the United States continue to adapt to the new requirements under the 2012 Forest Service Planning Rule, but this has not yet resulted in a significant change in the way most forests have considered ecosystem services in management plan revision. They still tend to emphasize ecological rather than social or cultural resources, not fully considering the benefits forests are providing to people [14]. And they still rely heavily on traditional methods and data for analysis and tend toward narrative descriptions rather than quantitative measures, even if they are categorical or rank order.

ESCMs provide an effective tool to support interdisciplinary planning teams in thinking beyond ecological outcomes to social and economic endpoints, and helping them come to common agreement. They also provide a transparent documentation of planning considerations that can be incorporated into their Environmental Impact Statement, perhaps helping to reduce legal challenges common for new forest plans in the U.S.

The collaborative cross-team effort to adapt a general ESCM to a specific forest context and to develop a set of representative metrics for social and economic outcomes, forces thinking about which communities are being impacted by a change in each outcome and how. This helps teams develop a more complete set of metrics that fully represent the diversity of outcomes and communities impacted. With support from social scientists within the agency, planning teams can develop a more quantitative and informative set of metrics for predicting the effects of plan alternatives and designing forest plan monitoring. Once developed, these metrics are likely to be applicable across National Forest lands.

The ESCM approach revealed ecosystem service outcomes (e.g., crowding, ease of access, human health aspects of recreation) on the Ashley National Forest that could serve to augment or refine the list of recreation and cultural outcomes available through international lists of criteria and indicators for sustainable forest management (e.g., Montréal Process Criterion 6). The access and quality of experience matrix further demonstrates how the ESCM approach can trigger additional tools or modes of communication to help forest managers and planning teams identify and communicate forest contributions to ecosystem services at a regional or localized level.

Ryan et al. suggested that there are insufficient resources to help forests with implementation of this ecosystem services element in the new planning rule [14]. Perhaps the availability of general ESCMs to support common planning priorities (e.g., recreation, timber and fire management, invasive species management, etc.) which could be adapted to

their needs, along with a set of example socio-ecological metrics that map to the outcomes in these models, could help fill this gap. These resources along with a few cases of how it has been applied within the planning context, could be a place to start.

**Supplementary Materials:** The following are available online at https://www.mdpi.com/1999-4907/12/3/267/s1, Document S1: Share-ahead materials for ecosystem service conceptual model workshop, Document S2: Share-ahead materials for metrics workshop, Document S3: Survey questions for planning team, Table S1: Final metrics table for the Ashley National Forest, Table S2: Metrics changes for the Ashley National Forest.

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