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Ecosystem Service Assessment and Mapping with Pacific Northwest National Forest Stakeholders

A Dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Geography

by

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ABSTRACT

Ecosystem Service Assessment and Mapping with Pacific Northwest National Forest Stakeholders

by

Stephen Everett Schultz Crook

The U.S. Forest Service is now required to include the concept of ecosystem services - defined as the idea that humankind receives a variety of tangible and intangible benefits from ecosystems - in National Forest planning. Pacific Northwest National Forests, however, are only in the early stages of considering ecosystem services within individual forest plans. This doctoral dissertation focuses on investigating how the identification and mapping of ecosystem services using participatory methods can be used to more effectively and equitably inform ecosystem service-based management in the National Forest context. This type of management-relevant, bottom-up identification and mapping of priority ecosystem services, integrating cultural values of diverse groups, is widely called for in the literature, yet case studies on U.S. public lands are lacking.

Semi-structured interviews and participatory mapping exercises were conducted with National Forest planners, managers, and involved stakeholders to better understand perceptions of the ecosystem services concept and the perceived value of ecosystem services to individuals and society. First, interviews with National Forest planners and

managers elicited insight on the understanding of the ecosystem services concept and the implications of the concept for management in the US National Forest context. Then, semi-structured interviews and participatory mapping exercises conducted with representatives of groups that are actively involved in stewardship and management of National Forest lands demonstrated methods that can be used for better understanding the wide range of uses, values, and benefits connected to National Forests.

Results indicate that there has been only limited application of the ecosystem services concept in National Forest management and that there are several perspectives among managers regarding what it means to manage for ecosystem services. Stakeholder interviews and mapping exercises revealed which uses, benefits, and values were most highly valued, where they were valued, and the reasons they were valued by participants. Analysis of identified use, value, and benefit categories indicated that while several cultural and provisioning ecosystem services were most highly valued, subcategories therein were complex, resulting in ambiguity, multiple interpretations, and overlapping meanings. Mapping of use, benefit, and value categories demonstrated the spatial distribution of valued categories, highlighting how these distributions appear complementary overall. However, they also pointed to specific areas of potential conflicts and synergies among categories. This dissertation provides useful data for updating National Forest plans to include ecosystem services, broadly, and cultural values toward ecosystem services, specifically. It also demonstrates methods that can used for fulfilling the requirement for National Forests to include ecosystem services throughout the Pacific Northwest and beyond.

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I. Introduction

The USDA Forest Service's motto has long been "caring for the land and serving people." Successfully balancing the demands required to achieve these joint goals on millions of acres of managed land has been a persistent challenge. Recently, the concept of ecosystem services (ES) has been identified as a way to better address these goals by explicitly including the variety of ways people benefit from National Forest lands in management decision making and connecting these benefits to functioning ecosystems (Smith 2011). Despite the calls to integrate ecosystem services into the management of all federal lands, there are few examples of the inclusion of ecosystem services in US National Forests (Donovan, Goldfuss, and Holdren 2015). Examples of inclusive, place-based assessments that integrate the positions, preferences, and knowledge of a wide variety of stakeholders, as well as their cultural values, are rarer still.

In its 2012 Planning Rule, the USDA Forest Service (USFS) committed to integrating ecosystem services into forest planning nationwide (USDA Forest Service 2012). This latest shift in management priorities reflects the next step in the historical progression of forest management from the dominant use era (focus on timber output) to multiple use management (focus on economic optimization) to ecosystem-based management (minimizing impact on ecological systems while maintaining production; Kline et al. 2013). Despite the evolving management foci during these periods it has still been 'difficult to overcome the inertia of the dominant-use era owing to prior training of forest managers in resource-specific disciplines,' and 'that lack of integrated assessment, whether real or perceived, has continued to foster distrust among NGOs and the public about whether the Forest Service adequately considers all factors affected by proposed management actions' (Kline et al. 2013, pg. 143-145).

With this new rule, the USFS aims to address these concerns by better understanding the ecosystem services concept and the value of National Forest lands to society, and demonstrating this value to decision makers, by connecting ecological function to public benefits (Smith 2011; Kline et al. 2013). Furthermore, by approaching forest management through an ecosystem services lens, the USFS aims to make more informed management decisions (Kline and Mazzotta 2012). Ultimately, the rule is intended to guide the development, amendment, and revision of individual forest plans for all 176 units in the service (USDA Forest Service 2012). In the first phase (assessment and public participation), forest managers are required to determine the range of ecosystem services and multiple uses in each forest unit, however, their in-house capacity to do so is limited. This dissertation research sets out to conduct an assessment of ecosystem service values, uses, and benefits using participatory methods in Pacific Northwest National Forests, with the goal of developing methods, processes, and knowledge that can be built upon for better including ecosystem services in National Forest planning throughout the Pacific Northwest.

Section II (Chapter 1) focuses on understanding the role of the ecosystem services concept within the current management context of Pacific Northwest National Forests. Because the concept has been interpreted and operationalized in a variety of ways since it emerged two decades ago, there is a pronounced knowledge gap related to understanding how it is framed and applied in different contexts. To more effectively understand the application of the ecosystem services concept in US National Forests, the following topics are addressed: 1) how the ecosystem services concept is perceived by managers and planners; 2) what the perceived key ecosystem services offered by National Forest lands are; 3) how the concept has been applied at multiple scales; and 4) what are the perceived challenges or

opportunities the concept offers in National Forest Management. To address these questions, semi-structured interviews with planners and managers of Pacific Northwest National Forests were conducted at the region, forest, and ranger district level, yielding insights into manager and planner understanding and experience with ecosystem services.

Section III (Chapter 2) addresses the methodological gaps identified in Forest Service planning documents that are required to better apply ecosystem services concepts to US National Forest (NF) lands by investigating active and involved stakeholders' perceptions of ecosystem services. Despite calls in the ecosystem services literature and Forest Service documents for better inclusion of public participation and understanding of cultural values toward ecosystem services at the early stages of the assessment process, examples of such participatory assessments in the National Forest context are rare. Here, in-depth, semi-structured interviews with stakeholders of Gifford Pinchot National Forest in Washington State were used to better understand the uses, values, and benefits that participants and society derive from the forest; as well as which of these they perceived as most important to themselves and for society. Results from this research can help the Forest Service better understand the ecosystem services most valued by stakeholders and lend insight into how this information might best be collected for management planning and decision-making going forward.

In Section IV (Chapter 3), participatory mapping is demonstrated as a method to gain a better understanding of the spatial characteristics of stakeholder perceptions toward ecosystem services. The Forest Service has a rich tradition of collecting and using spatial data on biophysical conditions in planning. Likewise, in considering ecosystem services, the most common approach is to use spatial models that relate land cover to the ability of

landscape to produce ecosystem services. In conceptualizing ecosystem services in this way, cultural ecosystem services and human values related to the other ecosystem service categories are not adequately integrated into analysis (Chan et al., 2012; Menzel and Teng, 2010). In this chapter, participatory mapping of ecosystem services with active and involved National Forest stakeholders is demonstrated as a methodology that can fulfill multiple aims of the 2012 Planning Rule and National Forest management. Meanwhile, methodological insights into participatory mapping and the applicability of participatory mapping to the National Forest context are explored.

Finally, a brief conclusion (Section V) reiterates and synthesizes key contributions from the preceding chapters and offers a few areas of future research into the participatory collection of ecosystem services data and the use of the ecosystem services concept in National Forest Management.

II. Chapter 1: Perceptions of ecosystem services among Pacific Northwest National Forest managers

A. Introduction

The ecosystem services concept, typically defined as the idea that functioning ecosystems provide humans with benefits that improve well-being, has become a guiding principle in global natural resource management (Braat & de Groot, 2012; Costanza et al., 1997). The integration of the concept into United States National Forest management was mandated in 2012 through the release of a new planning rule, which guides the preparation of new forest plans in the future (Kline, Mazzota, Spies, & Harmon, 2013; US Forest Service, 2012). Currently, the Forest Service is in the exploratory phase of considering how to integrate the concept into the planning and management of the 193 million acres of Forest Service land, and the implications of this shift in focus is unclear due to the wide range of interpretations about how to apply the concept on the ground (Martin-Ortega, Jorda-Capdevila, Glenk, & Holstead, 2015; Saarikoski et al., 2018). There is a noted gap in understanding the knowledge and perspectives that actors obligated to apply ecosystem service approaches have toward the concept, how ecosystem service approaches have been applied on the ground, and how knowledge regarding ecosystem services is integrated into natural resource decisions (Beery et al., 2016; Blicharska & Hilding-Rydevik, 2018; Laurans, Rankovic, Billé, Pirard, & Mermet, 2013).

The concept of ecosystem services has been interpreted and applied in a wide variety of ways since its emergence (Martin-Ortega et al., 2015). Early on, it was employed as a metaphor characterizing the reliance of human wellbeing on functioning ecosystems, thereby communicating the importance of nature to society (Beaumont, Mongruel, & Hooper, 2017; Norgaard, 2010). A multitude of studies following this line of reasoning have focused on

valuing aspects of a particular natural resource, or the sum total economic value of multiple resources at a given scale (Costanza et al., 1997). The metaphor that ecosystems provide benefits that have economic value evolved into the development of payment for ecosystem services (PES) programs, where those benefitting from ecosystem services provide monetary compensation to those providing services and benefits (Bremer, Farley, & Lopez-Carr, 2014; Engel, Pagiola, & Wunder, 2008; Farley, Anderson, Bremer, & Harden, 2011). PES programs often focus on compensation for and prioritization of the provision of one, or few, ecosystem services rather than considering tradeoffs, synergies, or aggregate provisioning of multiple services (Farley & Costanza, 2010).

More recently, academic and policy spheres have focused on using the ecosystem services concept to make more informed decisions in natural resource planning through considering tradeoffs and synergies among ecosystem service types under different land management scenarios (Daily et al., 2009; McKenzie et al., 2014; Nelson et al., 2009). This approach requires identification of the ecosystem service categories to be considered, mapping of landcover types and linking these with associated ecosystem services, understanding of ecosystem service preferences and values, and quantification of aggregate values at specific planning scales (Costanza et al., 2017; Nelson et al., 2009). Despite widespread conceptual development in the use of ecosystem services for natural resources planning and management, there are still few examples of effectively accomplishing this on the ground (Albert, Hauck, Buhr, & von Haaren, 2014; Beaumont et al., 2017; Schubert et al., 2018).

These multiple interpretations of how the ecosystem services concept might be applied has led to challenges in application (Hermelingmeier & Nicholas, 2017; Nahlik,

Kentula, Fennessy, & Landers, 2012), as to date "there is no clear consensus on how exactly ecosystem services should be defined and classified… and further interpretations might emerge" (Martin-Ortega et al. 2015, pg. 8). At least eleven different ecosystem service frameworks, each with its own definition and classification system, have been developed, leading to a lack of clarity as to what constitutes an ecosystem service that should be considered in analysis (Nahlik et al., 2012). There is further confusion about what managing for ecosystem services means. As noted above, the ecosystem services concept has been employed to address a wide range of potential goals using a variety of tools, with little consistency (Costanza et al., 2017).

Inconsistent definitions and a lack of conceptual clarity have hindered the adoption and application of the concept in planning and management (Costanza et al., 2017; Hermelingmeier & Nicholas, 2017). In some cases, its application has resulted in a "fake consensus," where different stakeholders agree on an approach for which they have different underlying understandings and interpretations (Martin-Ortega et al., 2015). It can also result in "business-as-usual" management, where new terminology and discourse is used to justify continuation of longstanding actions (Martin-Ortega et al., 2015). Furthermore, there has been a recognition that political conflicts between ecosystem service priorities among stakeholders remain despite the unifying language of an ecosystem services approach (Saarikoski et al., 2018).

In an attempt to establish a common baseline understanding of what constitutes an ecosystem services approach, Martin-Ortega et al., (2015, pg 8) state that it is "not a management tool *per se*, but rather a pair of glasses that one might wear to tackle the problem at hand." With a goal of clarifying the ambiguity of the concept they identify four

nested components of what makes up an ecosystem-services based approach: First, there is a focus on anthropocentric instrumentalism, in which the human-nature relationship is defined as revolving around "the benefits humans obtain from nature" (pg. 8). Second, these approaches consider the core outputs of ecosystem functioning to be service delivery, rather than traditional ecological outputs (biogeochemical cycles, energy flows etc). Third, an ecosystem services approach relies on integration of interdisciplinary scientific knowledge along with non-academic strands of local knowledge and preferences in the creation of models for tradeoffs. Finally, such an approach includes the assessment of a variety of services (either through qualitative or quantitative valuation) so that changes to these values upon different scenarios can be incorporated into the decision-making process (Martin-Ortega et al., 2015).

As Hummel et al., (2017) contend, "a mismatch between academic and management perceptions of ecosystem services and management priorities may well result in important shortcomings for the application of research outputs in adaptive protected area management." While a few scholars have recently investigated knowledge uptake upon direct application of the type of ecosystem services approach outlined in the previous paragraph (Bremer, Delevaux, Leary, Cox, & Oleson, 2015; McKenzie et al., 2014; Saarikoski et al., 2018), there is only limited research into the awareness, perception, and understanding of ecosystem services approaches among planners and managers who are ultimately tasked with applying the concept (Beery et al., 2016; Blicharska & Hilding-Rydevik, 2018; Hermelingmeier & Nicholas, 2017; Mascarenhas, Ramos, Haase, & Santos, 2014; Rinne & Primmer, 2016; Schubert et al., 2018; Stępniewska, Lupa, & Mizgajski, 2018). These studies have noted the challenge in translating academic and theoretical tools to on-the-ground management and the

importance of understanding practitioner perceptions to the implementation process (Beery et al., 2016).

1. *The Ecosystem Services Approach in US National Forest Management*

Investigating the current understanding and application of ecosystem services among decision-makers is important in the context of National Forests because ecosystem services have recently become the latest in a series of dominant approaches to National Forest management to be embraced by the US Forest Service (Kline et al., 2013). Prior to the 1960s, management of National Forests was characterized by the *dominant-use* era, focused primarily on sustained timber yield. That gave way to what is known as the *multiple-use* era, where the Forest Service (FS) focus was on balancing resource extraction with encouraging ecosystem health and recreation (Stevens & Montgomery, 2002). The *ecosystem management* era of the 1990s and early 2000s focused on furthering the goals of including multiple uses, yet witnessed continued tension between conflicting goals in resource extraction and the improvement of ecological conditions (Kline et al., 2013).

The transition to *ecosystem services based management* within the Forest Service began following the Millennium Ecosystem Assessment (Collins, 2007; Kline et al., 2013; Smith, 2011). The perceived potential benefits of focusing management on an ecosystem services approach include better communication of the benefits National Forest lands provide society, the potential ability to expand accounting of forest benefits beyond those that are currently quantified, and the establishment of payment for ecosystem service partnerships with public and private bodies (Kline et al., 2013; Smith, 2011). Because of the promise of these applications, the idea of ecosystem services was included as one of the key principles

of the 2012 Planning Rule, which guides the development of individual forest plans going forward. The text of the Planning Rule states that individual forest plans must "provide for multiple uses and ecosystem services, considering a full range of resources, uses, and benefits relevant to a unit." (US Forest Service, 2012).

A wide variety of pilot studies and projects have demonstrated how ecosystem services might be brought into National Forest planning, which can be categorized into two groups: studies that establish or refine how an ecosystem service approach can be integrated into National Forest management (Kline et al., 2013; Kline & Mazzotta, 2012; Olander, Tallis, Polasky, & Johnston, 2015; Smith, 2011), and studies that aim to demonstrate how one or more service could be measured, modeled, or valued (Asah, Blahna, & Ryan, 2012; Sherrouse, Clement, & Semmens, 2011). However, as previously noted, there is little understanding of how guiding frameworks and methods for ecosystem service assessment have been applied on the ground and have influenced decision making (McKenzie et al., 2014; Plant & Ryan, 2013; Saarikoski et al., 2018).

2. Research Goals

In this chapter, the current perceptions of ecosystem services and experiences with employing ecosystem services approaches are investigated within the Pacific Northwest Region of the US Forest Service. While National Forest lands implicitly provide a wide array of ecosystem services to local communities and society, it is unclear what forest managers think it means to manage for specific ecosystem services, or what are perceived as being key services that should prioritized in management. The aim is to investigate the current application of the ecosystem services concept in a specific context, Pacific Northwest

National Forests, to provide information to better inform its institutional application. In doing so, insights are provided regarding how actors involved in implementation currently understand the concept of ecosystem services and what are obstacles to implementation, while shedding light onto the perceived challenges and opportunities associated with this paradigm shift in the eyes of National Forest planners and managers.

To achieve these goals, I address the following research questions:

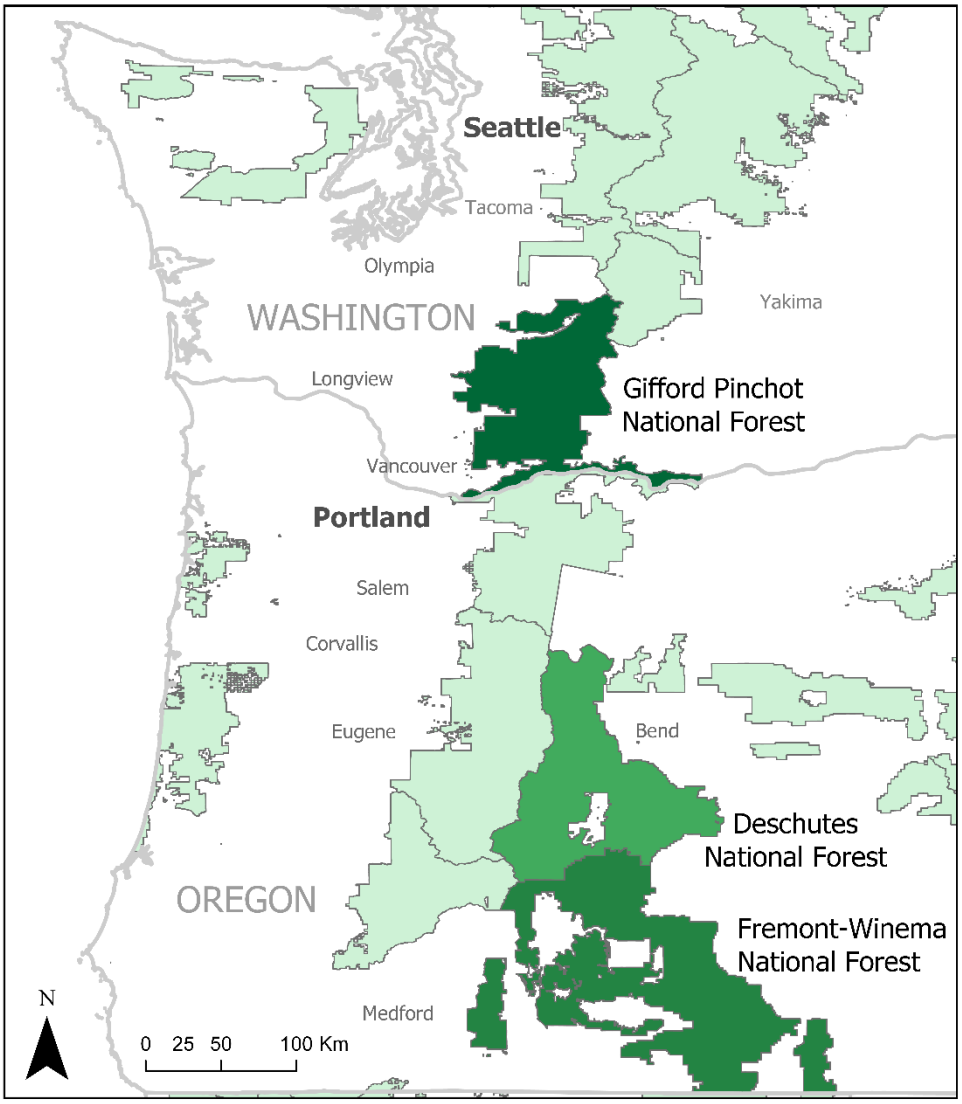
- How is the ecosystem services concept understood by Forest Service planners and managers in the Pacific Northwest?
- What are perceived as the key ecosystem services that Pacific Northwest National Forests offer society, according to Forest Service planners and managers?
- In what ways has the ecosystem services concept been applied in Pacific Northwest National Forest management?
- What are perceived challenges and/or opportunities in applying the concept?

3. Study Area

Three National Forests out of the seventeen in the Pacific Northwest Region were selected for this initial assessment: The Deschutes NF and Fremont-Winema NF in Oregon, and the Gifford Pinchot NF in Washington (Figure 1). These forests were selected primarily because they were determined to have different biophysical and socioeconomic contexts and differing levels of exposure to the ecosystem services concept based on initial review and informal interviews. Specifically, they offer management perspectives on forests on both the west side and east side of the Cascade mountains, resulting in areas that have different

rainfall patterns, fire patterns, and vegetation types. They are also areas that attract a diverse array of user groups, from predominantly urban recreational users to nearby rural communities that depend on National Forest lands for their livelihoods.

Figure 1 – Map of the National Forests in which participants worked.



Gifford Pinchot National Forest (1.4 million acres) is the southernmost National Forest of the Washington Cascades, stretching from just South of Mount Rainier to the

Columbia Gorge (USFS, 2018c). Included within these boundaries are Washington's second highest peak, Mount Adams, as well as the Mount St. Helens National Volcanic Monument. While the forest is easily accessed from the Portland-Vancouver metropolitan area, it is generally still considered a mixed urban-rural forest, with several local communities that have traditionally depended on forest lands for their livelihoods. Overall, it is very much a multiple use forest, being ranked 7th regionally in recreation visits (Charnley, 2006). Gifford Pinchot NF is located in close proximity to the Pacific Northwest Regional Office, and preliminary interviews indicated that it is in the early stages of considering ecosystem services concepts.

Deschutes National Forest (1.6 million acres) is located in Central Oregon, stretching from the crest of the Cascades toward the semi-arid steppes of Eastern Oregon (USFS, 2018a). It is located adjacent to Bend, Oregon, an outdoor sports hub and a major source of recreation visitors, and includes Mt. Bachelor, one of the most popular ski areas in the Pacific Northwest. Together, these things make it the third most visited forest for recreation regionally after Mount Hood and Mount-Baker Snoqualmie (Charnley, 2006). However, despite high visitation density near Bend, substantial areas of the forest are still highly rural and are used more for dispersed recreation and forestry activities. The forest was selected for this study primarily due to both its unique spatial context, and because it has been well-recognized as an early adopter of the ecosystem services concept within the Forest Service (Asah et al., 2012; Foley, Bowles, Smith, & Caligiuri, 2014).

Fremont-Winema National Forest (2.3 million acres) was administratively formed in 2002 upon the merger of the Fremont National Forest and the Winema National Forest (USFS, 2018b). It is located in Southern Oregon, and like the Deschutes stretches from the

forest-covered crest of the Cascades to the semi-arid steppes to the East. Far from any major urban areas (the largest city within an hour of the forest is Klamath Falls, population 21,524), the forest has a continued focus on supporting local communities through resource extraction, and recreational opportunities in areas that still allow for solitude: “where the self-reliant recreationist has the opportunity to discover nature in a rustic environment” (USFS, 2018b). As of the most recent estimate, it ranked second to last in the region in the number of recreation visits (Charnley, 2006). Additionally, a large portion of the forest is under a unique co-management arrangement with the Klamath Tribes (Hatcher, Rondeau, Johnson, Johnson, & Franklin, 2017). Fremont-Winema NF is physically distant from the regional office and there was little evidence in Forest Service documents and initial interviews that ecosystem services concepts are being applied in the management of this forest.

B. Methods

Semi-structured interviews were conducted with United States National Forest planners and managers in the Pacific Northwest region to address the research questions outlined above. Key informants were identified and contacted through pre-existing contacts at the Forest Service and through placing direct calls and emails to select forest offices in the project region. In total, 12 interviews were conducted with planners and managers from the Gifford Pinchot (5), Deschutes (3), and Fremont-Winema (3) National Forests, as well as the Pacific Northwest Regional Office (1). In addition to gaining perspectives from multiple National Forests with different spatial contexts and levels of exposure to the ecosystem services concept (described above), interviews were sought with planners and managers at different administrative levels within the Forest Service. Hierarchically, these interviews were made up of participants at the Region (1), National Forest (4), sub-forest (multiple ranger districts) (2), and ranger district (5) levels. All the interviews were conducted in-person between August 2017 and May 2018.

Interviews focused on several topics and themes, including the participant's understanding of the ecosystem services concept, their experiences implementing the concept, their perceptions of how the concept has been implemented within the Forest Service, the key ecosystem services provided by the National Forest in which they work, pressing management challenges on their forest, and stakeholder groups related to the forest. Interviews lasted from 36 to 111 minutes, with a median time of 54 minutes. Interviews were digitally recorded and transcribed for review. NVivo was used to conduct coding based on themes that arose in the data. Institutional Review Board human subjects research approval was granted for the research protocol by San Diego State University (approval number HS-

2017-0137), and participants were informed that confidentially and anonymity would be maintained.

C. Results

Overall, respondents stated that they were familiar with the concept of ecosystem services. However, respondents revealed different perspectives regarding what it meant to use an ecosystem service approach for management. Though respondents perceived a wide range of key services, cultural services were most commonly considered as the most important services offered by National Forest lands. Provisioning services in general, and timber production in particular, were perceived as ecosystem service priorities by most. The following sections elaborate in more detail the key findings in relation to understanding of ecosystem services, key forest ecosystem services, ecosystem services as a planning approach, and opportunities and challenges identified by participants.

1. Understanding of the ecosystem services concept

When asked how they might expand or modify the definition of ecosystem services as "the benefits people obtained from ecosystems," most people interviewed saw that definition as suitable and fairly comprehensive. Several expanded upon the definition by pointing out specific ecosystem services or categories (e.g. "drinking water, cultural, spiritual, etcetera"). Some respondents thought it was important to distinguish between economic and non-economic benefits: "I see ecosystem services more as things that are more noncommercial that the forest provides… though I think that timber and agriculture are benefits to humans, I think ecosystem services are more of those less marketable aspects." Others, however, considered both economic and non-economic benefits as ecosystem services, stating, for example: "I think [the term] benefits is fine, economic or otherwise." Some specifically

wanted to clarify that it is how people relate to or feel about the land or landscapes, rather than just how they benefit from it.

As in other studies, participants noted challenges with ecosystem services terminology and classification (Beery et al., 2016; Raum, 2017; Rinne & Primmer, 2016; Saarikoski et al., 2018). For those who had experience implementing individual projects that integrated an ecosystem services approach, they decided to "strip away" ecosystem services categories, such as 'provisioning', 'regulating', 'cultural', and 'supporting', which they did not find valuable in talking with the public. For those working at the project scale, presenting these categories was not "helpful in getting [the public] to talk about what they care about." Lack of definitional clarity among planners and mangers was apparent, as participants did not always associate things that were previous Forest Service priorities, particularly those with a primarily economic value, as being ecosystem services. Following discussion of priority ecosystem services one participant was asked a follow up question about how they thought timber fit into the ecosystem services framework: "I was thinking everything but timber as ecosystem services. Absolutely timber is still… it's our largest commodity."

2. *Perceptions of key ecosystem services for National Forest management*

Participants considered a wide range of ecosystem service types to be the most important offered by National Forests lands, though most responses fell into two categories. First, many of the perceived key services were those that had direct human benefits, including cultural services, provisioning services related to timber and forest products, and the direct economic impacts forest industries have on communities (Table 1). All but two respondents listed recreation among the most important services provided, with many

specifying more detailed cultural services including aesthetics, cultural heritage, spirituality, and solitude. Eight discussed provisioning services including special forest products like huckleberries, firewood, and mushrooms. Others discussed the cultural aspects of these provisioning services, stressing the importance of the harvest of certain plant and animal species to local tribes and communities. Likewise, though timber is generally considered a provisioning service, it was usually mentioned as a key ecosystem service in the context of the economic benefit it provides to local communities and its central place in the livelihoods of local individuals.

The second prominent grouping included those nontimber categories that have been longstanding Forest Service priorities predating the ecosystem services-based management era. Specifically, perceived priorities included habitat and clean water for certain fish species and habitat for terrestrial endangered species. Many respondents also mentioned the importance of clean water to local communities. Overall, regulating and supporting services (other than habitat) were seldom mentioned. One participant highlighted the intrinsic value of the forest, clarifying that the forest itself provided clean air and healthy soil, which were central to providing a wide range of other benefits. Another participant mentioned carbon sequestration as one of the key services offered society.

Participants gave fewer responses when asked about the perceived priority ecosystem services for management. The largest number of respondents perceived a continued focus on timber production. They communicated that it was still the Forest Service's mandate to provide timber, and that meeting timber targets was still a central goal of on-the-ground management. In many cases, this perception was also tied to the importance of the economic impacts of timber for local communities. Other frequently mentioned priority services for

management included fish and animal habitat, recreation, and special forest products. The largest discrepancy between perceived benefits that the forests provide and perceived priority ecosystem services for management included clean water, with only one respondent reporting clean water as a priority for management. No regulating services were mentioned as priorities for management. Notably, several respondents mentioned fire management and other public safety related efforts, as well as the management of conflicts between users, as key management priorities, but these do not fit neatly into any traditional ecosystem services categories.

Table 1 - Number of respondents who discussed categories as key ecosystem services provided by National Forest lands and key ecosystem services for management.

Ecosystem Service Category	Key Ecosystem Services Provided to Society	Ecosystem Service Priorities for Management
Recreation	10	4
Nontimber Forest Products	8	4
Clean water	7	1
Timber	5	7
Fish habitat	4	3
Jobs / local economy	4	3
Cultural heritage	3	1
Animal habitat	1	2
Hunting	1	1
Carbon sequestration	1	0
Intrinsic value	1	0
Clean air	1	0
Soil health	1	0
Aesthetics	1	1
Safety / fire thinning	0	3
Research	0	1
User conflict management	0	1

3. *Applications and understanding of the ecosystem services concept: Three perspectives*

The twelve interviews with National Forest planners and managers revealed three general perspectives towards the ecosystem services approach as applied to National Forest management (Table 2). The first perspective considered an ecosystem services approach as a *Regulatory Requirement* at the forest scale, in which ecosystem services terminology is used along with earlier Forest Service categories to describe a range of benefits the forest provides society. The second perspective viewed the ecosystem services approach as a new method for *Participatory Planning* that emphasized inclusion of local stakeholder values and priorities. The third perspective was a continuation of *Business as Usual,* where ecosystem services concepts were considered primarily as a repackaging of longstanding Forest Service priorities, while offering potential pragmatic benefits primarily within disciplinary (rather than interdisciplinary) contexts.

Table 2 – **Summary of the three perspectives toward ecosystem services.**

Perspective towards ecosystem services	**Key features**
Regulatory Requirement	• Ecosystem services included because of, or in anticipation of, statutory requirements • Forest-scale consideration of ecosystem services • Characterization of ecosystem services for Forest Plan Revision • Evolving forest plan beyond timber, wildlife, and water • Stakeholder outreach to investigate key services
Participatory Planning	• Integration of local stakeholder priorities at early stages of project planning • Local project-scale consideration of ecosystem services • Focus on providing what local stakeholders want • Multi-objective NEPA purpose and needs statement • Noted on-the-ground applications with positive outcomes
Business as Usual	• Blurred boundary between previous paradigms and ecosystem services • Pragmatic adoption of certain elements of ecosystem services concepts relevant to disciplinary needs • Ad hoc use of concepts rather than a unified framework

The *Regulatory Requirement* perspective considered ecosystem services as a new guiding principle for forest level planning and plan revision. Though plan revisions have not been carried out on Pacific Northwest Forests according to the 2012 Planning Rule, some respondents reported experience in integrating the concept into forests planning in other regions. These respondents held the general perspective that *integrating an ecosystem service*

approach meant realigning NF goals at the forest plan level, along with some modification in related Forest Service processes such as public outreach for plan revision. According to the draft forest plan assessment for one of the forests where participants had experience (Nez Perce Clearwater), the interdisciplinary team (IDT) worked with the public to identify key ecosystem services to include in plan revision (NPC Assessment, 2014). All the services identified were narrowed down by the IDT to those that 1) were the most important to people and 2) would be affected by a new land management plan (NPC Assessment, 2014). In the Assessment document, the IDT considered condition and trend, scale, connection to ecosystem type, importance to people, and the impact of management actions on a selection of ecosystem services that included clean water, clean air, wood products, forage, fish and wildlife, cultural/heritage values, aesthetics, recreation, soil stabilization and landslide protection, carbon sequestration and climate regulation, and flood control. This consideration of a wide range of objectives in the assessment process for plan revision marked a perceived departure in National Forest goals for respondents: "The old forest plans, at least in Region 6 here, were more focused around timber production and what we could get off of the forest instead of what the forests actually provide." The new focus worked "to make sure that we're paying attention to everything instead of just trying to get timber off [the forest]." Another participant remarked that the goal of the process was "trying to focus on what affects the people," *beyond* the timber, wildlife, and water services that had long been considered important for management.

Participants noted new processes that were associated with this implementation of an ecosystem services approach. Primarily, it represented a new way to gain input for a more participatory process for the Forest Plan level Environmental Impact Statement. Participants

reported doing their own research on ecosystem services in preparation for talking about the new emphasis in management with the public. At the public meetings they conducted and attended, discussion with the public was carried out using the vocabulary of ecosystem services. It was also noted that the concept had made it into the NEPA process, and that Forest Plan amendments required attention to how a proposed action would affect a set of ecosystem services, even in forests that had yet to start plan revision. Overall, the *Regulatory Requirement* perspective views an ecosystem services approach to focus on the establishment of new methods of conducting Forest Service business that expand vocabulary and outreach for plan revision and amendment at the forest scale.

The *Participatory Planning* perspective can be characterized as the view that an ecosystem services approach is a process that seeks to better integrate local stakeholder priorities related to a specific place into early stages of project level decision-making. This was the perspective generally held by those people who had experience with an ecosystem services approach that was conducted within the Deschutes National Forest. One participant expressed this perspective in stating "we've used ecosystem services as a way to interact with the public to determine the values that are most important to them in an area, to help us evolve a proposed action."

Respondents supportive of ecosystem services as a way to determine public value towards planning outcomes often expanded upon the generic definition of ecosystem services ("the benefits that people obtain from ecosystems") according to their experiences with local stakeholder outreach, stressing the importance of "social goods and services." While their definitions did include other ecosystem services like "clean fresh water, fresh air," many expanded upon a sense that the key innovation is the explicit attention to cultural values

related to place. Respondents stated that they would add that it is "how they (people) relate to the land" and that it's really about "what do people care about on the landscape." This view of ecosystem services focuses on including the benefits individuals know they want and consciously value versus those that benefit society more broadly. As an example, one respondent referred to firewood collection as a cultural ecosystem service uncovered through their outreach, where groups going together to cut firewood is an important social aspect of that place. Another expanded on these ideas:

> *"The services would be recreation, or spiritual benefit, or whatever… but as the public comes and looks at the land… how do they feel about it? That relationship can be 'I get my spiritual aspect…' or 'even though I'm not in the timber industry I think this land should produce timber.' It's how they feel about the National Forest."*

When asked about their experiences with ecosystem services in their professional role, these respondents focused on specific examples that they considered to be employing an ecosystem services approach at the project scale. The key example many discussed, which has previously been documented in the literature, is the Big Marsh Project carried out in the Deschutes National Forest (Foley et al., 2014; Smith, 2011). The ecosystem services approach applied in this project included substantial discussion about ecosystem services and values within the Forest Service district office and with members of the public, along with the use of participatory mapping and field visits for involved stakeholders. Upon collection of data on values, results were used to develop "a proposed action and to look at alternatives" for the NEPA process. At this stage, respondents noted that the process had resulted in an "atypical purpose and needs statement" for the NEPA document instead of the traditional statement that might focus on measurable outcomes for one resource area. For example, one respondent described previous projects as being guided by singular goals; stating either "we

want to reduce stand density, we want to create this type of habitat, (or) we want to have economic value...” Meanwhile, to them, employing an ecosystem services approach “was kind of saying we want to do a lot of different things all at once.”

Participants involved in the process stated that employing this approach resulted in different outcomes for the Big Marsh area. Through the process, the Forest Service learned that the stakeholders who were consulted preferred a semi-wilderness experience to developed recreation sites that would be more easily accessed by the wider public. Respondents stated that if they had not used an ecosystem services approach, the resulting decisions made surrounding Big Marsh would have been different and there likely would have been more developed recreation sites including trails and campgrounds.

Participants expanded upon other examples that applied lessons learned as part of the ecosystem services approach used during the Big Marsh Project. However, multiple respondents referred to these processes conducted elsewhere as “ecosystem services light” because some of the features from the Big Marsh Project were simplified or stripped away. Put another way by one respondent: ecosystem services light meant that the project proceeded with “a more traditional forest service planning process...” that was underpinned by the goal of making the project fit the local community’s interests. The three other projects carried out using the “ecosystem services light” approach in the Deschutes NF consisted of more limited outreach and data collection on place-based values and priorities with both Forest Service staff and with the public.

Participants from other contexts were aware of the new approach taken in the Deschutes, stating that their perception of the Deschutes approach was that it is “a really different way to come at planning from the kind of traditional forest service

perspective... you think of it differently if you're coming at it from an ecosystem services framework than if you're coming at it from a silviculture framework or just a straight ecological framework. You might just get a different perspective on it." This respondent confirmed the view that this perspective focuses on the values stakeholders derive from the landscape: a scrappy lodgepole stand by a lake that provides shade in summer might be considered as valued by stakeholders, while resource area experts might see it as a fire hazard or as only having silvicultural value.

The *Business as Usual* perspective was brought forth by respondents who considered ecosystem services primarily as new language and terminology for things that Forest Service has already been doing. Participants who discussed ecosystem services from this perspective understood the definition and terminology of ecosystem services but did not clearly consider ecosystem services as an integrative process that could be used in guiding planning and management decision-making. However, they did identify benefits to employing an ecosystem services lens largely within disciplinary contexts. This perspective often included references to past guiding principles within the Forest Service such as "multiple use management," "ecosystem management," or "integrated resource management." One respondent stated: "You know, we're a multiple use agency, we appreciate the range of benefits that are provided by the ecosystem. We manage for those. We just don't necessarily think of it as ecosystem services work all the time." Put more bluntly: "I feel like it (ecosystem services) is multiple use, just with fancy new language that people don't understand."

When respondents holding this perspective discussed management in terms of ecosystem services, they frequently referenced examples using terms and categories used in these earlier

frameworks. One respondent mentioned ‘viewsheds’, or aesthetics as an ecosystem service, in planning: “we could actually talk about so many acres of viewshed opened up or something like that... I think you could translate it easy enough… to ecosystem service terminology. But we’ve had that term for a long time in our planning. We actually manage for viewsheds, [and we] used to when we were doing clearcutting – there were concerns about impacting the viewshed.” Likewise, respondents with this view discussed the importance of habitat for fish and wildlife, which are resource areas more commonly associated with the ecosystem management paradigm than with ecosystem services. When asked about examples of the implementation of ecosystem services, one respondent stated: “I think we’ve always had a restoration program outside of timber. That seems to fit pretty cleanly into ecosystem services. Dam removals, road decommissioning, aquatic restoration specifically… There’s no economic benefit to those projects. There is no economic product coming off the forest... I didn’t label it ecosystem services but we have been doing that sort of work since I’ve worked for the Forest Service.”

Despite the lack of unified, process-based use of an ecosystem services approach, participants identified ways in which they had, or could, engage with ecosystem services in their work. Some respondents found it a useful framework for communicating the value of National Forest lands: “It’s more giving context to the public about our landscapes,” and that they use it “to tell the story of the benefits that the forest provides” in forest outreach and publications. There was also reference to the role of ecosystem service quantification within the communication context: “There is an element of quantification… to help people realize this [benefits from ecosystem services] is real. Even though they’re hard to quantify there are people in this agency who are working hard to do so.” They saw potential in reporting

accomplishments in terms of benefits provided beyond those that traditionally have been quantified. Though two respondents noted potential benefits of quantification of a wider range of ecosystem services, they did not give specific examples of that work in any specific forest context. Overall, it was apparent that there had been a move toward expanding the type of projects undertaken and the range of goals considered in those projects, whether or not these outcomes were directly related to explicit use of the ecosystem services concept.

Outside of these three perspectives, there was limited discussion of other uses of ecosystem services approaches. One participant referred to Forest Service involvement in a payment for ecosystem services program in private and state forests surrounding National Forest lands in the region. There was also one mention of the potential of scenario planning based around ecosystem services using a spatial modeling approach. However, this discussion centered around the lack of interoperability of disciplinary Forest Service data and the fact that data is not currently used in that way.

4. Opportunities and challenges identified by participants

Managers and planners holding the *Participatory Planning* perspective viewed the shift toward an ecosystem services approach as being positive for management, with several expressing surprise that other areas were more resistant to implementing ecosystem services approaches to management. Participants saw an ecosystem services approach as a useful mechanism for improving public outreach and inviting input early on in projects, which they viewed as important. One participant stated that the ecosystem services approach is "going to be helpful… a big part for me doing this process is just letting people tell us what they care

about regardless of whether it goes into the project… people just like being heard." Another discussed how an ecosystem services approach improves upon business as usual:

> *"The Forest Service is pretty good about… here's what we should do with vegetation, here's what we should do with hydrology issues, and spotted frog issues, and fish issues, those things are pretty easy for the government to figure out. We're all specialists in those areas. We're not necessarily specialists in 'how does the public feel about a particular area?' What did they value in that particular area? How would they like to see it? To me, that's kinda how ecosystem services plays into the modification of what we would potentially have done."*

Respondents who held either the *Regulatory Requirement* or *Participatory Planning* perspectives, having experience with using different ecosystem services approaches at two different planning scales (project versus forest-level), had trouble envisioning their version of the concept at alternative scales. One adherent of the *Regulatory Requirement* perspective stated "You cannot look at ecosystem services on a small project scale because the analysis would be meaningless. It wouldn't inform decision makers of alternatives… we're going to look at ecosystem services for this trail? No, we're not!" Another participant holding this perspective stated "at the 30,000 foot scale, you're really saying what you can do in those areas. At the project scale we're just managing for (timber) target..." Alternatively, adherents to the *Participatory Planning* perspective pointed out that the sheer scale of managing at the forest scale would create too much complexity in the range of values that would need to be understood and considered. At the forest scale, the "diversity of opinions, diversity of everything that you're working with becomes in my mind… I don't know how you would get your hands around what's the right thing to do… it's a huge thing to try to figure out… how that works at the broader scale." They believed that the project scale was ideal for listening

closely to a small group of stakeholders, and best for trying to integrate their place-specific values into alternatives.

Challenges were also identified in applying this approach to a wide range of project contexts. Among adherents to the *Participatory Planning* perspective, there was agreement that the Big Marsh Project represented an ideal context for the application of this type of ecosystem services approach. However, some expressed doubts that the process would result in useful data, insight, or different decisions if applied in a more heavily forested area where a more traditional timber-focused project would likely take place. In such a context there would be less public interest, less recreational use, and less obvious multi-functionality in the landscape; characteristics that were perceived as necessary in soliciting sufficient stakeholder input into the project.

D. Discussion

Results confirm the lack of clarity surrounding both the concept of ecosystem services and what it means to apply an ecosystem services approach. While respondents broadly understood the meaning of the concept, on the ground application revealed an explicit emphasis on cultural ecosystem services along with a view that, while other Forest Service management foci are implicitly ecosystem services, they are not considered a central part of employing an ecosystem services approach (Beery et al., 2016). All of the perspectives above contain at least some of the four core elements of an ecosystem service approach as defined by Martin-Ortega et al (2015), though to differing degrees. As their first element outlines, there has clearly been a shift in using ecosystem services language, and all participants were familiar with the concept. The second element, in which the core outputs of ecosystem functioning were considered to be service delivery, was present at the project scale, but not necessarily as a comprehensive guiding principle for respondents who viewed ecosystem services as a supplementary approach to other necessary Forest Service approaches. There was strong adherence to element three, which consists of having a focus on integrating transdisciplinary scientific and local knowledge and preferences, as two of the three (*Participatory Planning* and *Regulatory Requirement)* perspectives centered around explicit integration of local values as part of the ecosystem services process. The fourth element, which emphasizes quantitative or qualitative assessment of ecosystem service values delivered by ecosystems, was demonstrable only through limited qualitative assessment: increases or decreases in provision of prioritized ecosystem services were qualitatively described in the Big Marsh project (Foley et al., 2014). Additionally, few

participants referenced potential future use of monetary quantification or ecosystem services modeling.

While the approaches used largely fulfilled elements of the conceptual underpinnings of an ecosystem services approach, they diverged from methodologies and framing commonly employed in the academic literature. For example, only one of the participants discussed the use of quantitative spatial modeling of multiple ecosystem services in order to consider tradeoffs and synergies among according to different scenarios, methodologies frequently associated with using ecosystem services in spatial planning (Bremer et al., 2015; Daily et al., 2009; Mascarenhas et al., 2014; Nelson et al., 2009). Similarly, there was little consideration of the use of the concept to explicitly communicate the value of National Forest lands to society through calculation of economic value of one or more resources, or discussion of the potential for the establishment of payment for ecosystem services programs (Costanza et al., 1997; J. Farley & Costanza, 2010; Wunder, Engel, & Pagiola, 2008). This disconnect between the understanding of ecosystem services methodologies in the research community and among the management community is likely related to both the difficulty in adapting such methodologies to different spatial scales, policy settings, and land use settings (Rinne and Primmer, 2016), as well as the fact that these methodologies are simply not yet mandated as part of on-the-ground management, and therefore not among the day to day priorities of managers.

Participants discussed the degree to which the Forest Service had substantial data and models related to individual forest resource areas, though in only one case was this data described as potentially informing ecosystem services tradeoff modeling. Opportunities exist in connecting tools that have been developed for the quantification of ecosystem services in

the academic literature to quantification of National Forest ecosystem services. This could include the exploration of new integrative modeling frameworks or the adaptation of out-of-the box ecosystem service modeling solutions like ARIES and InVEST to Forest Service data (Albert et al., 2014; Bagstad, Semmens, Waage, & Winthrop, 2013; Bagstad, Semmens, Villa, & Johnson, 2014; Nelson et al., 2009). This would require transdisciplinary collaboration among Forest Service scientists working within narrow disciplinary areas, as well as the acceptance that early stages of integrated modeling necessarily include high levels of uncertainty when compared to highly developed single-resource models.

Overall, it is apparent that in the Pacific Northwest region, the concept of ecosystem services has been employed primarily as a way to implement forms of participatory planning at multiple levels. Through their outreach efforts focused on understanding values of interested groups, adherents to both the *Regulatory Requirement* and *Participatory Planning* perspectives prioritized local stakeholder uses and values over more distant stakeholders and societal interests. Multiple respondents holding the *Participatory Planning* perspective stated that in some cases they deferred to local stakeholder values and appeals to *not* develop recreation sites and trails that they might have been developed otherwise, serving the interests of local constituencies in keeping outsider groups away. The recreation sites that were not developed may have held greater value to more distant stakeholders who were not consulted in the outreach used in this version of an ecosystem services approach.

Participatory planning and stakeholder outreach within ecosystem services processes has long been called for to promote successful application of ecosystem services based management (Chan et al., 2012; Menzel & Teng, 2010). This focus, however, brings up important questions about who is included and excluded in the process. While National

Forests are made up of places that hold special meaning to local residents, as federally managed forests, they also explicitly serve larger regional and national constituencies (Asah et al., 2012). Employing multiple methods to qualitatively and quantitatively assess ecosystem services could better include these broader constituencies: web-based ecosystem service values mapping has been explored to include stakeholder values at the regional scale (Besser, McLain, Cerveny, Biedenweg, & Banis, 2014; Sherrouse et al., 2011), and integrative modeling exercises (introduced above) may better integrate ecosystem services that are valuable over larger scales (e.g. carbon sequestration). Methods are needed that can integrate and balance the ecosystem services that are valued by individuals at multiple scales, as well as those that have societal value more broadly.

Another hurdle to applying an ecosystem services approach is that some viewed it as an added burden to already stressed budgets and workflows that have been developed to address other priorities rather than a potential way to address those challenges. Respondents were unclear about how an ecosystem services approach might be used to address what they perceived as the most pressing challenges in managing the forest, which included ensuring public safety, reducing wildfire risk, or managing conflicting priorities with limited financial resources. In one case, a participant saw managing for ecosystem services as being in direct opposition to one of their largest concerns, pointing out that managing specifically for carbon would directly contradict their need to decrease forest fuel loads: “if you store carbon, it’s going to burn!” More broadly, there was poor understanding of how information on ecosystem services might help address day to day demands and priorities of decision makers: “It gets complicated using any type of research when you’re actually planning stuff.”

Considering how an ecosystem services approach might address current management priorities should be a focus of applied research.

Throughout the interviews, it was clear that concepts such as ecosystem services can disseminate quickly through the Forest Service in the region. Some respondents noted that, while perhaps their forest had not considered ecosystem services up to this point, they had experience in a forest where they had worked previously. As planners and managers move, which appears to have happened frequently, new viewpoints and experiences can move with them. In some cases, it seemed that individuals who had previous experience using the ecosystem services concept were sought after for their abilities to help adapt the approach to a new context. Additionally, there was clear identification of "ecosystem champions," people within the organization who are effective at spreading word of the concept (Saarikoski et al., 2018). Importantly, nearly all respondents report first hearing of the concept from some other source within the Forest Service. However, as Saarikoski et al., (2018) state, one potential problem with the application of the ecosystem services concept is that it can be employed to confirm the validity of suboptimal ways of doing things. This is a pronounced risk in the Pacific Northwest context, where there are multiple narratives regarding what ecosystem services are and what it means to manage for ecosystem services. If one particular ecosystem services workflow spreads in the Forest Service that does not best leverage the available tools and methodologies, there may be missed opportunities in improving outcomes. Even if clarity is established regarding definitions and conceptual frameworks, respondents perceived a large segment of their Forest Service colleagues as resistant to change. One respondent holding the *Participatory Planning* perspective pointed out, for example, that some districts

have “fought a bit against the concept for whatever reason,” not understanding “why people don’t embrace the idea.”

E. Conclusion

Pacific Northwest National Forest planners and managers shared strong understandings of the basic concept of ecosystem services and considered key ecosystem services to be cultural and provisioning services most valued by local stakeholder groups (e.g. recreation, non-timber forest products), along with longstanding Forest Service priorities (e.g. terrestrial and aquatic habitat maintenance). Although familiarity with the concept was high, there was not one clear widely adopted approach to ecosystem services-based management, and three general perspectives emerged that applied elements of the concept to different degrees at different scales. Overall, ecosystem service approaches were perceived to be useful in improving consideration of local stakeholder values, broadening the array of factors considered by management beyond disciplinary objectives like meeting timber targets or managing solely for habitat, and reframing the way forest benefits are communicated. This broadened consideration would allow management to more intentionally weigh the benefits and tradeoffs of the management actions they consider.

While ecosystem services are increasingly adapted to address specific management goals, there was little consideration of many ecosystem services methodologies as described in the academic literature (e.g. quantification of ecosystem services, spatial modeling, monetary valuation) as such methods were not understood as addressing day-to-day information needs and were not generally acknowledged as being a core part of an ecosystem services approach. Further development of the concept should consider the competing needs

of stakeholders at multiple scales, investigate the use of integrative modeling to quantify tradeoffs among ecosystem services by synthesizing interdisciplinary Forest Service data, better align ecosystem service approaches with a wider array of management priorities, and clarify definitions, classifications, and workflows that disseminate throughout the Forest Service. To start, the Forest Service should continue working with the research community to develop definitions and guidance for an ecosystem services approach that would improve understanding of the wide variety of ways National Forest ecosystems affect the wellbeing of a large number of stakeholders, and the equally numerous ways that decisions made on National Forest lands can result in tradeoffs in how ecosystem services are delivered. This requires both continued top-down consideration of the institutional role, and ideal scale, at which an ecosystem services approach should be employed, as well as continued development of methods aimed at better understanding what ecosystem services matter to whom, and how changes in ecosystem service delivery can be described or quantified.

III. Chapter 2: Perceptions of ecosystem service uses, benefits, and values on National Forest lands: a case study from Gifford Pinchot National Forest, Washington State, US

A. Introduction

Ecosystem services are defined by the United Nations-sponsored Millennium Ecosystem Assessment as the benefits that people obtain from ecosystems and are frequently categorized as belonging to one of four categories: provisioning, regulating, cultural, or supporting (MEA, 2005). The concept is increasingly invoked as a guiding principle for natural resource management at a wide variety of scales and contexts. For example, the 2012 Planning Rule, a US Forest Service rule established to guide the development of individual forest plans, explicitly stipulates that National Forest plans must "provide for ecosystem services… considering a full range of resources, uses, and benefits" (US Forest Service, 2012. p21167). Employing an ecosystem services lens means shifting management focus towards maintaining or improving the provision of one or more specific ecosystem services with a central goal of improving human well-being (Menzel & Teng, 2010).

In practice, the transition to environmental decision making based on an ecosystem services has resulted in the development of several distinct, yet related approaches (Costanza et al., 2017; Hermelingmeier & Nicholas, 2017). Payment for ecosystem service programs focus on improving the provision of one or a few services by structuring payments or other benefits from ecosystem service users to the landowners or managers providing the service(s). In other cases, monetary values are assigned to ecosystem components in order to communicate the value of nature in economic terms (e.g., the valuation of the entire world's ecosystem services at 33 trillion dollars by Costanza et al., 1997). In the land use planning context, spatially explicit models are used to quantify the provision of multiple ecosystem

services, and different scenarios based on land use change illustrate change in ecosystem service delivery (Daily et al., 2009; Nelson et al., 2009). Often, these spatial planning exercises revolve around the identification and consideration of tradeoffs and synergies where tradeoffs refer to cases where the delivery of one ecosystem service benefit occurs at the expense of the delivery of another, and synergies refer to the delivery of multiple distinct benefits together (Bennett, Peterson, & Gordon, 2009; Hicks, Graham, & Cinner, 2013; Raudsepp-Hearne, Peterson, & Bennett, 2010).

One of the key ethical questions regarding the use of the ecosystem services concept, raised by Jax et al., (2013) is the consideration of "which values are included or highlighted and which are excluded or obscured?" The first steps in each of these methodological approaches necessarily requires decisions about which ecosystem services merit inclusion in the analysis and subsequent assessment. Most ecosystem services assessments structure their consideration of ecosystem services around the Millennium Ecosystem Assessment categories or those of other similar frameworks that interpret what are considered ecosystem services (La Notte et al., 2017). Limited research into the applicability of these categories in specific local contexts suggests that the benefits derived from natural areas have a high degree of place specificity, and the application of any given framework may oversimplify some categories and overlook others (Asah, Blahna, & Ryan, 2012). Regardless of categorization used, individual services or benefits considered in modeling or tradeoff analysis are often chosen based on suitability for a given modeling exercise or upon expert deliberation of what matters. Overall, the vast majority of ecosystem services assessments have been based on quantifying, in economic or biophysical terms, select regulating and provisioning services (Chan, Shaw, Cameron, Underwood, & Daily, 2006; Costanza et al.,

1997; Hicks et al., 2013; Saunders et al., 2015). Meanwhile, Chan et al. (2012) express the need for ecosystem services approaches to consider, rather than dismiss, "ill-fitting" values, including harder to quantify cultural and/or provisioning services.

More broadly, there are widely articulated concerns that there has been a lack of inclusion of cultural values and stakeholder perceptions of which ecosystem services matter, and why, in ecosystem services-based management (K. M. Chan et al., 2012; Kumar & Kumar, 2008). This has resulted in a lack of attention to and understanding of, cultural ecosystem services and the priorities, values, wants, and needs of stakeholders (Menzel & Teng, 2010). Ecosystem services analysis that includes stakeholders in identifying and articulating their values related to a given management area can improve management in several ways. Tradeoffs and synergies can exist at multiple scales, and land use decisions can affect different stakeholder groups in ways that can be difficult to predict without a fully informed inventory of uses, benefits, and values of all groups. Furthermore, including participatory processes in assessing ecosystem services can lead to higher quality decisions, and increased legitimacy, as well as improved compliance with implemented measures (Menzel & Teng, 2010).

A wide variety of studies have reached out to stakeholders to understand what ecosystem services are most valued. Overwhelmingly, these studies establish the importance of cultural ecosystem services as being those that are most important to communities involved in natural resource management (Brown, Montag, & Lyon, 2012; Darvill & Lindo, 2016; Raymond et al., 2009). However, while encouraging participation, these outreach efforts generally provide a fixed list of indicators that can be selected or rated by participants (Alessa, Kliskey, & Brown, 2008; Darvill & Lindo, 2016). There are fewer examples of

studies that use open ended questioning to consider whether certain uses, values, and benefits are perceived, recognized, used, or valued at all, and whether common ecosystem services frameworks encompass the full range of benefits received (Asah et al., 2012; de Oliveira & Berkes, 2014; Hauru, Eskelinen, Yli-Pelkonen, Kuoppamäki, & Setälä, 2015). Asah (2012) find that ecosystem services and benefits received are highly place specific, and there is substantial complexity and overlap between the categories of commonly used classification schemes. De Oliveira & Berkes (2014) underline the importance of investigating how local people's perceptions of their surroundings relate to the an understanding of ecosystem services.

Within the US Forest Service context, the benefits of public participation have been noted in a recent technical report: "Understanding which ecosystem services are valued most highly in a community, and clarifying the rationale for management actions, will help the USFS to develop and implement plans in collaboration with people and communities, and to better manage the resources entrusted to the agency" (Deal, Fong, & Phelps, 2017). However, in the pilot studies investigating the application of ecosystem services in the Forest Service context, few studies explicitly investigated these things (Asah et al, 2012 as the notable exception).

The goal of this study is to understand stakeholder values, perceptions, and priorities related to ecosystem services at the National Forest scale to elucidate potential complexities and nuances in the application of an ecosystem services approach to forest planning. The first step in implementing a participatory, inclusive approach to managing for ecosystem services includes allowing stakeholders to articulate their wants and needs (Menzel & Teng, 2010). Here, this knowledge gap in the application of the ecosystem services concept as it relates to

National Forest stakeholders is addressed for the Gifford Pinchot National Forest. Specifically, the following questions are addressed:

- Which ecosystem services and forest benefits are recognized by National Forest stakeholders as being provided by Gifford Pinchot National Forest?
- Which ecosystem services are considered most important to US National Forest stakeholders as individuals and which do they perceive as most important to society more broadly?
- To what degree do ecosystem services and forest benefits identified by stakeholders in Gifford Pinchot National Forest align with or differ from Millennium Ecosystem Assessment categories?

B. Methods

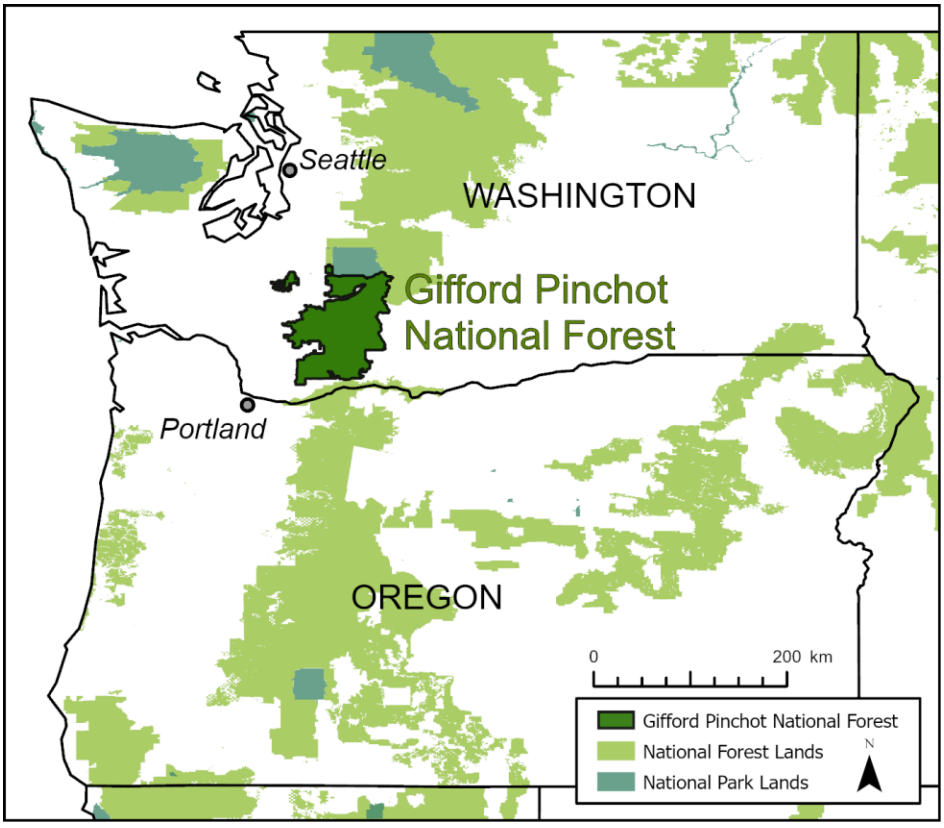
1. Study area

Gifford Pinchot National Forest covers 5,537 square kilometers along the western slope of the Cascade range in Southern Washington (USFS, 2018). Included within the National Forest boundaries are the Mount St. Helens National Volcanic Monument (44,636 hectares) and seven federally designated wilderness area (totaling 73,086 hectares). The majority of the National Forest consists of high-relief timberlands made up of species including the Douglas-fir, Western hemlock, various species of cedars, as well as lodgepole and ponderosa pines (USFS, 2017). Several areas within the National Forest rise above the tree line, including the high volcanic peaks of Mt. Adams, the second highest peak in Washington (3,743 meters) and Mt. St. Helens, a 2,549 meter volcano known for its destructive 1980 eruption, as well as the rocky ridges and peaks of the Goat Rocks. Scattered amongst these landscapes are unique physical features including high lakes, lava flows, lava tube caves, and high mountain glaciers. Several important rivers have their headwaters on National Forest lands, including the Cowlitz, Cispus, White Salmon, and Lewis.

The lands that now make up the National Forest have a history of human use dating back thousands of years. Native Americans used the area for hunting and the collection of numerous forest products and actively managed the forest through controlled burning. Through the 20th century, changing forest management paradigms resulted in widescale changes to the function of forest ecosystems, as timber yields increased through the use of clearcutting until the 1980s (Kline, Mazzota, Spies, & Harmon, 2013). Currently, Gifford Pinchot National Forest is used actively by both rural and urban constituencies and offers a wide array of ecosystem services to different people at multiple scales. Local population

centers include the communities of the Cowlitz Valley in the north (Packwood, Randle, Morton) and the Columbia River Gorge in the South (Carson, Stevenson). Smaller communities abutting the National Forest lands include Amboy and Cougar to the West and Trout Lake to the Southeast. The forest is also less than a two-hour drive from Portland, Oregon and three hours from Seattle, Washington. The National Forest is among the top producers of non-timber forest products in the nation, has a relatively high timber output, and hosts a large number of diverse urban and rural recreation users.

Figure 1 – Gifford Pinchot National Forest shown amongst other federal lands in the Pacific Northwest (National Forests and National Parks)



2. Survey data collection

Semi-structured interviews were conducted with representatives of stakeholder groups who are actively involved in stewardship and management of Gifford Pinchot National Forest. Groups were identified through initial contact with the two collaborative groups that work with the National Forest, through six interviews with Gifford Pinchot and regional Forest Service staff, and through a stakeholder analysis exercise that was conducted in ten of the first eleven stakeholder interviews. Once identified, groups were contacted by reaching out through the public contact information for the group posted on their website by email or phone and inviting them and their constituencies to participate in the study. In few cases, snowball sampling was employed as participants were invited to identify and contact qualified individuals who were then asked to contact the researchers if interested. Snowball sampling never resulted in more than one additional interviewee from a given group. In total, 23 interviews were conducted with participants from diverse groups including members of local government (2), tribal government (1), timber industry (3), recreation groups (3), environmental groups (4), urban residents who have a strong connection to the forest (1), and active local community members from the areas surrounding the National Forest (3 from the South, 4 from the North, 1 from the West, 1 from the Southeast).

Interviews focused on discussing which benefits the participant used and perceived as valuable in Gifford Pinchot National Forest and included a ranking exercise to establish which ecosystem services were considered to be most important to the participant as an individual and to society as a whole. Because there is ongoing debate about the approachability of the term "ecosystem services," recruitment documents and interviews referred to "National Forest uses, benefits, and values" (Chapter 1). Interviews first focused

on identifying forest ecosystem service uses, benefits, and values, moving from an assigned approach to an ascribed approach (Besser et al. 2014). Participants were asked open-ended questions designed to allow them to discuss the uses and benefits they value from National Forest lands. Specifically, participants were asked to list and describe the following:

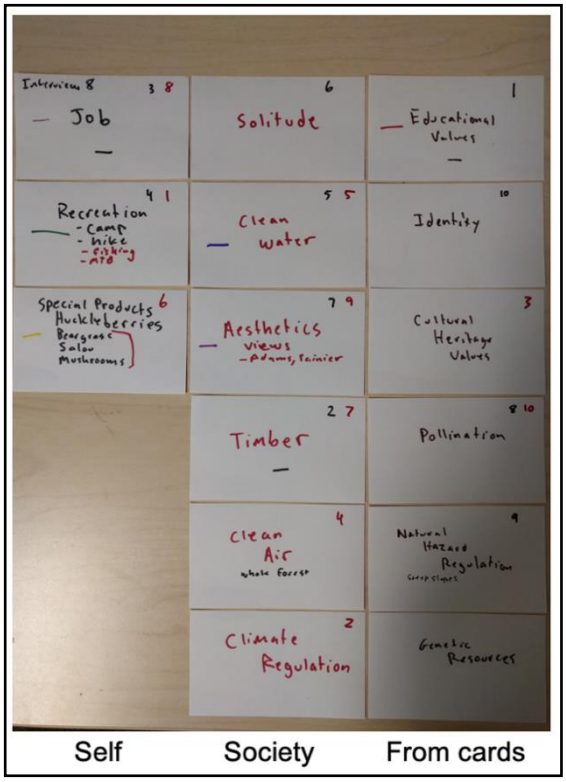
- Ways they use the forest
- Goods and products from which they benefit
- Less tangible thoughts, feelings, and ways the landscapes and ecosystems of the National Forest are meaningful to them

Following their discussion of the ways they use and value the forest, they were asked the same set of questions about the perceived uses and values other people, communities, and society in general have related to the lands of the National Forest. As participants identified and explained categories of uses, goods, and values, each was added to a 3" x 5" notecard.

Subsequently, participants were asked to supplement the uses, benefits, and values they identified with relevant Millennium Ecosystem Assessment (MEA) categories that they perceived as important from the National Forest which did not arise through open-ended identification (MEA 2005). Participants were given two sets of cards listing MEA categories (regulating/provisioning and cultural) with any categories that they had previously identified during the initial interview removed. Each card included an ecosystem service category and a brief description based on the MEA categories used by Asah et al (2012, pg. 150; Appendix F). From each of these, they were asked to select up to three additional categories that they perceived to be the most important benefits the forest provides, and they were asked to discuss why they believe each selected category to be important.

Finally, participants were asked to rank their top ten identified uses and values in order of importance to them and to other people, communities, and society by rearranging the cards (Lopez-Marrero & Hermansen-Baez, 2011). For both of the ranking exercises, participants were able to use and/or reuse any of the cards uses, values, and benefits identified, including those from the MEA categories identified (i.e. any card could be included as important to self, as well as important to other people, communities, and society). Participants were also asked to discuss which of the categories they identified they perceived to be priorities for the Forest Service in management of the forest, and what they believed priorities for management in the National Forest should be. The interview protocol used for this research was approved by the Institutional Review Board at San Diego State University and consent was obtained from each participant prior to the interview.

Figure 2 – Example of the National Forest uses, benefits, and values identified by one interview participant. Column one shows the categories that they personally valued. The middle column indicates those categories the participant deemed important to other people, communities, or society more broadly. The final column included categories selected from the Millennium Ecosystem Assessment. Rankings for the top 10 uses, benefits, and values to self (black) and society (red) are shown in the top right of each card.



3. Data management and analysis

Information on the cards of the use, value, and benefit categories identified by participants was entered into a database and coded as to whether they came up in discussion about a participant's individual uses, values, or benefits, discussion about societal uses, values or benefits, or if they came up upon review of further MEA categories. Separate datasets were created for data on use, benefit, and value category rankings in terms of importance to the individual and perceived importance to society. Interviews were digitally

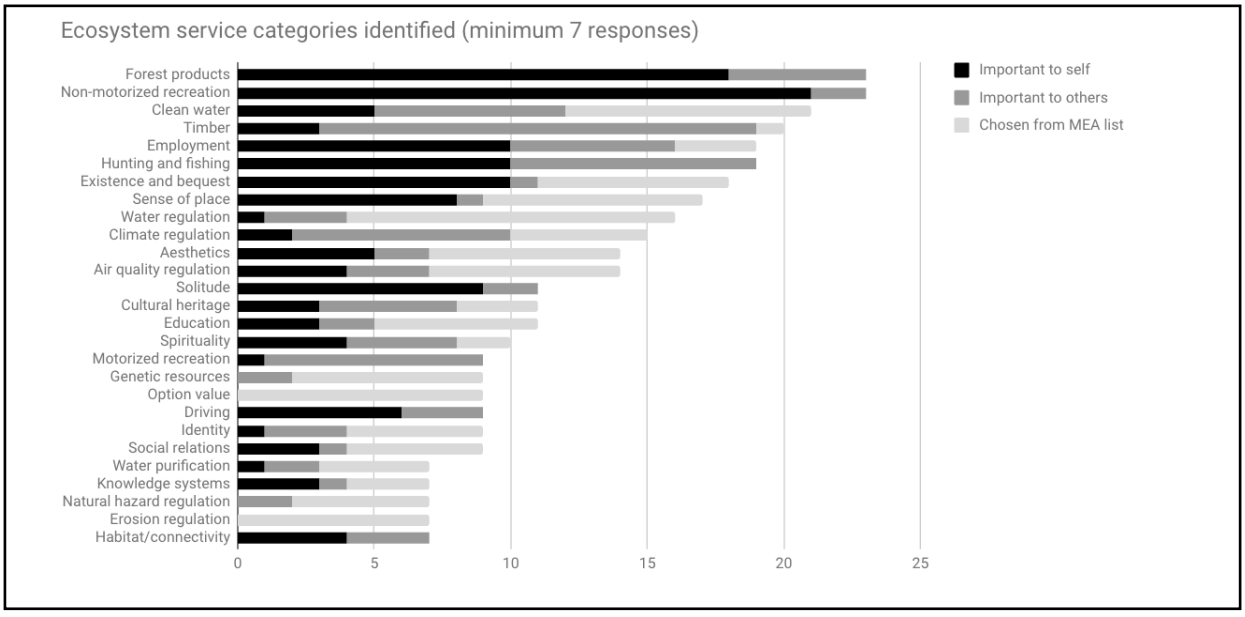
recorded, and notes were compiled both during the interview and upon subsequent review of recordings.

The number of times each use, value, or benefit category was mentioned during each part of the interview was quantified to understand the total number of times each category was recognized, and at which interview stage it was discussed. Datasets of category ranks were analyzed by summarizing the number of times a use, value, or benefit category appeared in the top three most valued categories for the participant individually and/or perceived importance to society. Interview recordings and extensive notes from the interviews were used to support and expand upon reasons for the identification and ranking of use, value, and benefit categories.

C. Results

Interviews revealed a wide range of National Forest land uses, benefits, and values, with nearly all of the ecosystem services and benefits identified pertaining to the cultural, provisioning, and regulating service categories (Figure 3). The only two ecosystem service categories identified by all 23 respondents were the provisioning of non-timber forest products and the use of National Forest areas for non-motorized recreation. Other ecosystem service categories frequently articulated included provisioning ecosystem services such as clean water and timber, and regulating ecosystem services, including water quality regulation, climate regulation, and air quality regulation. Participants also identified a wide variety of cultural ecosystem services that were often related to specific activities they undertook on the forest.

Figure 3 – Most frequently identified ecosystem services and benefits. The shade denotes the interview stage at which the ecosystem service or benefit arose and was discussed. Only those categories identified a minimum of seven times are included here.



1. *Provisioning ecosystem services*

Provisioning ecosystem services were well represented among the top identified forest uses, values, and benefits. Nearly all respondents recognized the importance of National Forest lands in providing non-timber forest products, timber, and clean water. The Gifford Pinchot has a large "special forest products" program, where a wide array of goods and products are collected for both personal and commercial uses by diverse groups of people. Goods and products identified as valued to individuals and society in this category included food products like huckleberries and diverse species of mushrooms, as well as ornamentals plants like beargrass, salal, Christmas trees, and boughs used in wreath creation. Unlike provisioning ecosystem services considered in many other contexts, these provisioning services are not cultivated intensively, and represent less of a spatial tradeoff with other ecosystem services. Regardless, they are often at the center of issues related to user conflict, permitting, and enforcement, and therefore make up an important category of ecosystem services for forest management.

The provisioning of clean water was widely recognized as an important ecosystem service. Five respondents considered the water coming from National Forest lands to be important to them personally, identifying specific watersheds, creeks, and rivers that supplied their community with water. Many more, however, recognized the importance of the forest as an origin to water supplied to other people, communities, and society. Taken together with those participants who selected this ecosystem service from the MEA cards, all respondents but two recognized this as an important ecosystem service.

Though timber harvest has decreased since the implementation of the Northwest Forest plan in the early 1990s, timber was perceived as a provisioning ecosystem service by

most respondents. In addition to special forest products, clean water, and timber, other provisioning ecosystem services identified by small numbers of participants included natural medicines, and rock collection, and mining. Food obtained from hunting and fishing was also a provisioning ecosystem service identified by many respondents, but this category may also be considered in this context to be a cultural service.

2. *Cultural ecosystem services*

The remaining ecosystem services recognized by respondents prominently feature a wide range of cultural services that illustrate some of the key ways that people perceive National Forest benefits. Beyond the widely articulated use of the forest for different types of recreation, additional identified cultural ecosystem service categories included existence and bequest, employment, solitude, sense of place, cultural heritage, and social relations. Open ended discussion about the ways the forest is meaningful to the participant allowed clarification of how these categories can have more complex meanings to respondents and gave insight into why the National Forest is important to people.

All participants engaged in some form of recreation on the forest lands, whether it was nonmotorized (hiking, backpacking, skiing, horseback riding), motorized (snowmobiling and motorcycle riding) or extractive (hunting/fishing). As noted by Asah et al., (2012), recreation often represented a gateway through which other important cultural ecosystem services were realized. Solitude was often considered an important cultural ecosystem service, as some participants valued the ability to go to certain places where they knew they would be unlikely to see anybody for days. Some referred to the National Forest as a place in which people can challenge themselves and undertake difficult or risky activities in a way

that is not possible in areas with more established rules and social norms. Other participants expressed a deeply spiritual relationship with the forest, citing either specific places that have held spiritual significance since before colonization (including the high mountain peaks of Mount Adams or Mount St. Helens) or more general feelings of deep spiritual connection to old growth forests. The complexity of spatial expression of all of these values related to diverse types of recreation can be easy to overlook in ecosystem services analysis.

Discussions also revealed substantial overlap between categories, especially between provisioning and intangible cultural services (as in Asah et al., 2012). Timber provisioning and employment were frequently identified forest uses and benefits that were often connected with identity, sense of place, and the survival of local communities. The importance of timber harvest to local communities was clearly stated by many respondents as related to the number of jobs the industry provided communities and due to the fact that timber sales on National Forest lands have long augmented the local tax base to provide funding for local schools. Respondents saw continued timber harvest as integral to the maintenance of a particular way of life that they valued. As further examples, many participants identified harvesting huckleberries (among other forest products) as having particular cultural significance to the Native American communities in the area and several discussed Christmas tree harvesting as a family tradition that had importance far beyond simply saving money on a store-bought product. Additionally, fuelwood was harvested and collected by respondents primarily for the sale to visiting campers from outside the area, creating spaces for social interaction and improving their experiences visiting the area.

Discussion of the reasons for the identification of some categories revealed complex underlying perceptions across stakeholders that were often at odds with each other. Though

many participants identified aesthetic value as important to them, different attributes of National Forest ecosystems provided that benefit to them. Some pointed out the beauty of grand vistas toward prominent mountain peaks while others focused their discussion on appreciation of the beauty of small-scale features of old growth forests like the moss growing on a decaying log. For others, the look of what they considered a "properly managed" forest, with sparser stands and a thicker understory was most beautiful. In one case, aesthetic benefit was realized through the smell of the forest obtained when first stepping out of a car.

Similarly, discussion of the reasons for which participants expressed option value made it clear that they held different visions of the array of future possibilities for the forest. Some saw option value in the potential for further recreation development, while others expressed the potential to return to increased managed timber harvest. The social relations described by participants included instances where what was valued was meeting like-minded people when undertaking a particular recreation activity as well as instances where value was derived from interacting with people very different than one would normally interact with in their day-to-day life.

3. *Regulating and supporting ecosystem services*

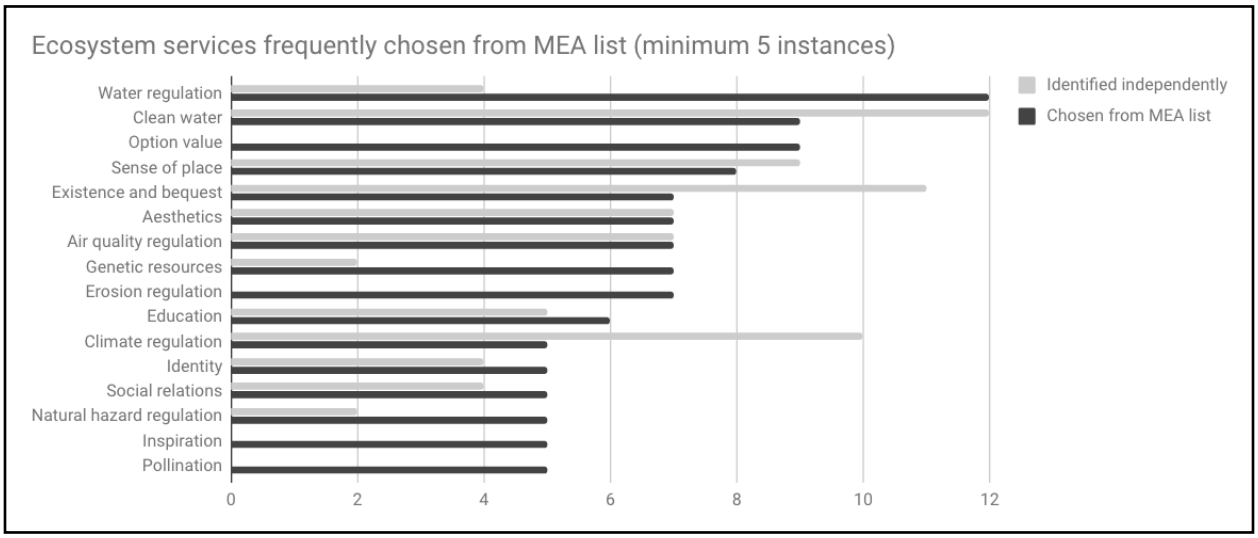
Regulating services were less frequently identified than provisioning services or cultural services. Climate regulation via carbon sequestration was identified by ten respondents and selected from MEA cards by five more. However, there was disagreement in the type of landscapes that were perceived as best for climate regulation: some perceived the rapidly growing areas of managed stands to sequester large volumes of atmospheric carbon, while others pointed to high biomass old growth stands as having particular importance in

storing and sequestering carbon. Water regulation and water purification were often selected from the MEA cards but frequently confounded with the provisioning service of clean water. A few other regulating ecosystem services, including natural hazard regulation, erosion regulation, and air quality regulation were recognized as being important primarily among the MEA cards. Supporting ecosystem services are traditionally difficult to define, and very few were identified or selected from the MEA cards. A supporting service identified by multiple participants was swaths of habitat that represented corridors for connectivity, and genetic resources was a supporting service frequently selected from the MEA cards.

4. Participant values and Millennium Ecosystem Assessment categories

The interview protocol differentiated National Forest ecosystem service and benefit categories that participants perceived intuitively and those that were not intuitive, but which resonated with them from Millennium Ecosystem Assessment categories. Figure 4 shows the ecosystem services that were most frequently selected from the MEA list, after respondents independently identified categories. This means that those categories selected were not necessarily intuitive to stakeholders but were perceived to be important once presented to respondents. The majority of forest uses and benefits discussed aligned with MEA categories, however, similar to Asah et al. (2012), discussion also revealed categories that merged MEA categories or did not fit within MEA categories at all.

Figure 4 – Ecosystem services and benefits most frequently identified upon introduction of Millennium Ecosystem Assessment categories.



There were several ecosystem service and benefit categories that were seldom identified independently but were often selected as important once participants were presented with MEA categories. Water regulation and clean water were discussed organically by several participants but selected by many more as important upon consideration of MEA categories. Erosion regulation, inspiration, option value, and pollination were categories that no stakeholder articulated as being important things National Forest lands offer but were selected by five or more participants upon presentation of MEA categories. Other cultural ecosystem services, including sense of place, existence and bequest, and aesthetics were also often identified from the cards.

Some frequently identified forest uses, benefits, and values did not relate directly to MEA categories. One group of these included the importance of National Forest lands to the economic wellbeing and way of life of surrounding communities. Many participants, not all of whom engaged in harvesting provisioning ecosystem services considered their employment as related to National Forest lands. While some of these participants

supplemented their livelihood through provisioning services like nontimber forest products or involvement in the timber industry, others were involved in stewardship, restoration, education, or trail building. In addition to direct employment, timber harvested and sold off of National Forest lands traditionally account for payments to local schools that were valued by many in local communities. There were differences in the perceived relative values of different types of employment to the community: some saw the growing number of recreation related jobs as a boon to the local economy, while others considered these to be undesirable jobs unable to deliver the family wage jobs that allow for healthy communities. The interplay of all of these economic relationships indicates that there is a more complicated interplay between economic well-being and livelihood benefits provided by National Forest ecosystem services than the typical relationship between extractive provisioning services and personal income that is considered in many ecosystem service-based studies.

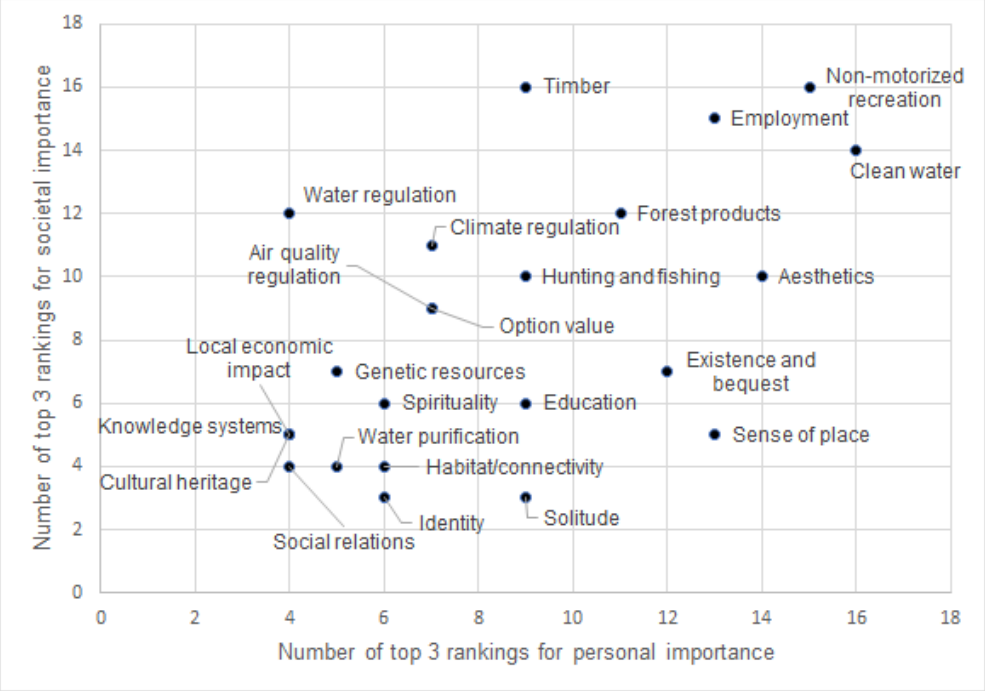
Presentation of cards with MEA categories revealed some challenges in employing the concept with stakeholders. As has been noted in other contexts, MEA categories were not always clear to participants (Berbés-Blázquez, 2012). There were several pairs of categories that were confusing to respondents and often required repeated clarification of differences between them. These included option and bequest, identity and sense of place, education and knowledge systems, and fresh water and water purification

5. *Priority ecosystem services for individuals and society*

Participants were asked to select and rank the top ten ecosystem service and benefit categories identified in terms of importance to themselves and to society (Figure 5). In this exercise the two ranking lists were done in sequence and the same category could be selected

for both rankings. The ecosystem service categories most often identified as one of the top three most important categories mirror those identified most frequently by respondents overall. These categories included non-motorized recreation, employment, clean water, timber, and aesthetics. The top three categories were identified as among the most important to self and society approximately an equal number of times, while timber was less frequently identified as being important to the individual, and aesthetics was more frequently identified as being important to the individual.

Figure 5 – Number of times each ecosystem service category was ranked in the top 3 most important to the participant or to society. Categories were included on the graph if they were selected a minimum of 8 times.



Several regulating and provisioning categories, including water regulation, climate regulation, air quality regulation, forest products cluster towards the top left of Figure 4, indicating that these were selected more often as among the top three most important

categories to society rather than to participants. Meanwhile, most of the categories toward the lower right of the graph include a variety of the most valued cultural ecosystem services that seem to have resonated as more important to the lives of individuals (including existence and bequest, sense of place, solitude, education, and identity) and were less frequently identified as among the most important to society. Some cultural ecosystem services, however, were selected as among the most important for self and society close to an equal number of times: social relations, knowledge systems, cultural heritage, and spirituality.

D. Discussion and Conclusion

In both the National Forest context in the US and the context of protected areas globally, reaching out to local stakeholders and providing them with an opportunity to describe the forest benefits they perceive as important to themselves and society is an important first step in establishing ecosystem service-based management. As a concept that is focused on assigning value to things that are not traditionally valued, it is crucial to not overlook or ignore benefits people perceive that are not easy to model or quantify, or do not fit neatly within predetermined categories. Through semi-structured interviews with a range of National Forest stakeholders, over forty distinct uses, benefits, and values were identified as being provided by the forest (Appendix B). Many of the most frequently identified uses, benefits, and values have long been acknowledged in forest management, but additional dimensions of these services were revealed during in-depth discussion. Overall, provisioning (nontimber forest products, timber, and clean water), cultural services (recreation, existence and bequest, aesthetics, sense of place, option values) and services that blur the boundaries between the two (hunting and fishing, employment, identity related to participation in extractive industry or recreation) were most frequently identified and most highly valued.

In contrast to those uses, values, and benefits that were frequently identified, these interviews revealed categories included as part of the MEA that are not intrinsically perceived as important by National Forest stakeholders. Few categories (i.e. disease regulation) were not identified nor selected from the MEA categories by participants. Follow-up interviews would be required to determine if this is more likely due to the National Forest's perceived inability to offer these ecosystem services (e.g. control of crop and/or tree diseases, pests, etc.), or whether there is a lack of understanding among

stakeholders as to how these seldom identified use, value, and benefit categories are linked to ecosystem function. Other forest uses and benefits were not intuitively recognized by forest stakeholders but were highly valued once revealed to participants on the MEA cards. Most regulating services, including pollination, water regulation, and erosion regulation, were selected from the MEA cards more often than they were identified organically. These cases represent opportunities for the Forest Service to clarify the links between regulating services and human benefit in outreach and communication efforts (Asah et al., 2012).

The results also reveal ecosystem service categories and forest management issues that are not typically included with an ecosystem services framework: when asked about priorities for management, many respondents diverged from the categories listed on the cards, citing things like fuel load levels, maintenance of jobs, driving for pleasure or as a commuter route, and maintenance of access as things that should be prioritized. Their absence from the ecosystem services literature does not imply that these are necessarily less important. Indeed, they may be seen as services that are unique to the Gifford Pinchot National Forest, or at least less prevalent elsewhere. Taking them into account would allow for the development of a management plan that is responsive to the specific needs and local values of this particular National Forest and its stakeholders.

Even though there was a high level of agreement regarding the identification of key ecosystem services and ranking of most important services for both individuals and society, these results point to substantial ambiguity in how categories may be perceived by National Forest stakeholders. This ambiguity in perceived benefit categories reveals challenges for quantification and modeling (Olander, Tallis, Polasky, & Johnston, 2015). In their paper on ethics and ecosystem services, Jax et al (2013) describe how “a large street tree may be seen

by pedestrians as providing aesthetic benefits, while a person living in a building close to it may see it as nuisance blocking the views out of his or her window." In the National Forest context, changes to a dense forest stand clearly have implications for aesthetics, but these implications vary with the perspective of the stakeholder. For instance, the results here show disagreement as to whether thinning would result in improved or degraded aesthetic values. Changes in each ecosystem service category can bring either benefits or disservices depending on the perception of the individual. Because of these conflicting interpretations, in any discussion of ecosystem service delivery, it may be necessary for managers to define their interpretation of each ecosystem service category and include multiple indicators for a given category to better reflect the multifaceted nature of some categories. For example, it may not be sufficient to simply consider "recreation", or "aesthetics" because they have been shown to be categories that mean different, sometimes conflicting, things to different stakeholders.

One of the MEA values that was frequently selected from the cards that deserves special note is that of option value, which we described as: "places here are important because there is a predicted future use for the natural resources that exist." The option category was selected from MEA cards second most frequently of all categories; however, it was interpreted in a manner largely befitting the participants' own future desired view of the forest. Some interpreted the "future use for natural resources" to be the expansion of recreation opportunities, while others saw an increase in potential timber harvests. It was clear throughout the interviews that stakeholders did not just want their priorities catalogued, but that they wanted a voice going forward in management, and a way to describe their vision of how the forest should be. This finding has implications for spatial planning: the

realization of one participant's vision for the forest would have substantial ramifications for the uses, benefits, and values considered important to others. Spatial modeling of ecosystem service outcomes for different scenarios may be helpful in communicating what the implications of these conflicting visions would be for other services, values, and benefits.

Several National Forests are beginning to collect spatially explicit data on ecosystem service values, yet these are predominantly based on a list of services created by managers and experts. Increasingly, outreach is carried out through web-based surveys and mapping exercises that may not be inclusive of the groups that most actively use the forest. Participatory ecosystem services analysis depends upon allowing diverse stakeholders to discuss what they value in their own words. While the sample interviewed in this study was limited, it included stakeholders who have a higher stake in forest management outcomes than respondents to a web-based portal. Asah et al. (2012) found that the use of focus groups in identifying ecosystem services resulted in rich qualitative data sets that allowed for more in depth understanding of social complexities. Similarly, semi-structured interviews here allowed for continued probing and the opportunity to clarify and expand on the underlying reasons for identification and ranking of uses, values, and benefits. A challenge in each of these methodologies, however, remains the identification and inclusion of stakeholders beyond those who already participate in forest management outreach and activities. Further challenges in understanding ecosystem services priorities related to the inclusion of the needs and desires of large, less involved urban populations along with the less populated local communities that have a way of life that is intimately tied to the forest. Overall, the inclusion of stakeholders in establishing what forest benefits matter most can improve communication between groups, strengthen the voices of local users, and increase the potential of ecosystem

service based management in creating more equitable and effective National Forest decision-making (Menzel & Teng, 2010).

Generating a clearer picture of what ecosystem services matter to stakeholder groups allows managers to better design projects that improve delivery of multiple ecosystem services, while allowing realistic acknowledgement of ecosystem services tradeoffs in cases where they may occur. At the project scale, interventions focused around providing multiple benefits can be prioritized, and the justification for such projects can be more easily communicated. For example, recent projects focusing on huckleberry restoration in Gifford Pinchot National Forest have been noted to provide benefits for passing on traditional knowledge systems, cultural heritage, recreation, opportunities for commercial harvest for local communities, habitat expansion for some species, spiritual benefits, economic benefits from related selective timber harvest, job creation, and increases in tourism (Hudec, 2017). At the forest plan level, understanding the full range of perceived benefits can help in understanding the tradeoffs among different potential management plan alternatives. Even if it is not possible to quantify or monetize most services, qualitative descriptions of the expected increase or decrease in service provision can be described (Kline et al., 2013).

IV. Chapter 3: Participatory mapping of ecosystem service uses, values, and benefits by stakeholders of Gifford Pinchot National Forest

A. Introduction

The ecosystem services paradigm for conceptualizing the environment grew from the recognition that functioning ecosystems provide a wide variety of benefits to humanity (Daily 1997). The full breadth of ecosystem services are generally divided into four categories: provisioning services (e.g. timber, food, and water), regulating services (e.g. water filtration and carbon storage), supporting services (e.g. habitat area and overall genetic diversity), and cultural services (e.g. recreation, mental health, aesthetic appreciation; Millenium Ecosystem Assessment 2005). The concept has gained traction due to its ability to bridge the conceptual gap between ecology and economics (Costanza et al. 1997), align economic forces with conservation policy (e.g. payment for ES programs; Liu et al. 2008), and its utility in framing land management decisions in a way that includes potential changes to multiple valued benefits (Daily et al. 2009). Considering ES in this last context (land management) centers on gaining insight into how a wide range of ecosystem services will be impacted upon alteration of environmental systems or changes in management (Brauman 2015).

In the last decade, US Federal agencies have begun incorporating the language and concepts of ecosystem services into planning and policy documents (Donovan, Goldfuss, and Holdren 2015). The 2012 National Forest Planning Rule, which guides the development of future individual National Forest plans, explicitly requires that forests integrate ecosystem services into new plans (US Forest Service 2012). Specifically, it requires that "plans provide for multiple uses and ecosystem services, considering a full range of resources, uses, and benefits relevant to the unit…" (US Forest Service 2012, 21166). In integrating these aims,

each National Forest is tasked with using the "best available scientific information to inform planning and plan decisions" while "providing meaningful opportunities for public participation early and throughout the planning process…" (US Forest Service 2012, 21162).

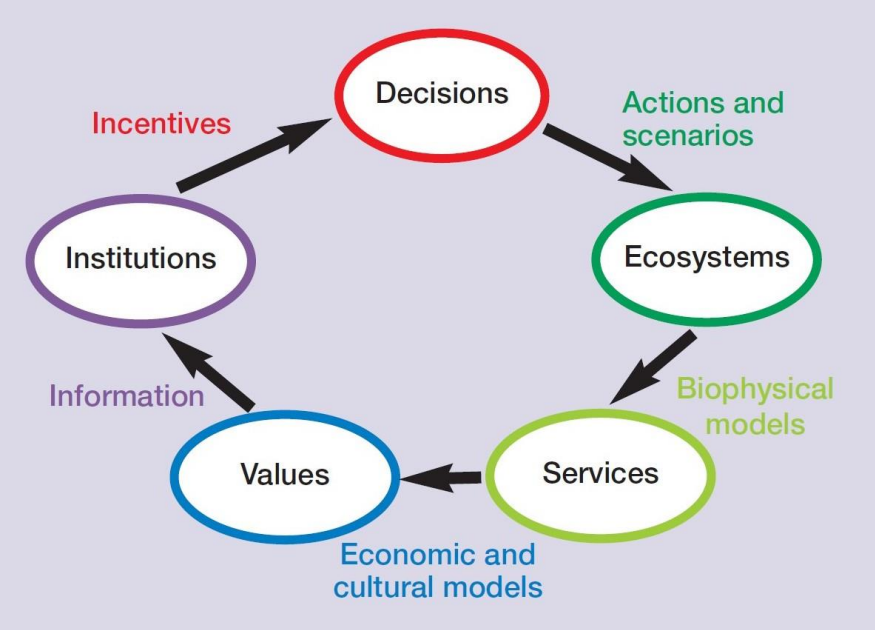
Currently, most National Forests are in the early stages of Forest Plan revision. As the conceptualization and development of a new plan takes a significant amount of time, most have not yet needed to address these new requirements. In discussing the limited number of early applications of ecosystem services based-thinking with National Forest staff, and assessing the few pilot projects that have been carried out, it is clear that new methods are needed at multiple levels within the Forest Service to better understand the ecosystem services uses, benefits, and values that National Forests provide (Chapter 1; Smith 2011). In this chapter, participatory mapping with a wide range of involved National Forest stakeholders is demonstrated as a methodology for better understanding the uses and values related to ecosystem services in a way that fulfills the 2012 Forest Plan's requirements of using best available (social) science for "considering a full range of resources, uses, and benefits relevant to a unit," while providing meaningful opportunities for public participation (Charnley et al. 2017; Cerveny, McLain, and Banis 2018; US Forest Service 2012).

1. Mapping and modeling ecosystem services

Recent research on the integration of ecosystem services into land management has focused on considering what impact land use, land cover, or land management changes would have on the provision and delivery of ecosystem service benefits. Figure 1 shows the theoretical framework guiding ecosystem-services based decision-making as an iterative process (Daily et al. 2009). According to this framework, biophysical spatial models connect

ecosystem type to quantitative or monetary ecosystem service values. Different management scenarios are considered along with these models to determine expected changes in ecosystem service delivery for each scenario. With information on expected ecosystem service outcomes according to these modeled scenarios, institutions tasked with land management can better assess the potential impact of their decisions on the entire suite of ecosystem services.

Figure 1 – The theoretical framework of Daily et al. (2009) portraying the data and models required for ecosystem services-based decision-making.



The dominant method for deriving spatial data and models related to the ability of a landscape to provide ecosystem services has been to use the 'production function' approach, in which biophysical models of the ability of each land cover type to provide a range of services is generalized over a study area to come up with estimates of ecosystem service provision or supply (Martínez-Harms and Balvanera 2012; Nelson et al. 2009). Numerous

studies using this dominant framework have been conducted, quantifying ecosystem service supply and demonstrating the tradeoffs between different ecosystem services based on a variety of scenarios (Martínez-Harms and Balvanera 2012; Kareiva et al. 2011; Crossman et al. 2013; Bagstad et al. 2013). Beyond assessing outcomes related to different management scenarios, this general framework has also been used to identify ecosystem service hotspots (where different ecosystem services coincide spatially), areas of conflicting ecosystem services, and priority areas for focusing restoration and conservation efforts (Darvill and Lindo 2015; Palomo et al. 2013)

While expert assessments and biophysical modeling give valuable insight into the provisioning of ecosystem services over large areas, they do a poor job of recognizing cultural services and characterizing the degree to which stakeholders receive the benefits that they most value (Fagerholm et al. 2012; Burkhard et al. 2012). Martínez-Harms and Balvanera (2012) found the vast majority of studies mapping cultural ecosystem services used the "causal approach," where secondary spatial data (e.g. distance to roads, land-use layers) was linked to cultural ecosystem service provision. Drawing on these causal relationships, most mapping and modeling tools for ecosystem services are not able to include the wide array of cultural ecosystem services beyond two basic types ("aesthetics" and "recreation") associated with few spatial indicators (such as viewsheds, distances to roads). For an example of how cultural ecosystems are often considered, the popular suite of modeling tools known as InVest (Integrated Valuation of Ecosystem Services and Tradeoffs) includes two cultural ecosystem service submodels: "Recreation" and "Scenic Quality" (The Natural Capital Project 2019). The recreation submodel uses the density of geotagged photographs on Flickr as a proxy for visitation rates, while the Scenic Quality model uses

viewshed calculations to identify the locations where proposed land cover/land use changes might be visible (The Natural Capital Project 2019). Overall, in their 2013 review, Crossman et al. found that cultural ecosystem services were considered in just 18% of all mapping and modeling studies, with only 6 studies mapping any cultural ecosystem services beyond recreation and aesthetic values. The continued prevalence of this status quo is reflected in the recent 5th European Union guidance on the "Mapping and Assessment of Ecosystems and their Services," (MAES), where different ecosystem types are linked to recommended indicators on ecosystem status and their ability to provide ecosystem services (Burkhard et al. 2018; European Commission 2018). For most ecosystem types, the only cultural ecosystem service type included is "nature-based recreation" and occasionally the broader category of "recreation and cultural services."

While approaches to spatial modeling of ecosystem services have become widespread, there have been calls in the literature to better consider the diverse range of cultural services on an equal footing with other services that are frequently modeled (Chan, Satterfield, and Goldstein 2012; Bagstad et al. 2013). Meanwhile, it has become increasingly clear that cultural ecosystem services are universally considered the most valued by stakeholders (Raymond et al. 2009; Darvill and Lindo 2015; Walsh 2015; Klain and Chan 2012; Chan et al. 2012). More broadly, there is a lack of studies on how different ecosystem services are used and valued by diverse groups of people that either impact or are impacted by natural resources and natural resource decision-making (Ruckelshaus et al. 2015; Menzel and Teng 2010).

2. Participatory mapping of social values and ecosystem services

To address these shortfalls, participatory mapping and participatory GIS (PGIS) have both been used as methods in eliciting local knowledge, values, and ecosystem service uses (Klain and Chan 2012; Raymond et al. 2009; Brown, Montag, and Lyon 2012; Brown and Reed 2009; Brown and Fagerholm 2015). Through participatory mapping methods, areas of tangible benefits (e.g. historic sites), intangible benefits (e.g. mental health benefits, spiritual appreciation), use benefits (e.g. recreation), and non-use benefits (e.g. bequest value for future generations, intrinsic value of wilderness) can be articulated. While place-based spatial assessments of ecosystem services allow local stakeholders to be included in the identification of the entire suite of ecosystem services, they excel in their ability to better characterize cultural ecosystem services, in particular. In addition to providing valuable place-based data to consider alongside biophysical models, these methods work to empower local stakeholders and include them in decision-making processes.

In the context of US public lands, participatory mapping with National Forest users can address the objectives of the 2012 Planning Rule, while informing management at other scales. Despite the long history of mapping biophysical data, there is noted absence of social spatial data that allows for an understanding of landscape values, management priorities, cultural ecosystem services, and human values related to the other categories of ecosystem services (Koch and Cerveny 2018). Beyond producing valuable social spatial data that can then be combined with the wide range of biophysical maps that already exist, mapping with stakeholders can increase trust and provide a new forum for forest users to converse with managers and others about natural resource issues (Cerveny, McLain, and Banis 2018). Due to the ability to achieve these multiple goals, researchers within the Forest Service have

begun to embrace participatory mapping as a method to address a range of land management questions and legal mandates. However, there is no clear consensus on which are the most effective participatory mapping methodologies, and forest managers continue to seek an understanding of how to best design outreach strategies and collect social spatial data given different goals at a range of spatial scales.

Several recent case studies illustrate the applicability of participatory mapping to the National Forest context, as well as the different methodologies employed. One of the earlier studies in US National Forests was conducted by Brown and Reed (2009) to understand landscape values for the Deschutes and Ochoco (together), Coconino, and Mt Hood National Forests, yielding thousands of points (from nearly 800 respondents) attached to one of twelve types of landscape value. A more recent large scale mapping project conducted by the Deschutes National Forest, Crooked River National Grassland, and Ochoco National Forest (all in Central Oregon) used an interactive web map hosted by a nonprofit partner ("Discover Your Forest") to survey forest users (Cerveny, McLain, and Banis 2018). Focusing on the idea of important places first, respondents were first asked about which places were important to them (placing them as points on a map) before being asked about the way they use and value those places. The several thousand points collected focused on key recreation sites while also pointing out several areas containing valued natural features like important water bodies and areas of snow (Cerveny, McLain, and Banis 2018). On Washington's Olympic Peninsula, researchers conducted eight workshops (attended by 169 area residents), where up to seven participants per map simultaneously drew polygons to identify meaningful places and locations where they undertook outdoor activities (McLain et al. 2013). For the mapping of meaningful places, a list of 14 values was included, drawn from the landscape

values typology of Brown and Reed (2009), resulting in a total of 818 meaningful places and 1594 activity areas mapped.

3. Methodological concerns related to participatory mapping of ecosystem services

In the overlapping literatures on landscape values mapping and participatory mapping of ecosystem services, there is a continuing emphasis on "methodological plurality" to better understand the implications of different methodological choices (Brown and Pullar 2012; Brown, Reed, and Raymond 2020). This has led to several ongoing debates regarding a series of decisions that must be made in any participatory mapping effort. The first of these issues concerns the primary mapping format: how internet-based surveys compare to in-person mapping, usually via a public workshop or focus group (McLain et al. 2017). Both strategies attract respondents that have higher levels of interest, experience, and familiarity with the study area though they reach two fundamentally different samples based on geographic extent (Brown 2012a). While internet based surveys attract respondents from across a state, nation, and even the world, the experiences and priorities of engaged local groups may be obscured (McLain, Banis, et al. 2017; Brown 2012a). Other studies have found that livelihood, income, stakeholder group affiliation, and technical proficiency, all of which are related to how a sample is drawn, can influence both participation rates and mapping results (McLain, Banis, et al. 2017; Darvill and Lindo 2015; Brown and Fagerholm 2015).

Participatory mapping studies also vary greatly in the classes that are mapped, also known as the typology that is used. Besser et al. (2014) refer to the "ascribed" approach, in which a predefined list of values or ecosystem services is presented to participants to map, and the "assigned" approach, where an open-ended discussion leads to the list of uses,

values, or benefits to be mapped. The vast majority of studies use the ascribed approach, where a predetermined list of landscape values or ecosystem services is given to participants to map (Brown and Reed 2009; McLain et al. 2013; Darvill and Lindo 2015). An assigned approach allows for participants to define and explain in detail what it is that they use, value, or benefit from (Besser et al. 2014; Klain and Chan 2012; Plieninger et al. 2018). With these more qualitative, inductive approaches, descriptions of uses, benefits, and values still need to be interpreted and classified by the researcher prior to assembling aggregate maps.

Another similar dichotomy that has received little to no attention in the literature is whether mapping is carried out "place-first" or "value / ecosystem service-type first." Place first mapping includes those exercises where participants identify important places and describe the values or uses related to that place, (i.e. Besser et al., 2014). Meanwhile, "value / ecosystem service type first" mapping asks respondents to consider, for each landscape value or ecosystem service type, where they use, value, or benefit from that type (i.e. Darvill and Lindo 2015). Place-first mapping may result in several values connected to one mapped feature, while value-first mapping can result in several features mapped in essentially the same location. Each presents unique challenges during data processing and analysis.

There are additional technical details related to participatory mapping that can have important impacts on resultant maps. Most studies engaging large samples have had respondents map with points rather than polygons (Besser et al. 2014; Brown and Pullar 2012). Points are relatively simple to map with, however a larger number of points is required in visualizing hotspots compared to polygons (due to the density functions employed to visualize point data; Brown and Pullar 2012). Using polygons (or in some cases multiple geometries as in R. McLain et al. (2013)) allows for mapping of areas of unusual

shapes at a range of scales, but requires a greater data processing effort, as all polygons must be digitized (Besser et al. 2014). Brown and Pullar (2012) advise that a map compiled from as few as 25 respondents' polygon-based maps is sufficient as compared to several hundred respondents for point-based maps. In few cases (ie. Plieninger 2013) the study area is organized into contiguous polygons representing predefined regions of the study area and values are ascribed to these predetermined areas.

4. Research goals

At this relatively early stage of participatory mapping on National Forest lands, few studies have focused specifically on how to gather social spatial data to inform ecosystem-services-based management. This chapter attempts to illustrate how spatial data on ecosystem services (and stakeholder values) can be collected in a way that facilitates their incorporation into National Forest management, fulfilling multiple requirements of the 2012 Planning Rule and informing management decision-making, more broadly.

In this chapter, five specific questions are addressed:

- What are the spatial patterns of ecosystem service uses, values, and benefits according to National Forest stakeholders?
- What are the characteristics of areas where overlapping uses, values, and benefits are perceived as being provided by National Forest lands?
- What are the differences in the spatial distribution of areas perceived as important for the four main ecosystem service categories?
- To what degree can participatory mapping data identify potential conflict between the uses, values, and benefits perceived by different user groups?
- How do the spatial data and maps produced during in-depth, semi-structured interviews compare to other methodologies for participatory mapping?

B. Methods

1. Participatory mapping interviews

Spatial data on ecosystem service uses, benefits, and values were collected during twenty-three semi-structured interviews conducted with participants who were actively involved with groups that play a role in forest stewardship and management on Gifford Pinchot National Forest lands (*for more in-depth details on participant identification, recruitment, and demographic profiles, refer to the previous chapter*). Interviews first focused on establishing which ecosystem service are used and valued by the respondent through open ended discussion about the benefits perceived as coming from National Forest lands. Following this, participants were introduced to the ecosystem services types used by the Millennium Ecosystem Assessment (MEA – Appendix F) and given the opportunity to include and discuss values, uses, or benefits that may not have arisen through open-ended identification. Following discussion, participants were asked to rank their top ten identified values, uses, and benefits in order of importance to themselves and perceived importance to society *(more details on the above parts of the interview in the previous chapter)*. After identifying the entire range of use, values, and benefits types perceived as important to themselves and society, participants were asked to make a map of the areas that were important for providing each type within Gifford Pinchot National Forest and its immediate surroundings.

Table 1: As this paper addresses classification of ecosystem services at different scales, the following terminology is used to clarify the scale

Table 1: Clarification of terminology used for ecosystem service classification	
Ecosystem services **category**	The four broad overarching groups of ecosystem services considered by foundational documents such as the Millennium Ecosystem Assessment (MEA) and the Economics of Ecosystems and Biodiversity (TEEB). These include the categories of Provisioning, Regulating, Supporting, and Cultural ecosystem services (Sukhdev et al. 2010; MEA 2005). In this study, ecosystem service categories perceived were the result of an aggregation of use, value, and benefit types (below).
Ecosystem service / use, value, benefit **type**	This terminology is used to refer to the individual ways that participants use the landscape, hold certain values related to places on the landscape, or directly benefit from ecosystem services. For example, different **types** of ecosystem services, or **use, value, or benefit types** within the Provisioning ecosystem service **category** include food, timber, fresh water, non-timber forest products (Sukhdev et al. 2010). In this study, use, value, and benefit types are those classes that were added to each card (Previous chapter).

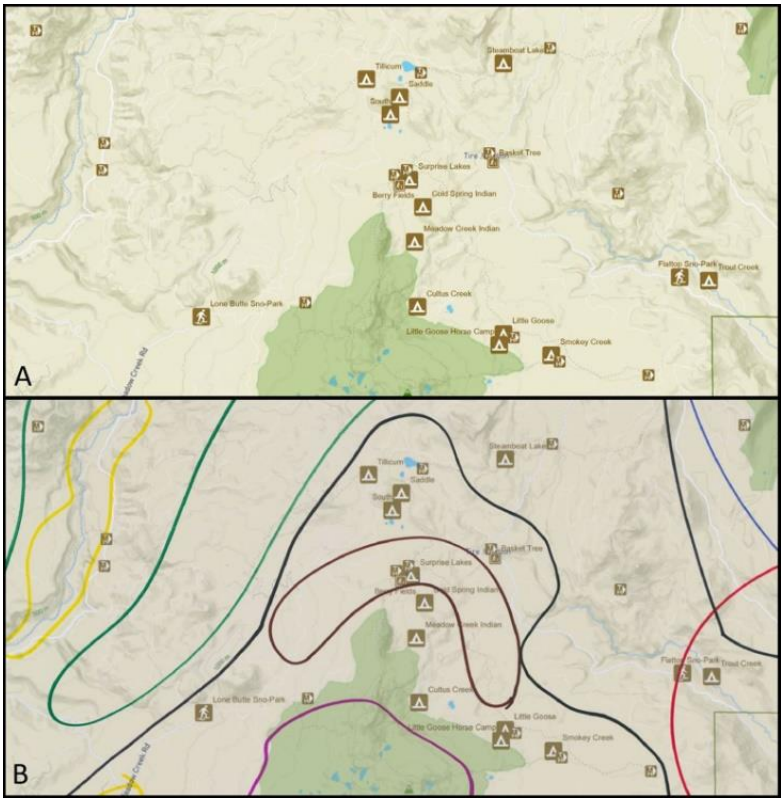
2. Base map design

Participants were presented with a 36-inch by 48-inch (91.4 x 121.9 centimeter) basemap of Gifford Pinchot National Forest and its immediate surroundings (Figure 2A) created in ArcGIS 10.5 using a combination of map tiles imported from Mapbox (2017) as a web map tile service (WMTS) along with National Forest-level geographic information systems (GIS) data obtained from the Gifford Pinchot National Forest web portal. The "Mapbox Outdoors" WMTS theme, described as a "a general-purpose map with curated

tilesets and specialized styling tailored to hiking, biking, and the most adventurous use cases" (Mapbox 2020, https://www.mapbox.com/maps/outdoors) was selected due to its similarity to recreation maps issued by federal agencies and private mapping companies, as well as the US Geological Service quadrangles frequently encountered while using public lands. It contains base layers made up of a hillshade model and contour lines that visualize elevation across the map, along with icons representing discrete features like lakes, waterways, roadways, trails, and points of interest.

Additionally, USFS feature classes featuring recreation sites, important trails, and Forest Service roads were imported and layered on top of the WMTS to further assist participants in orienting themselves to areas on the map based on familiar destinations and travel routes (see the trailheads, campgrounds, extended trail networks, and extended road networks in Figure 2A). Features were kept small and labelling was kept to a minimum so that both remained unobtrusive. Recent evidence indicates that having many large labels attached to multiple prominent features may bias results by guiding the mapper to circle label locations, though entirely omitting labels can frustrate participants (Besser et al. 2014).

Figure 2 – A. A blank section of the basemap provided to participants. B. Example of one participant's identification of important locations for a variety of use, value, and benefit types within a part of Gifford Pinchot National Forest.



3. Mapping protocol

Once presented the map, participants were asked to proceed through the stack of cards they had created and for each ecosystem service use, value, or benefit type, and consider which places in the National Forest they perceived as important for offering that ecosystem service type. They were asked to draw areas as polygons so that they would be able to easily compile them in ArcGIS (example in Figure 2B). Once all the locations for one use, value, or benefit type were mapped, participants were given a pen of a different color and/or tip width to map the next use, value, or benefit type. For each type, the pen used to draw on the map was also used to create a one to two inch line on the card, so that the stack

of cards created by the participant could be linked to mapped features. In the 15 cases where a line was drawn rather than a polygon (often delineating trails or roads), a default buffer of 500m was applied during data processing to turn the linear feature into a polygon. (In one case a linear feature was drawn with the explicit instruction that it should be expanded into a polygon made up of a 1 mile buffer around the line).

Uncertainty, precision, and accuracy are important concerns in any mapping exercise, yet they are difficult to assess in participatory mapping exercises and are often neglected entirely (Levine and Feinholz 2015). While many participatory maps of ecosystem services or landscape values refer to the importance of these types of assessments, few offer evidence regarding respondents' ability to indicate locations with accuracy and precision (Brown 2012b; Jankowski et al. 2016).

Here, two types of data addressing uncertainty and accuracy were collected. First, because of the large spatial extents being assessed, participants were asked to identify the parts of the National Forest with which they felt were "familiar." If asked to clarify what familiarity meant, participants were asked to circle those "areas that you feel you know well, where you would most likely feel comfortable getting around without a map." This prompt offers a variety of interpretations, but it enables those carrying out the mapping exercises to get an idea of not just what areas are used or valued in the forest, but what areas are *known* or *not known* by participants. Second, to gain a better understanding of the precision and accuracy with which participants mapped, special note was made during analysis of features that were drawn with the intent of identifying the Pacific Crest Trail (PCT), a particularly notable, spatially distinct feature within the study area. While many mapped areas were made up of larger, rounder polygons that demonstrated large variability in sizes, the Pacific Crest

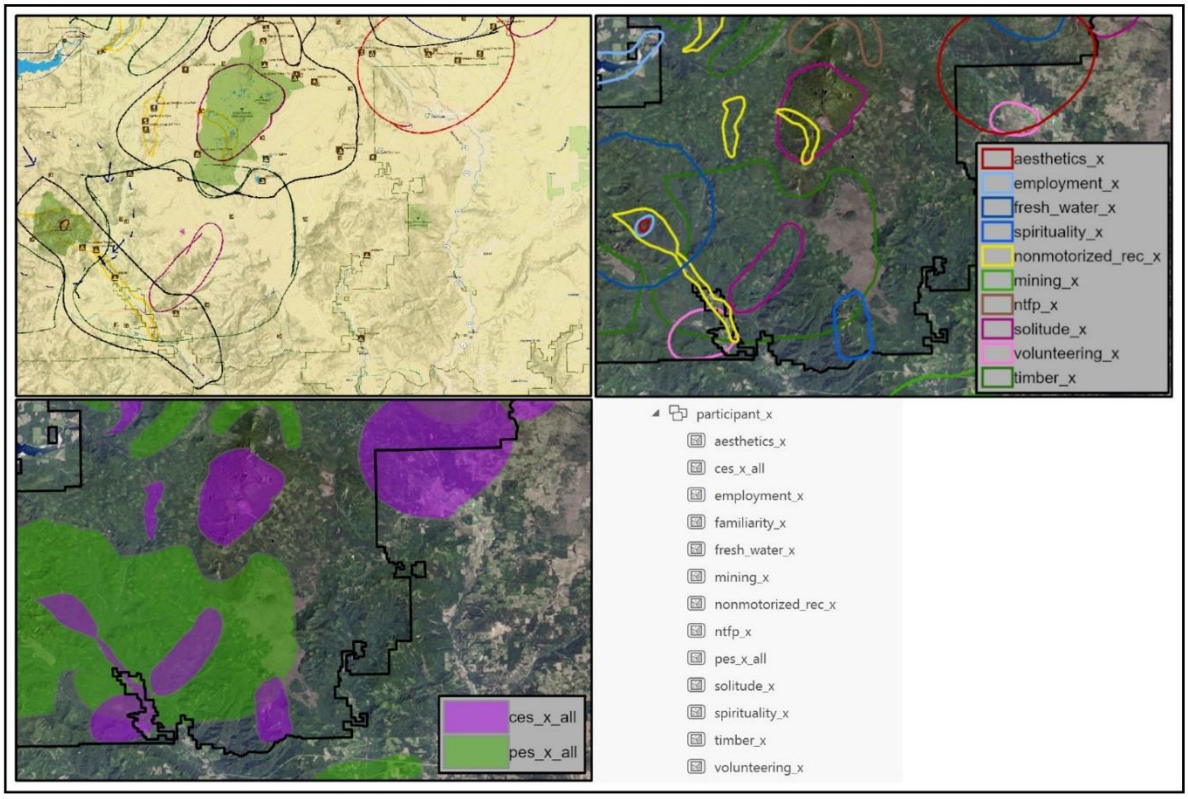
Trail is a feature that was mapped by many participants and was easily distinguishable on completed maps.

4. Data processing

Following spatial data collection, each map was scanned using a large format scanner. Polygons mapped for each use, value, and benefit type were digitized using ArcGIS 10.7.1. First, maps were georeferenced using Forest Service ground reference layers. Then each polygon drawn within each mapped type was digitized and added to a feature class (Figure 3). A feature dataset was created for each participant, within which there was a feature class for each mapped use, value, or benefit type (Figure 3).

ArcGIS spatial analyst tools were used to aggregate the number respondents who mapped each ecosystem service category (*e.g.* cultural, provisioning, regulating, and supporting) and use, value, or benefit type (*e.g.* nonmotorized recreation, motorized recreation, hunting and fishing, etc.) in all locations within the National Forest. First, the Dissolve tool converted individual features within a feature class to a multipart feature for each class. Then these were converted to raster data format (with 100m resolution) to enable the use of raster calculator and map algebra (Cell Statistics tool).

Figure 3 – Data processing steps involved in preparing participatory map data for aggregation by ecosystem services category and use, value, and benefit type. Top left: scan of one participant's map viewed in ArcMap after georeferencing. Top right: polygons for each use, benefit, and value type are digitized into feature classes of one or more mapped polygon. Bottom left: all feature classes are aggregated into their respective ecosystem service category. In this case, the participant mapped only cultural ecosystem services and provisioning ecosystem services. Bottom right: database structure for the example participant's mapped features. The project geodatabase is made up of a feature dataset for each respondent (*participant_x)*. These feature datasets are made up of feature classes for each use, value, or benefit type *(e.g. aesthetics_x, mining_x)* as well as for ecosystem service category (in this case *ces_all* and *pes_all*).

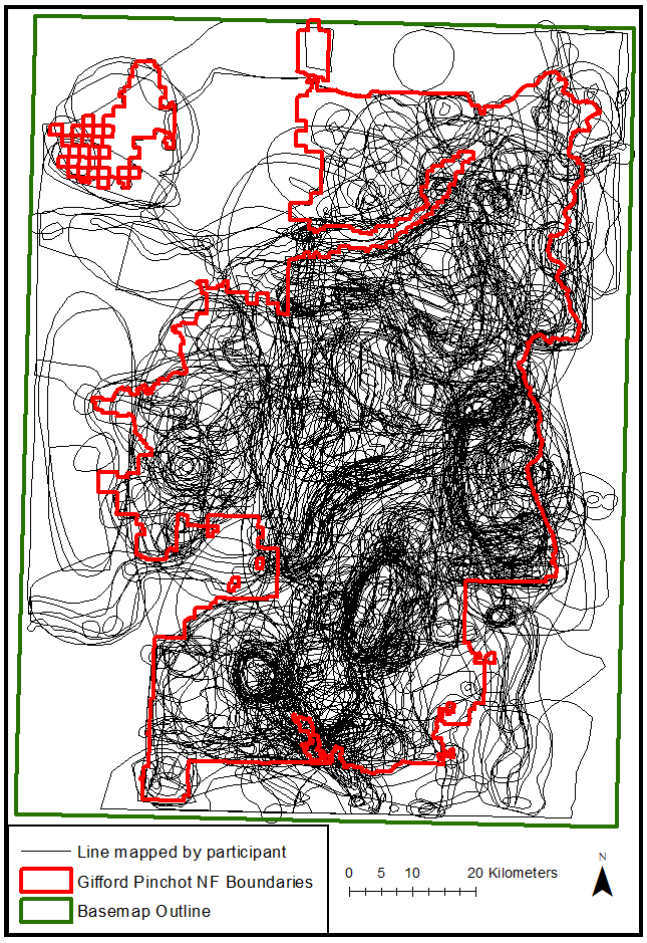


C. Results

1. Descriptive statistics of participant mapping behaviors and patterns

Overall, the 23 participants drew 1001 polygons in 232 different feature classes (use, value, or benefit type; Figure 4). On average, each respondent drew 43.5 different polygons to identify important locations for an average of 10.1 use, value, and benefit types.

Figure 4 – Outlines of all polygons drawn by participants among all ecosystem service categories.



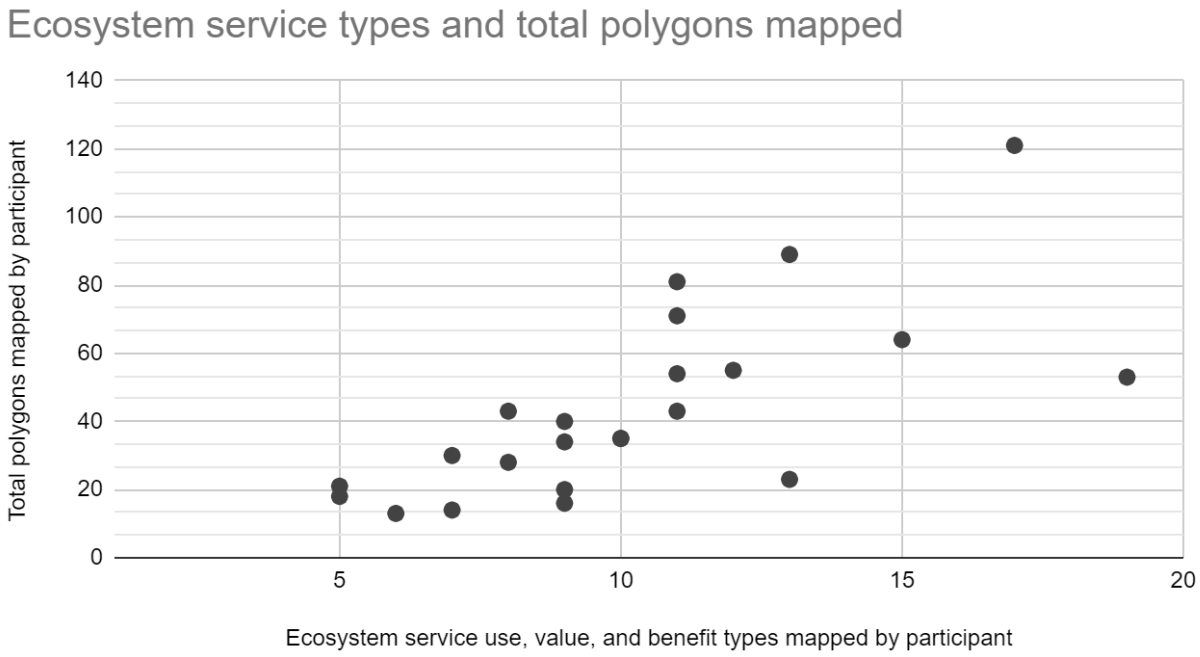
When aggregated into the four overarching ecosystem service categories, cultural ecosystem services were mapped most often. In total, 136 groups of cultural ecosystem service types were mapped compared to 67 for provisioning ecosystem services, 19 for regulating ecosystem services types, and 7 for supporting ecosystem services. The pattern continues when examining total numbers of polygons; there were 686 polygons drawn illustrating locations where cultural ecosystem services were identified, 214 polygons showing areas important for provisioning ecosystem services, 51 polygons showing areas important for regulating ecosystem services, and 22 polygons showing areas important for supporting ecosystem services. (Note: a handful of polygons [28 from 3 use, value, and benefit types] that did not clearly fit in any of the four ecosystem service categories were excluded in this analysis).

Participant analysis revealed a wide range of mapping behaviors. All 23 participants were able to map at least one use, value, or benefit type in the cultural ecosystem services and provisioning ecosystem services categories. There was more difficulty in mapping regulating ecosystem services and supporting ecosystem services; only 14 and 6 participants mapped these two categories, respectively. In many cases, when participants considered the cards that were available for them to add to the map in these categories, they articulated that the "whole forest" offered these services.

The number of use, value, and benefit types mapped by each participant as compared to the number of specific locations identified by that participant is shown in Figure 5. Overall, the number of mapped use, value, and benefit types ranged from 5 to 19, while the total number of polygons mapped ranged from 13 to 121. There is a trend between the number of use, value, and benefit types mapped and the total number of polygons mapped,

however, some outliers show that this pattern is not universal. Participants occasionally mapped relatively few individual polygons over many types; while the opposite never appeared to be true (*i.e.* few types mapped, but a greater than expected total number of polygons).

Figure 5 – Ecosystem service use, value, and benefit types mapped, and total polygons mapped by participant. There was a wide range in participants' interest and/or ability to map different use, value, and benefit types as well as the quantity of total polygons mapped. This table also sets up further analysis seen in Table 2.



Most of the use, value, and benefit types identified in the previous chapter were included on at least one map. However, several specific categories were mapped far more often than others. Table 2 shows all use, value, and benefit types ranked by the number of times features of that type were mapped. The most frequently mapped group was nonmotorized recreation, which was mapped 156 times by 21 participants. Other commonly mapped use, value, and benefit types included aesthetics, nontimber forest products, timber, and sense of place. In the third column, the ranking of the total number of features mapped is

compared with the rankings of overall number of times a category was recognized during interviews (see the previous chapter and Appendix G). This allows a preliminary assessment of the degree to which different ecosystem service use, value, or benefit types are either considered easy to map frequently or difficult to map. A drawback with this analysis is that in some cases, it could mean that a use, value, or benefit type was drawn as several small rather than fewer large polygons. A positive value for the "Change in rank" column indicates that, relative to other types, there was a greater number of polygons mapped for that type than would be expected based on how often it was identified, overall. As an example, the second most frequently mapped use, value, or benefit type was *aesthetics* with 75 mapped features. Its rank as second place here is 9 places higher than its rank in terms of the frequency with which participants identified it overall (where it ranked 11th – see Appendix G). This analysis indicates that cultural ecosystem service types had higher rankings in terms of the number of times mapped compared to their earlier identification, while regulating ecosystem services had lower rankings in number of times mapped compared to their identification. Provisioning ecosystem services generally showed little change in rank, and because only one supporting ecosystem service type (*habitat*) is mapped frequently enough to be included in this list (> 2 participants mapping), it is challenging to speculate about a trend.

Table 2 – Number of participants mapping each use, benefit, and value type and number of polygons mapped for each. The change in rank column shows compares ranking of "total features mapped" here to overall number of times recognized earlier in the interview (Chapter 2; see Appendix G for complete table).

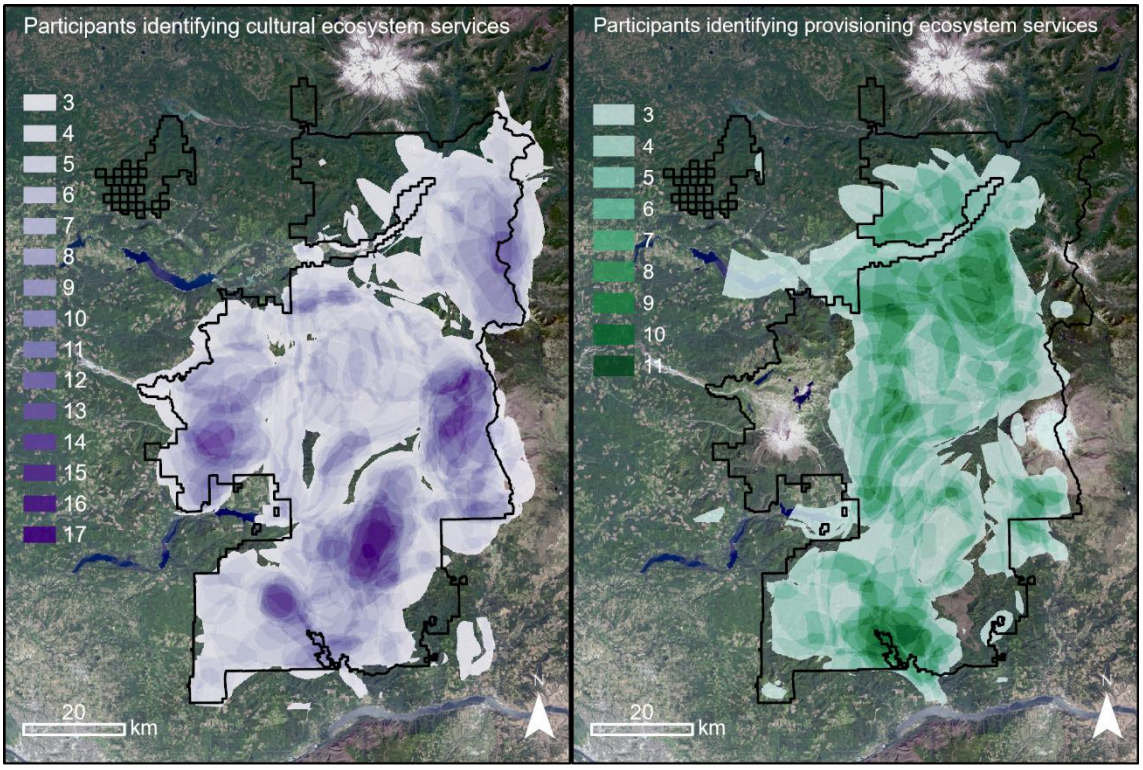
Table 2 – Details on the frequency of mapping for each use, value, and benefit type			
Use, value, benefit type	**Total features mapped**	**# participants mapping**	**Change in rank**
Nonmotorized recreation	156	21	0
Aesthetics	75	10	9
Nontimber forest products	67	20	-2
Timber	50	14	0
Sense of place	45	7	3
Social relations	45	5	12
Clean water (provisioning)	44	12	-4
Existence and bequest	43	9	-1
Hunting and/or fishing	42	14	-4
Motorized recreation	34	8	7
Education	31	9	2
Cultural heritage	28	8	1
Option	27	6	4
Driving	26	9	3
Employment	22	8	-10
Knowledge systems	21	4	7
Solitude	21	6	-3
Water regulation	21	6	-7
Tourism	19	2	15
Habitat	16	5	3
Inspiration	16	3	9
Challenge	13	2	21
Exploration	12	2	5
Local economic impact	11	3	5
Spirituality	10	4	-9
Relaxation	9	2	10
Water purification (regulating)	8	3	-4
Volunteering	8	2	7
Job	8	2	-21
Climate regulation	7	2	-20
Air quality regulation	6	2	-20
Identity	6	3	-14
Mining	5	3	-4
Biochemicals/natural medicine	4	2	-5
Natural hazard regulation	4	3	-8
Erosion regulation	3	2	-13
Ceremonial	2	2	3
Rock hunting	2	2	4

2. Spatial analysis of mapped ecosystem services categories

Aggregated digitized polygons of areas of ecosystem service provision or value were identified in twenty-three stakeholder interviews. All participants frequently mapped cultural ecosystem services (Figure 6). Areas with the highest numbers of responses included wilderness areas (Indian Heaven, Trapper Creek, Goat Rocks), the high mountain peaks (Mt. St. Helens and Mt. Adams), and transit corridors (particularly for driving, motorized recreation, and non-motorized recreation). Few participants mapped locations in the far north of the forest, including the several, smaller wilderness areas there (Tatoosh, Glacier View, and a small part of William O. Douglas).

Provisioning ecosystem services most often included key watersheds, areas of perceived high-quality timber, and important areas for harvesting non-timber forest products (mushrooms, huckleberries, boughs, salal, beargrass, Christmas trees). There are clear patterns of clustering near all of the entrances to the National Forest that are adjacent to nearby local communities (Figure 6). These areas included the adaptive management area just south of Packwood, the southern entrance to the National Forest just north of Carson, and the main transit corridors extending to the northeast from Northwoods. Additionally, the corridor along Forest Road 25, the main North-South transit corridor within the park, shows many responses. In contrast to the maps for cultural ecosystem services, there are very few respondents noting any provisioning ecosystem services near the high mountain peaks or in any of the wilderness areas of the National Forest. There were also few ecosystem services noted in the far southeast of the National Forest.

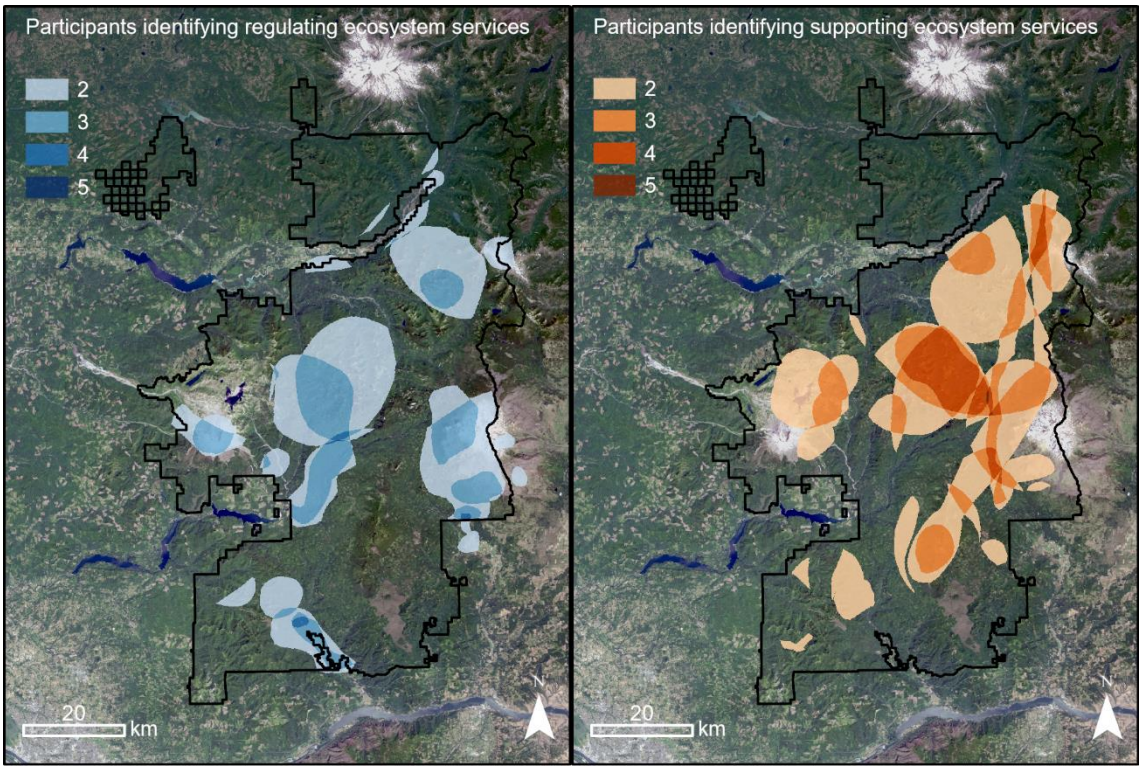
Figure 6 – Mapped cultural ecosystem services and provisioning ecosystem services.



Regulating and supporting ecosystem services were mapped far less often than cultural and provisioning ecosystem services (Figure 7). The only regulating ecosystem services that were mapped included water regulation, climate regulation, natural hazard regulation, and air quality regulation. These were largely identified along the flanks of the high volcanoes and in important watersheds. Supporting ecosystem services, including areas of important habitat and pollination, were mapped by the fewest participants, yet polygons in this category were often large. In both categories, many of the specific ecosystem services noted earlier in the interview were considered by participants to be provided by the "whole forest," and mapping them was not considered useful. As Brown and Pullar (2012) state: when "(respondents) select between 50% and 100% of the study region as a PPGIS polygon

(it) does little to identify collective spatial significance while simultaneously increasing potential error."

Figure 7 – Mapped provisioning ecosystem services and supporting ecosystem services.

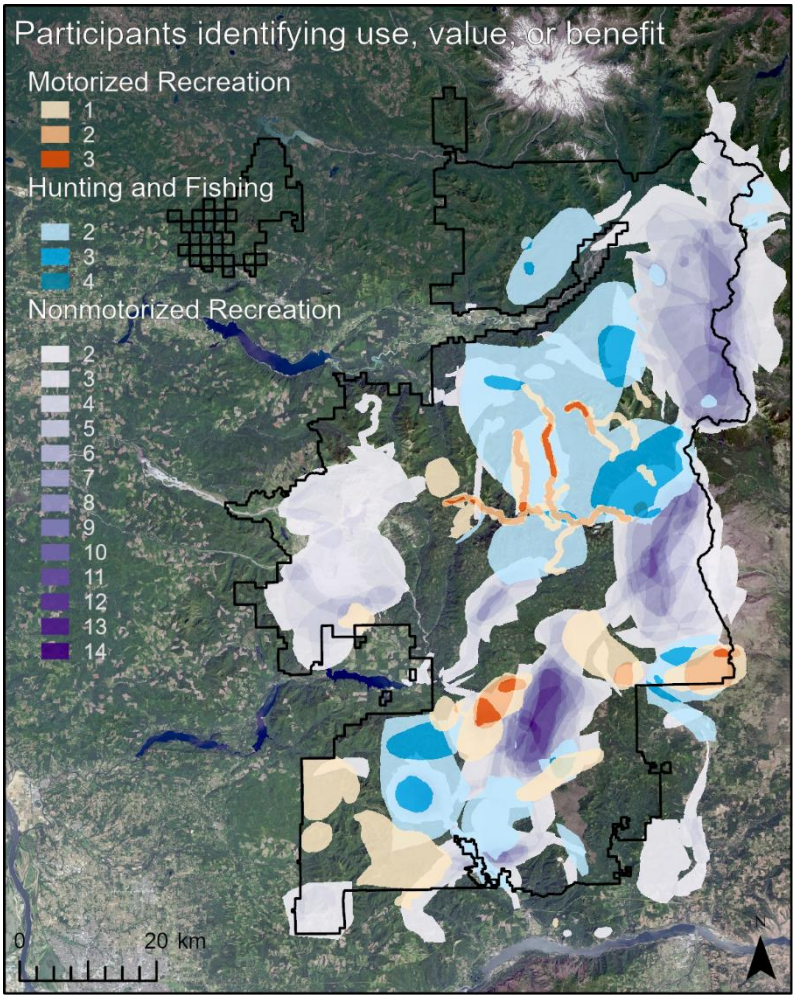


1. Spatial analysis of potential conflicts and synergies

Conducting spatial analysis of specific use, value, and benefit types in addition to the broader ecosystem services categories shown above is potentially very useful for managers in understanding conflict among uses or to aid in management decision making. For instance, using the participatory mapping data enables analysis of areas perceived as important for multiple types of recreation. In Figure 8, nonmotorized recreation, motorized recreation, hunting and fishing are visualized together on one map. This shows that there is substantial spatial separation between these use types. Nonmotorized recreation is focused in southern

and eastern wilderness areas, areas valued for hunting and fishing are generally larger areas without significant overlap, and motorized recreation areas are often smaller and/or linear in nature (along specific routes of travel). Nonetheless, there are areas of overlap that may be of interest to managers.

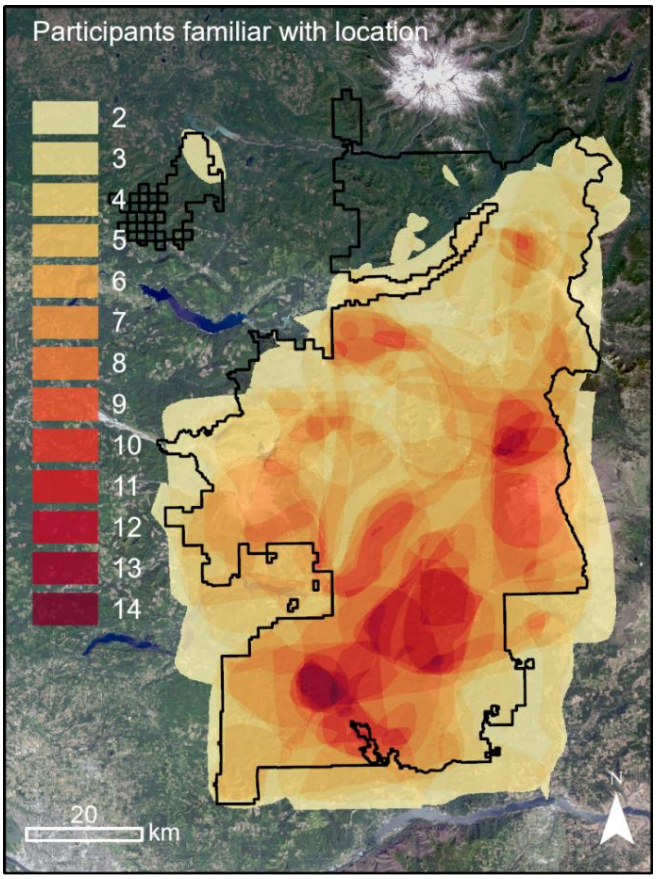
Figure 8 – Comparison of the locations identified by participants for three different, potentially conflicting, uses of the landscape. Motorized recreation (predominantly snowmobiling, off road motorcycle riding) is shown in shades of orange, hunting and fishing in shades of blue, and nonmotorized recreation in shades of purple. The categories are mapped with the least frequently mapped category on top (motorized recreation) as the least amount of map is obscured. Note: In many cases one participant mapped multiple categories.



3. Uncertainty, precision, and accuracy

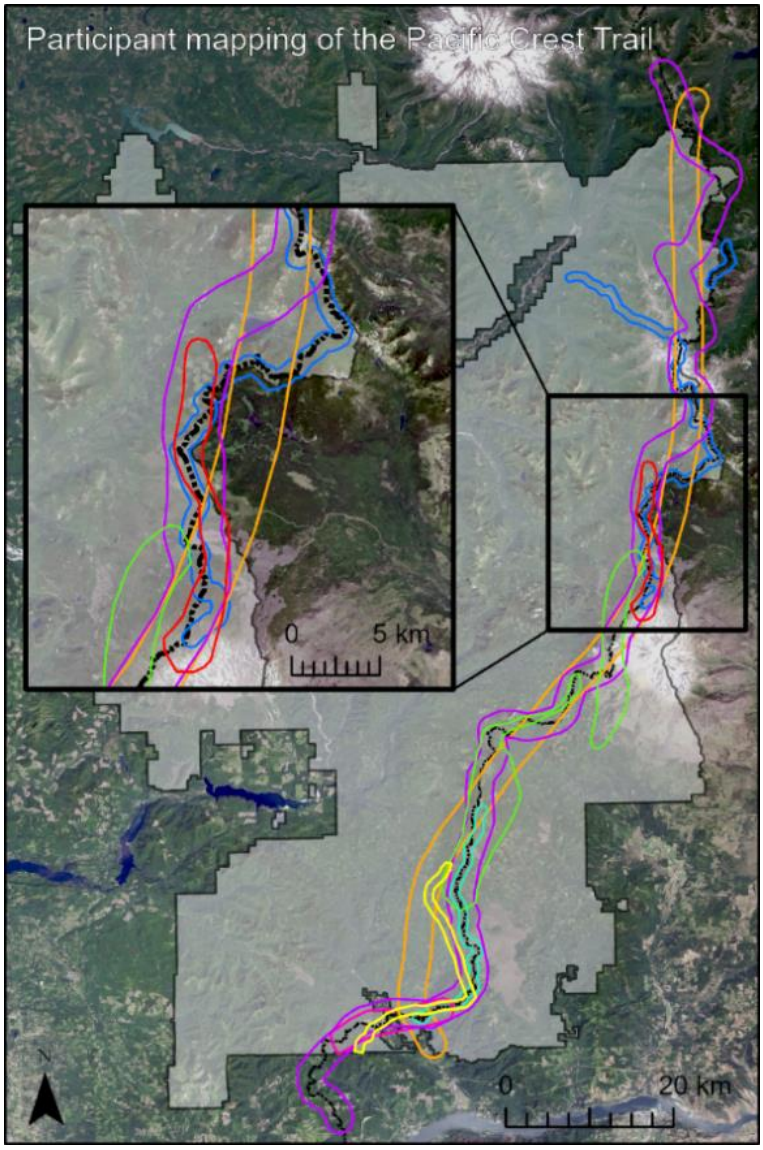
Aggregation of the polygons drawn to indicate participant familiarity with different locations in and around GPNF gives a first look into reliability of some of the previous results (Figure 9). Results indicate that areas of familiarity closely correspond to areas of perceived importance for offering cultural ecosystem services (specifically, wilderness areas, high mountain peaks, and transit corridors that are used to access and travel through the National Forest). These results could also be useful in prioritizing future data collection, as there is an apparent lack of familiarity among participants in this study with the North and Northwestern parts of the National Forest.

Figure 9 – Participants considering themselves familiar with areas in and around Gifford Pinchot National Forest. Overall, areas of high familiarity correspond with areas frequently identified as offering cultural ecosystem services.



To better understand accuracy and precision of mapping, all features that were intended to identify the Pacific Crest Trail (PCT) were identified and mapped (Figure 10). In total, 8 participants mapped all or part of the Pacific Crest Trail. Of those, two attempted to map the entire length of the PCT that fell within Gifford Pinchot National Forest, while the other six mapped shorter segments. The inset in Figure 10 demonstrates the range of levels of precision (the scale with which participants mapped this linear feature) and accuracy (whether the feature drawn corresponded with the real-world location of the PCT) (Brown 2012b). Despite the variety of mapping styles, when examining the map of the entire forest, the resultant polygons clearly indicate where this linear feature falls within the National Forest. (Note: several other larger features drawn included sections of the Pacific Crest Trail, but they were not included in this analysis because they were not drawn with the intent of identifying the trail itself but larger areas of wilderness that also included the trail.)

Figure 10 – The Pacific Crest Trail, as mapped by participants. Each unique color shows where a different participant mapped all or part of the PCT. The inset demonstrates the range of mapping strategies and attention to accuracy employed.



D. Discussion

Mapping ecosystem service uses, values, and benefits with active and involved National Forest stakeholders via semi-structured interviews proved a useful methodology for fulfilling the aims of the 2012 Planning Rule. In addition to producing spatial data on ecosystem service uses, values, and benefits at the National Forest scale, the outcomes of this work can help in addressing some of the extant methodological questions in participatory mapping of human values towards the landscape in the National Forest context.

1. Patterns of ecosystem services identification

As in studies on cultural ecosystem services in other contexts, it was found that cultural and provisioning ecosystem services were most often mapped. Cultural ecosystem services, in particular, had the largest mapping effort by far both in terms of number of polygons and number of categories, as in most similar studies that have been conducted (Bryan et al. 2010; Darvill and Lindo 2015; Raymond et al. 2009). The breadth of cultural ecosystem service categories that were widely mapped confirm the importance of considering more than biophysical models when mapping ecosystem services. Recreation alone, even if modeled accurately, would not fully reflect the diversity of uses, values, and benefits that participants spatially identified in Gifford Pinchot National Forest or the different values people attach to their recreation experiences (Asah, Blahna, and Ryan 2012).

Due to mapping frequency of both cultural and provisioning categories, clear overall spatial trends and a surprising degree of separation between these categories can be observed. The largest hotspots of cultural ecosystem services focused around Congressionally designated wilderness areas and the National Volcanic Monument. This differs from the

findings of Darvill and Lindo (2015) and Plieninger et al., (2013) who, at two different scales and ecological contexts, found a pronounced affinity toward riparian areas and water bodies. In contrast, the largest hotspots of provisioning services used and valued were in easily accessible locations near forest entrances and roadways. This indicates that the land management designations that have been applied in certain locations over the past several decades have a strong influence on the perceived ability of a landscape to offer ecosystem services. This is an important divergence from mapping using the biophysical spatial modeling approach – where physical features and land cover types are used to predict ecosystem service value. Here, participants demonstrate that administrative designations have a tremendous influence on where some ecosystem service uses, values, and benefits are delivered. Biophysical models would likely indicate that the potential value for timber (a provisioning ecosystem service) would be high in areas of dense forest, whether inside or outside of areas where harvesting is permitted. By acknowledging on-the-ground realities, participant perceptions may more accurately reflect real world conditions for some categories.

Though analysis of hotspots revealed pronounced spatial separation, resultant maps enabled the identification of potential areas conflict where there was overlap among different ecosystem services types. By identifying these conflicts among hotspots of different ecosystem service types, managers have data on the spatial extent of conflict, can better understand the nature of conflict, and are able to design more specific plans for management in these key areas (Brown and Donovan 2013). In addition to identifying areas that are perceived as important for providing multiple ecosystem services, this analysis can be useful for management to identify locations that are not highly valued by stakeholders (e.g.

coldspots). These may indicate areas that could be used for the development of pilot projects or demonstrates sites with fewer challenges that come along with implementing change in an area highly valued by the public.

As one of the few participatory mapping studies using an "assigned" approach to the categories that are mapped, this study offers insights into the perceived suitability for mapping of different use, value, and benefit types. Many participatory mapping studies focused on human values solely map what, in ecosystem services parlance, would be called cultural ecosystem services (Brown and Reed 2009). Those that specifically engage with an ecosystem services typology often extend mapping to provisioning ecosystem services (Darvill and Lindo 2015; Brown, Montag, and Lyon 2012). However, by allowing participants to identify which ecosystem services types they use, value, and benefit from, and giving them the opportunity to choose which of those types to map, it was found that cultural and provisioning ecosystem services were much easier to map. As seen in Table 2, water regulation is the most frequently mapped regulating or supporting service, yet it was only mapped twenty-one times by six participants. Meanwhile, it was found that the largest drop-offs between the number of people valuing an ecosystem service type, and then mapping that type, were found in the regulating and supporting services categories (i.e. climate regulation, air quality regulation, natural hazard regulation). Though they were seldom mapped, it is worth noting that these categories can be mapped, and were mapped by a handful of participants – a number that would surely grow as the number of participants increases. Tweaking the interview protocol to more directly address these lesser mapped services may increase their mapping: in an interview protocol focused on identification of values and

threats related to a location (place-first mapping), Raymond et al., (2009) received a large proportion of responses in these lesser used categories.

Other use, value, and benefit types stood out as being mapped more often or less often than expected. In the cultural ecosystem services category, aesthetics, social relations, motorized recreation, tourism, inspiration, challenge, relaxation, and volunteering were use, value, or benefit types mapped more often than would be expected based on the times they were identified. These categories seem to fit into two groups – things that are particularly easy to identify on the landscape (tourist sites, volunteering, social relations – often identified at campgrounds), and areas that are seemingly subgroups of nonmotorized recreation that may have a unique spatial expression (areas where one is "challenged," or inspired by the landscape). Other cultural ecosystem service types were mapped less often than expected, these were once again mostly related to nonmotorized recreation cases where there was not a clear spatial expression (including solitude, spirituality, and identity).

Among other categories, regulating services saw the largest drop-off in rank. These services were mapped sporadically compared to how often they were discussed earlier in the interview (Chapter 2). Due to the open-ended nature of the interview protocol, participants were able to articulate why they could not or would not map particular use, value, or benefit. A common reason given for challenges in mapping any of these use, value, or benefit types was that they were provided by the "whole forest" rather than one location. In many cases, once participants learned this was an acceptable response, they used it to describe a large proportion of remaining use, value and benefit types. This supports the idea that designing concise and relevant typologies is indeed important and may be preferable to an open-ended approach. In this case participants started with easy to map categories and often seemed to

tire of the process or find the “whole forest” loophole before getting to some of the more difficult-to-map categories. As in other similar studies, features in which more than half of the study area was included (including “whole forest” responses) were not added to maps because they do not add any information in terms of spatially identifying uses, values, and benefits (Brown and Pullar 2012). In contrast with Raymond et al., (2009) large differences were found between the frequently mapped cultural and provisioning services and the less frequently mapped regulating and supporting ecosystem services.

Two other reasons participants chose not to map categories related to spatial coincidence among categories and inappropriateness of mapping. Spatial coincidence among categories commonly occurred with cultural ecosystem services, where there might be several values coincident with the spatial expression of a use (such as nonmotorized recreation). In this study, participants were encouraged to map all of the use, value, and benefit types they identified, yet many chose not to continue mapping new features in locations where they had already mapped one, or several, related types. In some cases participants chose not to map locations that they considered as sensitive. The reasons that areas are valued for cultural heritage, and the spatial expression of those areas, is often not considered appropriate for including in participatory mapping exercises, and that sentiment was echoed by several participants once arriving at the category (Levine and Feinholz 2015). Additionally, the location of nontimber forest products that participants value for personal use or economic value (huckleberries, mushrooms in this context) can be sensitive. Charnley et al (2017) address this clearly: “it is important to recognize that some (traditional ecological knowledge) and (local ecological knowledge) is sacred or proprietary.”

2. Sampling and methodology

The participatory mapping literature has actively debated the advantages and disadvantages of in-person mapping (usually via workshops) vs. web-based mapping. Here, some insight is offered into this debate, while further illustrating the differences between public workshops and semi-structured interviews with individuals. As noted by McLain et al (2017) online survey instruments generally result in far fewer destinations mapped per participant, and some result in no usable spatial data at all. As in other studies using workshops and interviews, face-to-face interviews were found to offer several strengths in terms of the richness of data obtained. Furthermore, either type of in-person mapping may achieve other goals that a web survey may not, including fostering two-way communication, building trust between the agency and the public, and allowing participants to interact among groups (McLain, Banis, et al. 2017; Levine and Feinholz 2015).

There are other important differences between in-person mapping via semi-structured interviews versus workshops. Though a relatively small sample was engaged in the mapping exercise here, the total number of areas identified on the map compares favorably to other studies carried out in ways that elicited larger samples. The methodology here resulted in similar levels of mapping effort to Darvill and Lindo (2015) who, using a similar process, ended up with 895 polygons from 31 participants. Evidence indicates that individual interviews, when conducted with the general public rather than involved stakeholders, results in sparser data. Styers et al. (2018), drawing from a convenience sample at outdoor events in North Carolina, obtained 419 polygons from 116 respondents. In-person workshops and focus groups, as carried out on the Olympic Peninsula by McLain et al. (2017), offer another approach that may result in a larger sample with less efficiency in terms of numbers of

features mapped. In their study, 818 meaningful places and 1594 activity sites were mapped over 9 workshops with 169 participants. Individual mapping also decreases what McLain et al. (2017) describe as the "table effect," where multiple participants drawing upon the same map at a workshop table may emulate mapping strategies and polygon locations.

Another advantage of using the semi-structured interview rather than a public workshop is that it may help reduce the politicization of mapping workshops. In their workshops on the Olympic Peninsula, McLain et al. (2017) found interest groups organizing attendance and mapping strategically in support of several political causes (pushing for road repair to popular recreation destinations, support for off highway vehicle use in certain areas, and fighting against wilderness expansion in the name of furthering economic opportunities). The strategy employed here, of inviting interviewees from a wide range of involved groups and local communities, allowed prioritization of a degree of balance within the respondent pool. Though it was noted that some respondents clearly had political motivations and were in contact with each other regarding political aims and participation in the study, following an interview protocol limited the ability of any single issue to derail or dominate discussion. If new rounds of interviews were to be carried out, researchers would be able to consider the degree to which certain groups had already been represented and which groups should be reached out to in order to supplement project data. Meanwhile, another advantage of individual interviews is that participants were able to explain their mapping choices and patterns directly to the interviewer.

There are also drawbacks to conducting interviews via semi-structured interviews. Previously mentioned benefits beyond the spatial data obtained, like building trust and fostering communication, may be more difficult to achieve in a face-to-face setting. In this

study, this may be especially true as the researcher conducting the outreach was not closely tied to the Forest Service. There are also limitations in obtaining a larger number of features from a smaller number of participants: it is more difficult to ensure representation and saturation, meaning a few individuals can have an outsized impact on final maps and some perspectives are more likely to be overlooked. Though the above examples from the participatory mapping of ecosystem services literature focus on gaining sufficient representative of individual perceptions, workshops can also enable mapping of uses via consensus that would not be possible during individual interviews.

3. Utility for management

The utility of participatory mapping in the National Forest Context has primarily been connected to the ability to provide place-based information and data that can be used to guide forest planning and due to its potential in improving opportunities for public participation (Brown and Reed 2009). Now, with the 2012 National Forest Planning, both are explicitly required in new Forest Plan revisions. The methods outlined in this paper demonstrate that participatory mapping of ecosystem services is a methodology with unique potential in these areas.

In the first phase of plan revision ("assessment and public participation"), forest managers are required to determine the range of ecosystem services and multiple uses in each forest unit. Doing so requires that assessments based on best available science are available for all ecosystem service types (Charnley et al. 2017). While National Forests have long collected biophysical data that can be used along with modeling tools to estimate changes upon a proposed management action, the collection of social spatial data has long been

lacking (Koch and Cerveny 2018; Chan et al. 2012). The National Visitor Use Monitoring program is the key social science data collection program on National Forest System lands, collecting data from over 100,000 visitors to National Forests regarding forest visitation and use types (Zarnoch et al. 2011). This data, however, does not fit well into an ecosystem services framework, where an understanding of a wider range of cultural ecosystem services is needed. Additionally, ecosystem services are inherently spatial, and identification of where those ecosystem services exist on the landscape is crucial in efforts to manage for them or to consider the range of potential impacts that may come from different management scenarios. Charnley et al. (2017) have called for an increase in the use of qualitative methods to fulfill mandates for best available social science (BASS):

> *"…local ecological knowledge can provide a rich source of scientific information to consider in any best available natural or social science effort… (it is) fundamentally tied to the place based individuals and communities… (and is) often excluded from BASS that seeks to generalize information for wider application."*

Another ongoing Forest Service goal that is specifically called for in the 2012 Planning Rule is improved public engagement. In-depth interviews have led to a deeper understanding of how stakeholders value ecosystem services and experience the forest in a way that can be insightful for management planning. Through participatory mapping, lived experiences can be linked to data that can then be included in the planning process. By investigating the reasons for mapping certain use, value and benefit types in given location, spatial data derived from these interviews can go beyond pointing out areas of potential conflict to delivering more insight into what the conflicts are and how they affect ecosystem service benefits. In an example from one interview, a participant recounted the joy with

which he would snowmobile on the flanks of Mt. St. Helens prior to its designation as a National Volcanic Monument in 1982. He then talked about an experience he had when, while snowmobiling up a nearby forest road, he was shamed by hikers who he perceived to be from out of the area as they dramatically covered their mouths and waved away "fumes." Furthermore, by breaking the larger categories into use, value, and benefit types clear examples areas of conflict that may need management input can be identified. Examples include the potential conflict between nonmotorized recreation and hunting (Figure 8) or between intrinsic value and timber provision.

A related finding is that many respondents here wanted more freedom in mapping how things ought to be in their forest (rather than how they use and value it now). This was reflected in the popularity of the relatively vague "option value" in both discussion (Chapter 2) and mapping: upon considering the definition of this ecosystem service type, participants often selected it and then mapped it to be able to ascribe their own views for the future onto specific locations. Many identified areas that are currently undeveloped as areas where more tourism, or trails, or adventure sports, or timber (etc.) could be developed in the future in a way that would fulfill their vision for the National Forest.

There are several noted challenges, as well as pockets of resistance, to implementing ecosystem services approaches within the Forest Service, and it is unlikely that progress will be made without further top-down mandates. However, there is evidence that some forward-thinking jurisdictions are already developing methods and approaches that make use of the concept. In earlier interviews (Chapter 1), interviewees from several ranger districts revealed that they had asked members of the public to draw on National Forest maps to inform the development of scenarios for planning. In these cases, maps were used as a communication

tool and as a way for stakeholders to express their values and desired conditions. The methods demonstrated here may help guide these early efforts toward the creation of more durable baseline datasets that can later be referenced for planning or built upon in future data collection efforts. It would not be too much of a leap to conduct the data processing and analysis carried out here to obtain a dataset that can be compared to, and synthesized with, biophysical data in considering larger-scale management questions and forest plans. Collecting, processing, and analyzing these data would result in valuable baseline data upon which to begin formulating new management plans or project plans.

4. Limitations

This study sought to get a view from a wide variety of National Forest stakeholders, yet collecting an adequate and representative sample is a persistent challenge. In many cases, due to the sampling strategy of contacting the constituencies of involved groups, the effort was hampered by a "gatekeeper effect," where public-facing contacts were uninterested in reaching out to their constituents regarding participation. In other cases, stakeholder groups with important ties to the forest were poorly represented simply because they did not have a clear organizational structure. Three examples of important groups in this context that fall within these categories were members of the two nearby Native American tribes, commercial harvesters of forest products (mushrooms, beargrass, salal), and motorized recreation groups. The map of participant familiarity with different parts of the forests also indicates that more spatially stratified outreach could be prioritized in the future to make sure there is even more spatially-balanced representation.

E. Conclusion

Though US National Forests have a mandate to consider ecosystem services and conduct meaningful stakeholder outreach early in their Forest Plan revision process, standardized methodologies for carrying out these requirements are lacking. Here, participatory mapping via semi-structured interviews is demonstrated as a methodology that can address these requirements without high resource demands. In these mapping interviews, participants provided a wealth of information on *what*, and *where*, is valued in Gifford Pinchot National Forest. The spatial data on areas of use, areas that are valued, and areas that are perceived as delivering benefits offer valuable social spatial data in a management context that has long lacked such inputs. Unlike most other participatory mapping approaches demonstrated in the literature, the interview approach used here also gave substantial information on *why* people value places, improving understanding of place-specific values and what it means for there to be spatial conflict among values. Though the fact that the study was carried out in an academic context limits the degree to which the results of this particular study could be considered stakeholder outreach, this approach could easily be adopted by Forest Service staff or modified in a workshop setting to increase interaction between the agency and multiple stakeholder groups. If employed in either of these ways, participatory mapping would provide a solid foundation for fulfilling the requirements of the 2012 Planning Rule.

This study highlights a few areas that should be considered in future research. First, both the interviews with National Forest managers (Chapter 1) and survey participants here expressed interest in integrating questions that would allow them to communicate desired future conditions into mapping. This may improve management uptake of such techniques, as

one goal expressed in several manager interviews is a way to better include stakeholder preferences in scenario development. Second, though several jurisdictions are engaging with ecosystem services concepts on a general level, continued research is needed into changing management approaches that would help agencies move past business-as-usual practices and towards a meaningful and consistent application of ecosystem services-based management (Chapter 1; Deal, Fong, and Phelps 2017). Third, while participatory mapping of human values and ecosystem services is still in a period of "methodological plurality," more research into the outcomes of different methodological choices is needed. In the Forest Service context this could focus on comparing both the process and outputs of interviews, workshops, and internet-based mapping for greater corroboration within the same management context. Finally, more research is needed into figuring out how to tie together the two diverging branches of the ecosystem services mapping literature: participatory approaches and spatial modeling approaches. Mapping and spatial analysis methods that integrate these two general approaches would positively impact the acceptance of ecosystem services analysis within agencies like the Forest Service. One major challenge related to this in the Pacific Northwest is that spatial modeling usually uses land cover as an input; these models will have to be modified to consider the provisioning ability of different land management units in cases where the area being analyzed is almost completely covered with coniferous forest.

V. Conclusions

1. Summary

United States National Forest lands have long been called the "land of many uses," though management and planning efforts have only begun to attempt to consider all these uses along with the societal benefit and value of National Forest lands to society. The ecosystem services concept has been popularized globally as a way to connect people to the many benefits they get from the functioning ecosystems around them. With the adoption of the 2012 Planning Rule, the Forest Service has committed to applying the ecosystem services concept to highlight the range of services National Forest lands provide the public, describe management outcomes in terms of both ecological and socioeconomic outcomes, better target management action to deliver ecosystem services, and understand how human values relate to the natural resources on National Forest lands (Deal et al., 2017).

Despite the commitment to applying the concept, there are limited examples of how National Forest planners and managers have engaged with it in order to achieve the key aims of the 2012 Planning Rule. Meanwhile, there have been calls in the literature to better include public participation and an improved understanding of cultural ecosystem services early in the assessment process. The three studies that make up this dissertation research offer an improved understanding of the application of the ecosystem services concept within the National Forest system while also filling knowledge gaps in the understanding of stakeholder perceptions and values related to the diverse range of ecosystem services – including those than can be difficult to categorize or quantify - provided by National Forest lands. Consideration of these in the development process of forest management plans is crucial to better integrating cultural ecosystem services and human values into analysis, delivering on

the objectives of the 2012 Planning Rule, and ultimately creating more equitable and effective National Forest decision-making (Menzel & Teng, 2010).

To address these knowledge gaps, three distinct studies were conducted. Chapter 1 (Section II) focused on learning about management perceptions of ecosystem services by interviewing planners and managers about their understanding of the ecosystem services concept, their perceptions of the role of National Forests in providing ecosystem services, and their experiences using the concept in management. Chapter 2 (Section III) employed semi-structured interview techniques to better understand the ecosystem services that are used or valued by stakeholders, or those that are perceived to offer a benefit to individuals or society. Chapter 3 (Section IV) demonstrated a participatory mapping approach to gaining a better understanding about where, and why, stakeholders perceive different use, value, and benefit categories.

2. Key findings and contributions

These above areas of research revealed important findings for both advancing theoretical understanding of the way that society values ecosystem services, as well as practical implications for management of National Forest lands using an ecosystem services approach. In interviews with National Forest planners and managers, it was clear that even though understanding of the ecosystem services concept was high, there was not a clear, widely adopted approach to considering ecosystem services in management. Elements of the concept were applied at different scales to various degrees, but overall, the general ecosystem services frameworks described in the academic literature (i.e. spatial modeling of ecosystem services, monetary valuation, etc.) was not employed.

The in-depth semi-structured interviews with stakeholders of Gifford Pinchot National forest yield insights into the uses, values, and benefits that participants and society derive from the forest, as well as which of these are perceived as most important. Cultural ecosystem services were by far the most valued ecosystem services category identified by respondents. These cultural ecosystem services were ranked highly in terms of personal importance to participants. However, provisioning ecosystem services like non-timber forest products, clean water, and timber were often ranked highly in terms of their importance to society. Though the most frequently identified uses, benefits, and values have long been acknowledged in forest management, additional dimensions of these ecosystem services were revealed through these interviews. Interviews also illuminated which of the widely used Millennium Ecosystem Assessment categories are not intuitively considered, but upon prompting, are highly valued. These cases, including ecosystem services like pollination, water regulation, and erosion regulation represent opportunities for the Forest Service to clarify links between regulating ecosystem services and human benefit in outreach and communication (Asah et al., 2012). Interviews also revealed ambiguity within use, benefit, and value categories. The overarching idea of a category may be considered valuable to stakeholders, but their own personal interpretation of that category may be at odds with other stakeholders or managers. One notable example of this was that category of "option value," which relates to "places of predicted future use of natural resources." Participants often described valuing this category in a manner befitting their own future desired view of an area of the National Forest.

Participatory mapping of ecosystem services is a methodology that allows for better inclusion of cultural values alongside the spatial modeling and scenario analysis efforts often

central to ecosystem services-based analysis. While spatial modeling exercises do a poor job of portraying the spatial distribution of cultural ecosystem services and National Forest uses, benefits, and values beyond few basic categories, participatory mapping revealed a large variety of cultural ecosystem use, benefit, and value categories distributed throughout the National Forest. Overall, cultural ecosystem services were the most frequently mapped ecosystem services category and were mapped most often at the high mountain peaks, along routes of travel, and near wilderness areas. Provisioning ecosystem services were also mapped fairly frequently and were most frequently identified along transit corridors and closer to forest access points. Participants mapped regulating and supporting ecosystem services less frequently and expressed difficulty with spatially identifying them They were, however, able to map them, indicating that some of the more frequently identified categories should be included in future typologies for ecosystem service identification and mapping.

Mapping via semi-structured interviews revealed several opportunities when compared to other methodologies. Surveying active and involved stakeholders rather than the general public (in web-based surveys) yielded rich qualitative insight into the array of uses, values, and benefits that are perceived as related to the National Forest. By focusing attention on one participant at a time through one-on-one questioning, there were possibilities for continued probing as opportunities for clarification and expansion on the perceptions toward use, value, and benefit categories. When compared to other methodologies there was a notably high numbers of featured mapped on a per-participant basis. By allowing for a targeted group of participants from different stakeholder groups, the impact of participants participating in order to achieve political aims was diminished. Overall, this approach introduced a methodology that, despite relatively low resource demands, yields rich insights

into uses, benefits, and values that are currently lacking in National Forest management as well as ecosystem services approaches in the literature.

3. Future research

This research opens the door to several new areas of enquiry. Further research should first extend the methods of Chapter 2 and 3 to a greater number of participants in order to obtain a sample that would allow meaningful investigation among groups. Several studies (i.e. Darvill and Lindo, 2015) have considered spatial differences in uses, values, and benefits among groups, but all have consistently relied upon small group sizes. This research area is related to the more general need for more research into how to better engage stakeholders beyond those who already participate in forest outreach and management. Conducting participatory mapping using different mapping methodologies in the same National Forest context may help inform researchers regarding tradeoffs between the size and representativeness of the sample and the depth of insights gained.

Research is also needed to advance the application of ecosystem services-based management within the Forest Service. To improve the concept's relevance to managers and stakeholders, research should be devoted to improving methods that enable integration of desired conditions into interviews and mapping. This would help connect stakeholder-derived insights on perceptions and preferences into scenario development, one of the explicit goals of applying an ecosystem services approach.

Furthermore, as ecosystem services modeling and participatory mapping methodologies both continue to be developed, there is a substantial knowledge gap related to figuring out how to combine the data and insights from each. Currently these represent two diverging research trends with limited integration or insight into how regulating,

provisioning, and supporting services can be assessed and described along with cultural values related to these and cultural ecosystem services. The ability to consider the outcomes of management decisions on all categories of ecosystem services would be vastly improved if tools were able to include both of these data sources for ecosystem services information simultaneously. Overall, further investigating any of these lines of research and/or working on similar pilot projects along with Forest Service partners in different contexts would help the agency move beyond business-as-usual practices, helping to build staff capacity and furthering meaningful application of ecosystem services-based management.

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Appendix A. IRB Approval for surveys with National Forest Staff and Stakeholders

SAN DIEGO STATE UNIVERSITY
Leadership Starts Here

Graduate and Research Affairs
Division of Research Affairs San Diego Statue University 5500 Campanile Drive San Diego, CA 92182-1933 Phone 619-594-6622
irb@mail.sdsu.edu

Exempt Verification

11-Apr-2017

Principal Investigator:	**Crook, Stephen**
Co-Principal Investigator:	**Farley, Kathleen**
Department:	**Geography**
Protocol Number:	**HS-2017-0137**

Title: Ecosystem Service Assessment and Mapping Among National Forest Stakeholders using Participatory Methods

Dear Stephen,

The proposal or proposed study amendment was reviewed and verified as exempt in accordance with SDSU's Assurance and federal requirements pertaining to human subjects protections within the Code of Federal Regulations (45 CFR 46.101). This review applies to the conditions and procedures described in your protocol or amendment. The determination of exemption if final and continuing review (Progress Reports) are not required for this study. However, **if any changes to your study are proposed**, you must submit an amendment and receive IRB cerification that the study still meets exemption criteria (per 45 CFR 46.101). Additionally, please notify the Human Research Protection Program office at 619-594-6622 or at irb@mail.sdsu.edu if your status as an SDSU-affiliate changes while conducting this research study (you are no longer a SDSU faculty member).

Sincerely,

Rick Gulizia

Rick Gulizia
Director of Research Affairs
San Diego State University

The amendment below (April 2018) was sought for approval to conduct interviews with managers and staff who worked in any Pacific Northwest National Forest.

SAN DIEGO STATE UNIVERSITY

Graduate and Research Affairs
Division of Research Affairs San Diego Statue University 5500 Campanile Drive San Diego, CA 92182-1933 Phone 619-594-6622
irb@mail.sdsu.edu

Exempt Verification

23-Apr-2018

Principal Investigator:	**Crook, Stephen**
Co-Principal Investigator:	**Farley, Kathleen**
Department:	**Geography**
Protocol Number:	**HS-2017-0137**

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Sincerely,

Rick Gulizia

Rick Gulizia
Director of Research Affairs
San Diego State University

Appendix B. IRB Approved Consent form for Chapter 2

Verified
Exempt
23-Apr-2018

Consent to Act as a Research Participant
San Diego State University
Uses and Values of Ecosystem Services in Pacific Northwest National Forests

You are being asked to participate in a research study. Before you give your consent to volunteer, it is important that you understand the purpose of the study and ask as many questions as necessary.

Investigators: This study is being conducted by Stephen Crook, a doctoral student in the Department of Geography, San Diego State University, with the oversight of Dr. Kathleen Farley, a professor in the department.

Purpose of the study: The purpose of this study is to better understand the application of the ecosystem services framework in US National Forests in the context of the 2012 National Forest Planning Rule, and to investigate the uses of and values toward ecosystem services according to stakeholders of Gifford Pinchot National Forest. The reason you may want to participate in this study is that this research may increase the researchers' understanding of use of the ecosystem services concept in National Forest management and may positively influence National Forest management in the future. The reason you may not want to participate in this study is a potential breach of confidentiality, in which your responses would be obtained by individuals other than the research team. This may result in a modification of their attitudes toward you. You do not have to answer any questions that make you uncomfortable. If, at any time, you want to stop participating you may do so.

Description: If you volunteer to take part in this study, you will be asked to participate in an interview that will last approximately one hour. You will be asked questions related to the concept of ecosystem services in National Forest management, the identification of National Forest stakeholders, and the ways that Pacific Northwest Forests are used and valued by diverse groups.

Confidentiality: We will take written notes and will record an audio-transcript of your responses, but your identity will be held in strict confidentiality and will not be shared outside of the research team. Interview notes, data, and recordings will be linked by an code, which will be held separately and not linked with this consent form or contact information if provided below. Data and this consent form will be transported in a locked container and then stored in locked cabinets and password protected folders in the Geography Department at San Diego State University. Only the researchers affiliated with this study will have access to interview notes and recordings. Your contact information will be kept in a file for potential follow-up research, but will not be connected in any way with your responses.

Compensation to participate/costs: You will not be paid to participate in this study and there is no cost to participate.

Voluntary Nature of Participation: Participation in this study is voluntary. Your choice of whether or not to participate will not influence your future relations with San Diego State University or with the organizations or individuals through whom we contacted you. If you decide to participate, you are free to withdraw your consent and to stop your participation at any time.

Questions about the study: If you have questions about the research, you may ask now. For future question, you may contact: Stephen Crook: 831-406-7601; scrook@sdsu.edu or Kathleen Farley: 206-554-1355; kfarley@mail.sdsu.edu. If you have questions about your rights as a participant in this study, you may contact the Division of Research Affairs at San Diego State University (619-594-6622, irb@mail.sdsu.edu).

Consent to Participate: The San Diego State University Institutional Review Board has approved this consent form, as signified by the Board's stamp. The consent form must be reviewed annually and expires on the date indicated on the stamp. Your signature below indicates that you have read the information in this document and have and have had a chance to ask any questions you have about the study. Your signature also indicates that you agree to be in the study and have been told that you can change your mind and withdraw your consent to participate at any time. You have been given a copy of this consent form and have been told that by signing it you are not giving up any of your legal rights.

Interviewer	Signature	Date
Participant	Signature	Date

Verified
Exempt
23-Apr-2018

Consent for future research: Please indicate below if you are willing to consent to having your contact information retained for future research related to this project. If you mark the box next to **YES** and fill out your email address and phone number, these details will be retained for a follow-up exercise that will help us better understand the ability of different land cover types to provide different ecosystem services. Your contact information will be kept apart from survey responses. If you mark the box next to **NO** your contact details will not be retained. Your response to this will not in any way affect your participation in the current research, nor will it affect your relationship with the researchers or San Diego State University. If you decide to mark **YES**, you are free to withdraw your consent and to stop your participation at any time.

☐ **YES** ☐ **NO**

_____ _____

Email Phone number

_____ _____ _____

Participant Signature Date

Appendix C. Interview Guide for Chapter 2

MI #_____
4-19-2018
V6

Ecosystem Service Uses and Values in Pacific Northwest National Forests – Manager Survey

Introduction – Thank you – This first part of the research project is designed to get information on three related topics: To discuss role of ES in forest management, to identify the stakeholders involved in ecosystem services, and to identify spatial attributes specific to Pacific Northwest National Forests that are related to ES delivery.

1. **Demographics (5 min)**

   1.1. How long have you worked for the US Forest Service?

   1.2. How long have you worked for the US Forest Service in the Pacific Northwest Region?

   1.3. How long have you worked in the field of natural resource management in the region?

   1.4. What is your current position in the US Forest Service?

2. **Experience with the ecosystem services concept (30 min)** – *This section investigates the role of ecosystem services in management and decision making in the region and in Pacific Northwest National Forests.*

   2.1. On a scale of 0-5, How familiar are you with the concept of ecosystem services? (0 being completely unfamiliar, 5 being very familiar).

   2.2. Broadly, *ecosystem services* are defined as "the benefits people obtain from ecosystems." Based on your understanding of the concept, how would you expand or modify this definition?

2.3. When did you first encounter the term “ecosystem services”?

2.4. What type of experience do you have with ecosystem services in your role? (e.g. strategic planning, community engagement, project implementation)

2.5. More broadly, how have you seen the ecosystem services framework been implemented in National Forest management and planning? (e.g. strategic planning, community engagement, project implementation)

2.6. In your opinion, what are the most important ecosystem services that [The National Forest in which the participants works] provides society?

2.7. Are there any specific ecosystem services that are considered high priority for the management of [The National Forest in which the participants works]?

2.8. What data, knowledge, or information gaps would need to be addressed to apply an ecosystem services framework or manage for ecosystem services?

2.9. What are the most pressing management issues for planners and decision-makers in [The National Forest in which the participants works]?

2.10. What influence has the 2012 planning rule, and the requirement to include ecosystem services into National Forest decision making, had on the way the Forest Service makes management decisions?

3. **Land use and Ecosystem Services (10 min)** – *Ecosystem services delivery differs based on land use/land cover, as well as how the land is managed. This next section is about identifying different land uses and management designations that may result in different levels of ES supply. provide different amounts of different ecosystem services.*

3.1. In academic circles, a lot of attention has been paid to spatial models of ecosystem services for decision support. These are usually based on land cover type. What spatial units and what scale would be useful for mapping ES in a NF?

3.2. More specifically, what are management designations exist within the NF, and how do they differ in their ability to provide ES?

4. Stakeholder Identification and Analysis (10 min)

4.1. What groups influence, or are influenced by, management decision making in [The National Forest in which the participants works]?

4.2. For each group identified, on a scale of 0 (no influence/not influenced by) to 5 (high degree of influence/highly influenced by), how much do they influence or are influenced by management decision making in [The National Forest in which the participants works]?

4.3. For each of the top priority ecosystem services identified in Section 1, which of the groups identified above is associated with that service?

4.3.1. Service 1: Groups:

4.3.2. Service 2: Groups:

4.3.3. Service 3: Groups:

4.3.4. Service 4: Groups:

4.3.5. Service 5: Groups:

5. Follow-up Questions (5 min)

5.1. Is there anything you would like to add?

Appendix D. IRB Approved Consent form for Chapter 3

Verified
Exempt
11-Apr-2017

Consent to Act as a Research Participant
San Diego State University
Uses and Values of Ecosystem Services in Gifford Pinchot National Forest

You are being asked to participate in a research study. Before you give your consent to volunteer, it is important that you understand the purpose of the study and ask as many questions as necessary.

Investigators: This study is being conducted by Stephen Crook, a doctoral student in the Department of Geography, San Diego State University, with the oversight of Dr. Kathleen Farley, a professor in the department.

Purpose of the study: The purpose of this study is to better understand the uses of and values toward natural resources according to stakeholders of Gifford Pinchot National Forest.

Description: If you volunteer to take part in this study, you will be asked to participate in an interview that will last approximately one hour. You will be asked questions related to National Forest management, the way you use and value the forest, and you will be asked to show where aspects of the forest are used and valued on a map.

Risks or Discomfort: The primary risk to participating in this research is a potential breach of confidentiality, in which your responses would be obtained by individuals other than the research team. This may result in a modification of their attitudes toward you or your affiliated groups. You do not have to answer any questions that make you uncomfortable. If, at any time, you want to stop participating you may do so.

Confidentiality: We will take written notes and will record an audio-transcript of your responses, but your identity will be held in strict confidentiality and will not be shared outside of the research team. Interview notes, data, and recordings will be linked by an code, which will be held separately and not linked with this consent form. Data and this consent form will be transported in a locked container and stored in locked cabinets and password protected folders in the Geography Department at San Diego State University. Only the researchers affiliated with this study will have access to the interview notes and recordings.

Benefits: While we cannot guarantee that you will receive any benefits from participating in this study, by contributing information that will be presented to the Forest Service you may potentially be advocating on behalf of your (or your group's) priorities and preferences for forest management. Your participation in this research may also increase the researchers' understanding of the values and uses related to Gifford Pinchot National Forest, and may influence national forest management in the future.

Compensation to participate/costs: You will not be paid to participate in this study and there is no cost to participate.

Voluntary Nature of Participation: Participation in this study is voluntary. Your choice of whether or not to participate will not influence your future relations with San Diego State University or with the organizations or individuals through whom we contacted you. If you decide to participate, you are free to withdraw your consent and to stop your participation at any time.

Questions about the study: If you have questions about the research, you may ask now. For future question, you may contact: Stephen Crook: 831-406-7601; scrook@sdsu.edu or Kathleen Farley: 206-554-1355; kfarley@mail.sdsu.edu. If you have questions about your rights as a participant in this study, you may contact the Division of Research Affairs at San Diego State University (619-594-6622, irb@mail.sdsu.edu).

Consent to Participate: The San Diego State University Institutional Review Board has approved this consent form, as signified by the Board's stamp. The consent form must be reviewed annually and expires on the date indicated on the stamp. Your signature below indicates that you have read the information in this document and have and have had a chance to ask any questions you have about the study. Your signature also indicates that you agree to be in the study and have been told that you can change your mind and withdraw your consent to participate at any time. You have been given a copy of this consent form and have been told that by signing it you are not giving up any of your legal rights.

_____	_____	_____
Interviewer	Signature	Date
_____	_____	_____
Participant	Signature	Date

Appendix E. Interview Guide for Chapter 3

Survey v4.3
7-27-2017

Respondent #____ Start time_____

Ecosystem Service Uses and Values in Gifford Pinchot National Forest
Stakeholder Survey

Introduction

- Present consent form. Address 1) recording 2) confidentiality and anonymity 3) no direct benefit nor cost 4) Participation is voluntary and you may stop participation at any time. Ask for questions.
- Project description and interview outline – background, stakeholders, forest uses and benefits, mapping, management.
- Exploratory study with no right or wrong answers.

---

1. **Background (5 minutes)**
   1.1. What's your name and what is/was/were your occupation(s)?

   1.2. How often do you go to GPNF?

   1.3. Where do you live and how long does it take you to get from where you live to GPNF

   1.4. How long have you lived in the area?

   1.5. Have you worked in GPNF or surrounding forest?

      1.5.1. What kind of work did you do in GPNF?

      1.5.2. When, and for how long, did you work in GPNF?

   1.6. In what ways is your relationship with the forest important to you?

   1.7. Age? 18-35 36-50 50-65 66 or over

   1.8. Gender? M F

---

2. **Stakeholder analysis (10 minutes)**

   2.1. What groups of people influence, or are influenced by, decision-making and management in Gifford Pinchot National Forest?

   2.2. With regard to the forest, do you consider yourself a part of any specific group or groups? Which do you most identify with?

   2.3. For each group identified, on a scale of 0 (is not influenced by/does not influence) to 5 (highly influenced by/high influence), how much does each group impact or is each group impacted by GPNF decision-making and management?

3. **Forest uses/benefits/values identification (15 min): In this section, we're going to talk about forest uses, benefits, and values, and I'll jot down on notecards what you identify**

   3.1. In what different ways do you use GPNF? *(Add to notecards – color #1)*

   3.2. Are there specific products or goods that you get from the forest? *(Add to notecards – color #1)*

   3.3. Are there other ways GPNF is valuable or meaningful to you? (These might include more abstract, less tangible thoughts or feelings) *(Add to notecards – color #1)*

   3.4. Beyond what you've already identified, what ways do communities, society in general, or other people use GPNF? *(add to notecards – color #2)*

   3.5. What other specific goods or products do other communities, society, or other people get from the forest? *(add to notecards – color #2)*

   3.6. Are there other ways GPNF is valuable or meaningful to communities, society, or other people? (Again, this might include more abstract, less tangible thoughts or feelings) *(Add to notecards – color #2)*

   3.7. To your knowledge, how have these benefits, uses, or values of the forest changed over the last twenty-five years? Add a + or – sign to the cards.

      3.7.1. Are there any other forest uses, benefits derived from the forest, or forest values held by yourself or society that used to exist but no longer exist?

      3.7.2. Are any of these uses, benefits, or values completely new within the last 25 years?

4. **Participatory Mapping (30 minutes)**

   4.1. For each of the ways you have identified that you or society benefits from or uses GPNF, outline on this map where that benefit/service is provided, or that benefit/service is used. *(add a line of selected color to card before mapping)*

   (While mapping – sort through ES typology cards and remove those ES already identified)

5. **Ecosystem services framework (10 minutes)**

   5.1. Here are some other potential services/benefits/values have been identified in other areas *(Provide note cards with MEA categories and short descriptions)*. In each of the two piles, select up to five which you think are most important in and around GPNF *(Set aside those that are not identified)*.

   5.2. Add these newly identified services to the map.

   5.3. Draw an outlines of the parts of the map that you feel like you know well *(in thick BLACK Sharpie)*.

6. **Ranking of Ecosystem Services (5 minutes)**

   6.1. Order the notecards of the uses, benefits, and values you've identified over the course of this interview from most to least important to you? (*add ranking to card in RED ink)*

      6.1.1. Can you explain why you placed these ones at the top?

   6.2. Can you re-order the notecards from most to least important to society? *(add ranking to card in BLACK ink)*

      6.2.1. Can you explain why you placed these ones at the top?

7. **Management Preferences and Ecosystem Services (5 minutes)**

7.1. Of these services, benefits, or uses identified, which do you believe are prioritized for management by the Forest Service in GPNF? (Feel free to order the cards again, or just tell me the top few).

7.2. Of these services, benefits, or uses, which do you believe should be prioritized for management by the Forest Service in GPNF?

7.3. Which of the services, benefits, or uses identified are best protected in GPNF?

7.4. Which of the services, benefits, or uses identified are most threatened in GPNF?

7.5. Can you draw one last outline on the map where the uses/benefits you've identified from the forest are most threatened? *(Draw in think RED Sharpie)*

8. **Conclusion**

8.1. Do you have any contacts in any of the stakeholder groups you identified earlier that may be interested in taking part in this research?

8.2. Thank you

End time_____

Total time_____

Wrap up

- Create replacement cards for inserted *(color 3)* ecosystem service typology cards.
- Place rubber band around all ES identified by participant.
- Check for interview number on top of notebook section, map, and pile of cards.
- Check that times are recorded.

Appendix F. Ecosystem Services typology and information presented to respondents

a. Cultural ecosystem services

Employment	The natural resources in this area support industries that provide valuable jobs and monetary income.	**Existence / bequest values**	Intangible benefit associated with satisfaction that places exist and in preserving a natural landscape or place for future generations.
Spiritual / religious values	This area contains places that make one think about forces larger than themselves.	**Option value**	Places here are important because there is a predicted future use for the natural resources that exist.
Knowledge systems	This area helps people cultivate and maintain important skills, theoretical knowledge, and scientific research.	**Ceremonial value**	This area is important due to one or more sets of actions that are performed on a special occasions for symbolic value.
Educational values	Ecosystems in this area provide the basis for both formal and informal education.	**Recreation and ecotourism**	The natural characteristics of this place make it appealing for recreational activities as well as tourism.
Inspiration	Ecosystems in this area inspire arts, folklore, national symbols, architecture, or advertising.	**Identity**	Sense of belonging tied to places, ecosystems, or landscapes; or through doing specific things in those places.
Aesthetic values	This area contains ecosystems and landscapes that are particularly beautiful.	**Cultural diversity**	Ecosystems in this area influence cultural diversity.
Social relations	This area has places that allow for activities that result in meaningful social interaction.	**Cultural heritage values**	This area contains historical or culturally important sites, important cultural landscapes, or culturally significant species.
Sense of place	This area contains places that are especially valuable for personal reasons; important places that are often visited or thought about.		**Ecosystem service categories and descriptions adapted from Asah (2012) and Klain (2010)**

b. Provisioning, regulating, and supporting ecosystem services

Food	This area produces food from plants, animals, and microbes.
Fiber	This area produces things like timber, wood products, cotton, hemp, silk, wool, and more.
Genetic resources	This area contains valuable genes and genetic information for plant and animal breeding.
Biochemicals, natural medicines	This area contains (or potentially contains) medicines, food additives, other biological materials.
Ornamental resources	This area provides ornamental animal and plant products such as flowers, skins, and whole plants.
Fresh water	This area provides fresh water for drinking, agriculture, energy supply, and other uses.
Air quality regulation	The plants in this area can extract chemicals from the air and atmosphere.
Climate regulation	Ecosystems in this area regulate temperature and precipitation and/or sequester greenhouse gases.
Water regulation	The vegetation in this area affects the timing and magnitude of runoff, flooding, and aquifer recharge.

Pest regulation	Ecosystems in this area regulate the prevalence of pests and diseases that affect livestock and crops.
Pollination	Ecosystems in this area support abundant pollinators and effective pollination.
Natural hazard regulation	Natural systems in this area can decrease the impact of natural hazards.
Erosion regulation	The vegetation cover in this area helps decrease soil erosion and degradation, and prevents landslides.
Water purification and waste treatment	The soils and plants in this area help filtration and decomposition of organic waste introduced into water systems.
Disease regulation	Ecosystems in this area regulate the abundance of human pathogens and disease vectors.

Ecosystem service categories and descriptions adapted from Asah (2012) and Klain (2010)

Appendix G. All National Forest uses, values, and benefits identified

	Total responses	Important to self	Important to others	Total identified	Chosen from MEA cards
Forest products	23	18	5	23	0
Non-motorized recreation	23	21	2	23	0
Clean water	21	5	7	12	9
Timber	20	3	16	19	1
Hunting and fishing	19	10	9	19	0
Employment	19	10	6	16	3
Existence and bequest	18	10	1	11	7
Sense of place	17	8	1	9	8
Water regulation	16	1	3	4	12
Climate regulation	15	2	8	10	5
Aesthetics	14	5	2	7	7
Air quality regulation	14	4	3	7	7
Solitude	11	9	2	11	0
Cultural heritage	11	3	5	8	3
Education	11	3	2	5	6
Spirituality	10	4	4	8	2
Motorized recreation	9	1	8	9	0
Driving	9	6	3	9	0
Identity	9	1	3	4	5
Social relations	9	3	1	4	5
Genetic resources	9	0	2	2	7
Option value	9	0	0	0	9
Habitat/connectivity	7	4	3	7	0
Knowledge systems	7	3	1	4	3
Water purification	7	1	2	3	4
Natural hazard regulation	7	0	2	2	5
Erosion regulation	7	0	0	0	7
Exploration	6	5	1	6	0
Mining	5	0	5	5	0
Local economic impact	5	0	4	4	1
Biochemicals and medicines	5	1	1	2	3
Inspiration	5	0	0	0	5
Pollination	5	0	0	0	5
Volunteering	4	4	0	4	0
Tourism	4	0	4	4	0
Relaxation	3	3	0	3	0
Wildlife viewing	3	1	2	3	0
Health	3	2	1	3	0
Energy production	3	0	3	3	0
Ceremonial	3	0	0	0	3
Rock collection	2	2	0	2	0
Buffer to development	2	2	0	2	0
Place to challenge oneself	2	2	0	2	0
Urban proximity	1	0	1	1	0
Social dischord	1	0	1	1	0
Dump trash	1	0	1	1	0
Cultural diversity	1	0	0	0	1