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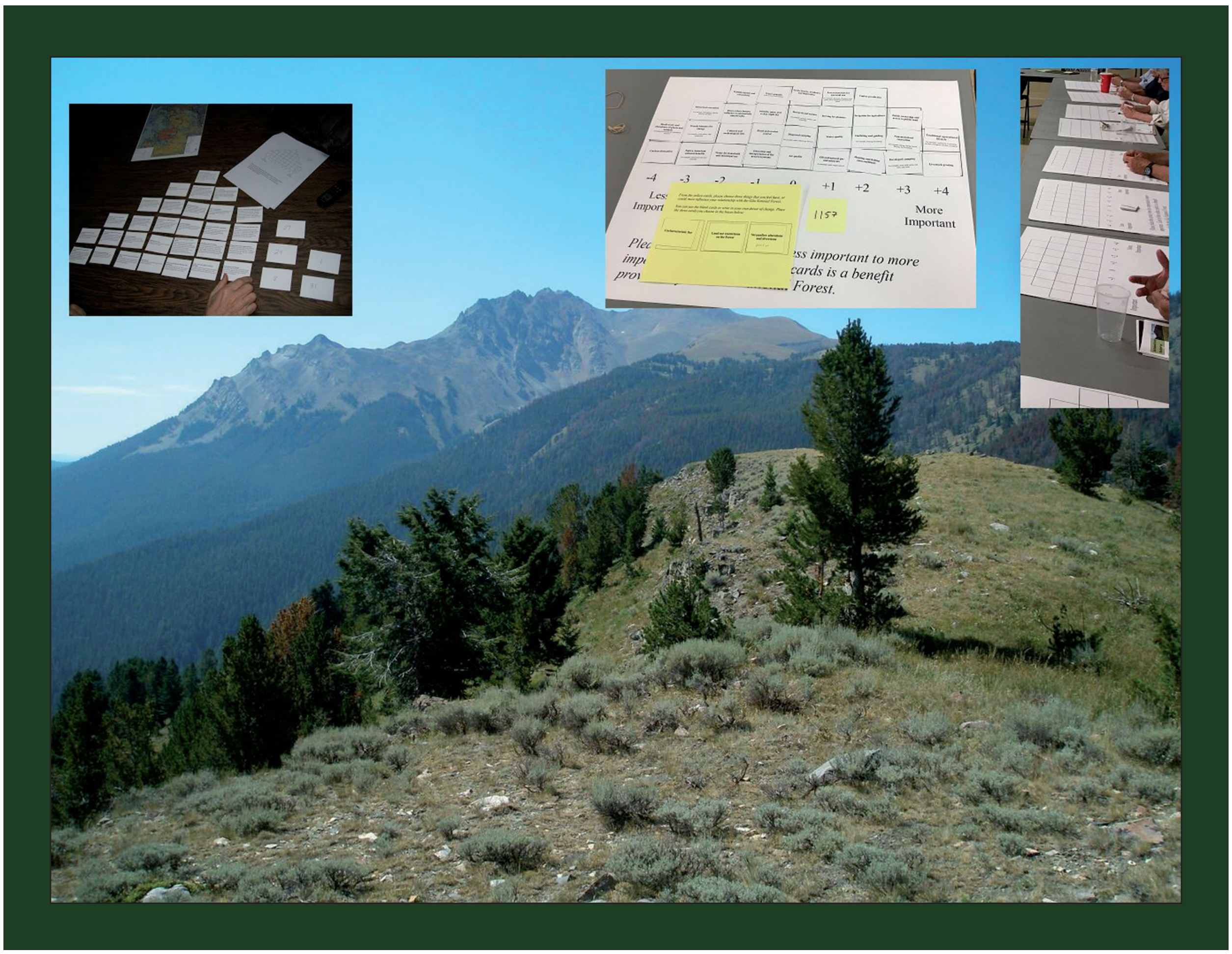
Protocol for Social Vulnerability Assessment to Support National Forest Planning and Management:

A Technical Manual for Engaging the Public to Understand Ecosystem Service Tradeoffs and Drivers of Change

Christopher A. Armatas, William T. Borrie, and Alan E. Watson



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Abstract

Despite the generally accepted need for understanding social vulnerability within the context of USDA Forest Service planning and management, there is a lack of structured approaches available to practitioners to gain such an understanding. This social vulnerability protocol provides a step-by-step manual for engaging the public about ecosystem service tradeoffs and the drivers of change considered influential to the continued provision of important ecosystem services. This protocol provides a rigorous social science approach for implementation alongside common public engagement practices such as listening sessions, open houses, and focus groups. The approach includes a fun, thought-provoking exercise to be completed during the public engagement process, and we suggest that the approach can be implemented within the context of already busy work schedules and without outside expertise.

This protocol, which is based on the social science method known as Q-methodology, includes guidance from the initial step of describing the decisionmaking context to the final steps of analysis and interpretation. The final results include multiple perspectives held by the public, and the perspectives are conveyed through engaging and understandable illustrations. The knowledge created through implementation of this protocol can inform both natural resource decisionmaking and public relations.

Keywords: stakeholder engagement, public meeting, Q-methodology, social science

Cover photos

(Insets) Examples of people completing the prioritization of ecosystem services.
Background: View of a peak in the Rocky Mountains (photos: C. Armatas, USDA Forest Service).

Authors

Chris Armatas is an Oak Ridge Institute for Science and Education (ORISE) Research Fellow sponsored by the Aldo Leopold Wilderness Research Institute, USDA Forest Service, Rocky Mountain Research Station. He has a Ph.D. from the University of Montana in Missoula, Montana. He conducts research on national forest land management and planning through an interdisciplinary, social science lens. His research focuses on understanding how human well-being is supported by the variety of benefits flowing from our public lands.

Bill Borrie is a Professor in the Franke College of Forestry and Conservation at the University of Montana in Missoula. His research interests are focused on the meanings, experiences, and management of parks and wilderness areas. Dr. Borrie has helped with research in Yellowstone National Park, the Bob Marshall Wilderness Complex, the Arctic National Wildlife Refuge, the Okefenokee National Wildlife Refuge, the Selway-Bitterroot Wilderness, and Petrified Forest National Park. He has a Ph.D. in Forestry from Virginia Polytechnic Institute and State University and a B.S. and M.S. in Forest Science from the University of Melbourne, Australia.

Alan Watson is the Research Social Scientist at the Aldo Leopold Wilderness Research Institute in Missoula. He conducts or contributes to research to support stewardship of wilderness and wildlands across the United States and internationally. Dr. Watson has provided oversight and continuity for many social science studies of protected areas since becoming a Forest Service scientist in 1988. He completed a B.S., M.S., and Ph.D. in human aspects of natural resources planning and management at Virginia Polytechnic Institute and State University.

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Contents

1. Introduction

Leadership in the Forest Service, U.S. Department of Agriculture has identified the need for social vulnerability assessments of communities dependent on national forests, because such assessments can support adaptation strategies in the face of ecological and socioeconomic changes such as those stemming from climate change (Murphy et al. 2015). In addition, social vulnerability assessments can help Forest Service managers and planners meet formal policy mandates such as the Forest Planning Rule of 2012, which requires decisionmakers to consider ecological, social, and economic sustainability (U.S. Department of Agriculture, Forest Service 2012).

The general need for social vulnerability assessments, and the conceptual components of such assessments, is well established. But national forest practitioners and decisionmakers lack structured approaches that are methodologically robust, yield usable results and, perhaps most importantly, are practical both within planning and management processes and the already busy work schedules of staff. This report provides one protocol, or step-by-step instructions, on how to assess, analyze, and describe social vulnerability within the context of forest planning and management. The methods described are straightforward and ready for adoption by national forest planners and managers to support a variety of natural resource stewardship activities. This protocol has been applied within three different planning and management contexts: wilderness management (Irey 2014), water resource stewardship at a basin-level scale (Armatas 2013), and the forest plan revision process (Armatas et al. 2017a). In addition, this protocol is currently in the early planning phases for application to assessment of environmental and social threats for the Comprehensive River Management Planning process on the Flathead Wild and Scenic River System in northwest Montana. These case study and potential applications highlight the adaptable and flexible nature of the protocol for addressing the needs of different national forest planning and management situations. In addition, the methodology (conceptual and theoretical underpinnings of the methods) supporting this protocol is well established within the scientific literature, as reflected by peer-reviewed publications (Armatas et al. 2014, 2017b, 2018). Thus, those considering adoption of this protocol can be confident in the scientific integrity of this approach.

In the rest of this section, we (1) outline the basics of the vulnerability concept and the definition of social vulnerability applied within this document, (2) briefly describe the public engagement process for application of this protocol, and (3) list management implications of the protocol. A detailed description of the protocol is provided in section 2. Management implications of this protocol are expanded upon in section 3.

1.1. Vulnerability Basics and the Conceptualization of Social Vulnerability for This Protocol

The literature on social vulnerability assessments is broad. As outlined by Murphy et al. (2015), there are several different definitions of social vulnerability and underlying conceptual frameworks, which have unique implications for types of research questions asked, resulting knowledge, and influences on decisionmaking. This report does not thoroughly review the literature on the concept of vulnerability, or the general methodologies that may be appropriate for its assessment. Several high-quality reviews and discussions already exist, both in a general context (Adger 2006; Hinkel 2011; Murphy et al. 2015) and specifically within the context of national forest decisionmaking (Fischer et al. 2013). However, because there is no single unified meaning of social vulnerability (or how it is assessed), we briefly discuss the broad idea of vulnerability, as well as the conceptualization of social vulnerability applied herein.

Vulnerability is often defined in relation to three main components: exposure, sensitivity, and adaptive capacity. "Exposure" refers to the likelihood that some entity (e.g., community, individual, species, watershed, region, nation, social-ecological system) may be affected by a driver of change (e.g., flood, wildfire, invasive species, urban development, crop tariffs, increased water quality standards). "Sensitivity" refers to the extent to which a driver of change may affect the entity. "Adaptive capacity" refers to the ability of the entity to cope or adjust in the face of some driver of change. The definitions of vulnerability and of these components, as well as their relationship to each other, are not consistent across disciplines. Perhaps most traditionally, vulnerability is represented as a basic function: Vulnerability = $\boldsymbol{f}$ (exposure, sensitivity, adaptive capacity) (Hinkel 2011; Murphy et al. 2015). Such calculations of vulnerability often incorporate a "vulnerability indicator," or a single *measurable* number that can "synthesize complex state-of-affairs such as the vulnerability of regions, households, or countries" for the purposes of decisionmaking (Hinkel 2011: 198). Such vulnerability indicators could include per capita income at the county level, or annual healthcare expenditures. It has been argued that this simplistic and quantitative representation of vulnerability may not be appropriate in all cases, because it can lead to overlooking political, cultural, and economic influences on how an entity is affected by a driver of change (Hinkel 2011; Murphy et al. 2015).

Some acknowledge the potential shortcomings of reducing the complexity of an entity's vulnerability to a single number or formula and instead view vulnerability in a less concrete, more holistic way. Although such approaches may not apply a vulnerability indicator as defined earlier, or define exposure, sensitivity, and adaptive capacity as quantifiable components of a vulnerability equation, these basic ideas remain important tools for decisionmakers. Experts from a variety of disciplines use the vulnerability concept, and the Forest Service has adopted the concept (Murphy et al. 2015; U.S. Department of Agriculture, Forest Service 2011).

The vulnerability concept can help natural resource planners and managers think about how individuals and communities that are supported by public land are potentially at risk in the face of various drivers of change.

For example, consider the situation where the availability of timber resources on a national forest decreases, which may result from natural disturbances like fire, a change in management due to the presence of an endangered species, or a broad political-economic factor such as the increasing availability of cheap wood substitutes. In this case, it may be helpful for Federal land managers and planners, who are charged with considering potential adaptation strategies, to think about which individuals or communities are potentially exposed to the impacts of this change (e.g., timber industry, motorized recreationists), the potential magnitude of the impact (e.g., loss of livelihood, loss of opportunities for recreation), and the ability to cope with such changes (e.g., the ability and desire to find a different job or apply for government assistance, ability and desire to recreate elsewhere).

This example highlights several points that are important to the protocol presented herein. First, changes that take place within the context of natural resource management and planning are likely to influence the benefits, or ecosystem services, that are important to a broad range of stakeholders. Second, there are multiple different perspectives about which ecosystem services are important and, as a result, a single driver of change may influence different people in different ways (as reflected by the ecosystem services that are important to particular people). Last, the drivers of change, and the tradeoffs among ecosystem services, that are of concern to people are likely to be determined by those ecosystem services that are important. For these reasons, we consider vulnerability as *the potential influence on human well-being that results from a change in the provision of an ecosystem service*. Therefore, this protocol focuses on the discovery and exploration of multiple perspectives on the importance of ecosystem services and the drivers of change considered relevant to their continued provision.

For this protocol, ecosystem services are defined broadly as “the benefits people obtain from ecosystems” (Millennium Ecosystem Assessment 2003: 53), which is a definition that allows for a flexible interpretation of the concept. It is worth noting that the meaning of “ecosystem services” is not settled, and there is significant debate about what exactly constitutes an ecosystem service; however, we do not provide any background here, but only acknowledge the debate to prevent potential confusion (see, for example, Wallace (2007) for an overview of the issue). Despite the lack of consensus on the ecosystem services concept, integrating it into a vulnerability assessment is a well-established practice, as it can effectively communicate the diverse ways that natural resources contribute to human well-being (Armatas et al. 2017b; Kumar et al. 2011; Micheli et al. 2014; Stratford et al. 2011). Integrating the ecosystem services concept into vulnerability assessment designed for Forest Service management and planning may be particularly relevant. Kline et al. (2013: 140) note that the

Forest Service considers the ecosystem services concept to be promising, in part, because it can "tell a richer story to Congress and the public about the benefits and tradeoffs associated with managing national forests, support decisions that promote sustainability, and facilitate partnerships with local communities."

To understand how important ecosystem services may change, this protocol focuses on identifying public perceptions about drivers of change, by which we mean factors, influences, stressors, threats, or agents of impact that may potentially affect the provision of ecosystem services. A driver of change could be nearly anything, including disturbance related to climate change, such as wildfire, drought, and invasive species, or management actions (e.g., road closures), policy mandates, price of gas, tariffs, congested traffic, crowded trails, and light pollution. This protocol explicitly identifies the prevalent relationships between people and the environment by connecting who (i.e., specific stakeholder groups) values what (i.e., ecosystem services) with stakeholder perceptions on the extent that particular drivers of change influence stakeholder well-being.

1.2. Defining the Relationship Between the Public and Public Land Through a "Fun, Engaging, and Thought-Provoking Exercise"

In section 2 of this report, we list the steps that need to be completed for this protocol, and the first component of step 6 is "Engage stakeholders through completion of a fun, engaging, and thought-provoking exercise." When considered chronologically, this protocol does not engage the public, or the diverse people invested and interested in the stewardship of our public lands, in a structured manner until after several other steps have been completed. However, the five steps prior to structured engagement of stakeholders are completed in preparation for step 6. Therefore, it may be beneficial to briefly describe this foundational aspect of this protocol, as it provides context for the entire document.

The primary purpose of this protocol is to provide managers and planners with a structured approach to understand what ecosystem services are important to a broad range of people, as well as their perceptions of factors or influences (i.e., drivers of change) likely to affect the provision of such ecosystem services. This approach can complement, or potentially replace, unstructured public engagement processes such as listening sessions, open houses, open-comment periods, and informal voting procedures (e.g., placing stickers on a list of options based on which are most appealing to the participant).

The foundation of this structured approach is what we call a fun, though-provoking exercise. This name stems from descriptions given by past participants, who suggested that the activity was fun and engaging. The interactive process is also an established strength of Q-methodology. Fundamentally, this protocol is an application of Q-methodology, which is a social science method that provides a structured approach to measuring people's opinions. A strength of the method is that the process for collecting participant input is not reminiscent of a traditional survey. That is, we do not ask participants to complete a survey with a list of separate questions (which typically ask for relative importance or ranking by importance); instead, most of the input from participants is gathered through completion of a single task.

That task asks respondents to sort through a deck of cards, and on each card is an ecosystem service relevant to the planning and management context. The participant is asked to prioritize the ecosystem services on a scale of "most important" to "most unimportant" using a ranking board (fig. 1A, 1B). To complete this exercise, people are instructed to fill in the board and it is made clear that each column denotes a different level of importance, while the rows do not. In other words, participants are instructed to choose their two "most important" ecosystem services (+4 column), followed by their next three most important ecosystem services (+3 column), and so on until the entire board is filled in. These ecosystem services rankings, or Q-sorts, are the primary method for actively engaging members of the public. We will provide further details about the Q-sort process in step 6 of this protocol.

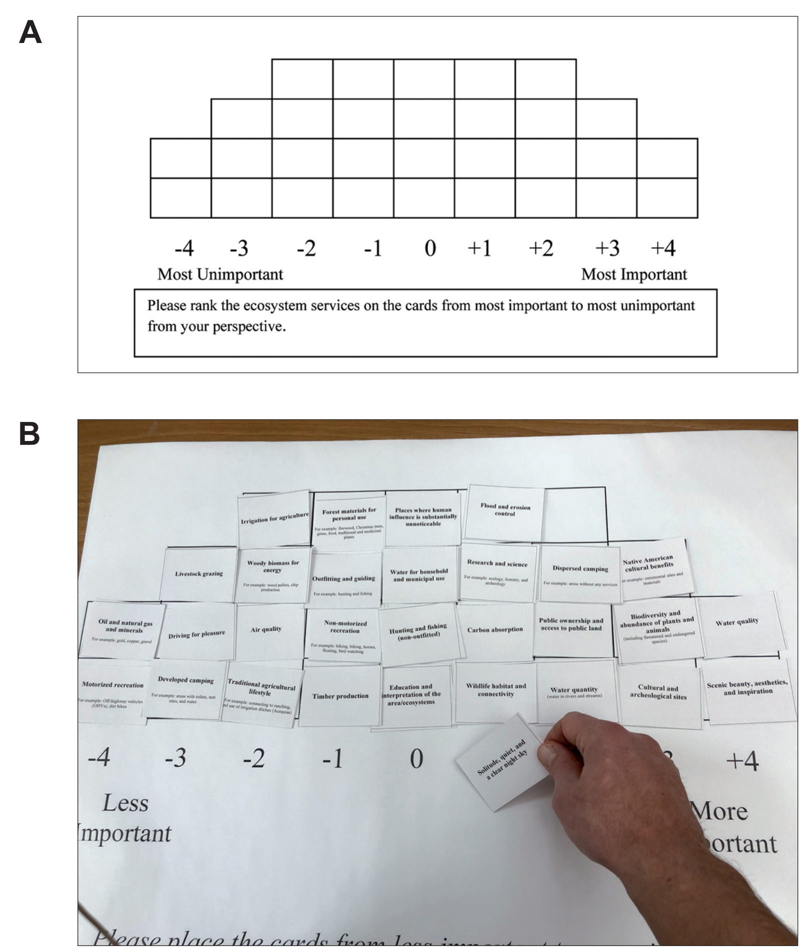


Figure 1—(A) Ranking board that participants used to prioritize 30 ecosystem services; (B) example of participant completing prioritization exercise (photo: C. Armatas, USDA Forest Service).

1.3. Management Implications: A Brief Overview

This document provides Federal land managers and planners, specifically those within the Forest Service, with a set of steps and guidelines (i.e., a protocol) for collecting information that provides a holistic understanding of social vulnerability. Deciding on whether to adopt this protocol to facilitate planning and management requires a full discussion of management implications, which is presented in section 3; however, we list those implications here to provide context for the detailed description of the protocol that follows.

The protocol described herein, both through its process and the results yielded, provides many benefits for forest managers and planners, including: (1) the ability to collect a broad range of stakeholder perspectives within public planning meetings or other forums without the risk of dominant personalities overtaking the process; (2) a systematic and structured process that is relatively straightforward to implement, which facilitates individual engagement of participants; (3) a limited number of general perspectives that illustrate the diversity of individual perspectives on the important benefits derived from national forests and the views about factors or influences threatening such benefits; (4) an understandable communication tool for highlighting to stakeholders and the public the broad range of interests that forest practitioners are charged with accommodating (i.e., clear communication of how difficult national forest decisionmaking is, and the inherent tradeoffs within the process). The hope is that such communication, through the presentation and inspection of colorful "relationships" (many of which are different from one's own relationship), can allow stakeholders to understand how other people, who think differently from them, value national forests. This understanding may foster empathy both with national forest decisionmakers (who are charged with a tough task) and members of the public (who think national forests are important for a variety of reasons). Additional benefits for forest managers and planners are (5) a foundation for further research on the value of ecosystem services, including monetary quantification of marketed and nonmarketed forest ecosystem services; (6) informing public relations; (7) setting objectives and monitoring; (8) relational marketing (i.e., protection of relationships between the public and the national forest); (9) adaptation planning; (10) decisionmaking in a fair and rigorous way to quantify and summarize clusters of values; and (11) a fun approach to engaging the public on questions of values.

2. The Protocol for Understanding Social Vulnerability

A “protocol” can be thought of as a “a system of rules that explain the correct conduct and procedures to be followed in formal situations” (Merriam-Webster 2017). The *formal situation* in this case is the need to understand social vulnerability within the context of forest planning and management. The *correct conduct and procedures* are described next and as previously mentioned, are primarily based on Q-methodology. The method is detailed in Brown (1980) and Watts and Stenner (2012); a detailed discussion of the method (and its underpinning theory) is not included in this document. Instead, this protocol is discussed only in the context of assessing social vulnerability and tradeoffs of ecosystem services without much reference to the details and jargon of Q-methodology. The exception to this is our use of the term “Q-sort,” which is used interchangeably with “fun, thought-provoking exercise.”

Understanding social vulnerability and tradeoffs among ecosystem services using this approach requires the completion of eight steps:

1. Describe the national forest planning and management context.
2. Identify, to the greatest extent practicable, all ecosystem services relevant to the planning and management context.
3. Distill the list of ecosystem services established in step 2 to a manageable number of ecosystem services for participants to consider.
4. Decide how to incorporate the drivers-of-change component.
5. Identify a broad range of stakeholders to provide input through completion of: (a) the Q-sort, (b) the drivers-of-change component, and (c) three to five demographic questions.
6. Gather input from participants.
7. Analyze participant input using a statistical approach that distills understanding of a limited number of viewpoints towards ecosystem services and the drivers of change considered influential to provision of such benefits.
8. Communicate results to participants and receive feedback about the validity of the viewpoints identified and summarized.

In the subsections that follow, the objective of each step is described generally, followed by a discussion of how the objective was met within the case-study application of this protocol on the Gila National Forest in New Mexico. In the interest of both being concise and providing a document that clearly demonstrates how this protocol is implemented, we rely on the Gila National Forest application as an example, and do not provide a full explanation of the other two case-study applications. The other two applications are briefly described in step 1 with full references for the interested reader. In addition, there are particular aspects of this protocol where the Gila National Forest application was significantly different from the other two applications (e.g., step 4); therefore, when discussing these aspects of the protocol we will remind the reader of such differences and refer them to the appropriate documents for further information.

Before explaining each step, we think it is worthwhile to address two sentiments that may impede a manager or planner from adopting this protocol. The first is that these eight steps collectively might represent a task that is too arduous to complete within the context of one's already busy work schedule. The second sentiment is that particular steps, such as step 7 (i.e., statistical analysis of the ranking exercise), may not be feasible because of limited statistical ability or expertise. We encourage practitioners considering the incorporation of this science-based protocol into their management or planning process to reject both of these potential concerns.

Regarding the first concern, we believe that many of the following steps do not constitute "extra" work but instead require the application of already existing knowledge. For example, step 2 requires developing a list of ecosystem services that are derived from the national forest (and perhaps surrounding area) of interest. This information that may be present explicitly in planning and management materials, and implicitly in the minds of managers and planners who often spend their careers and personal lives invested in public lands and the communities surrounding them. In other words, completing step 2 is likely to be a more arduous task for "outside researchers" than for those working on-the-ground and within the relevant communities every day.

Regarding the second potential concern, we feel that a thorough reading of this report will assuage some of these potential concerns. The directions provided are detailed and, in addition, we do our best to not burden users of this protocol with some of the methods questions that are subject to theoretical debate. As researchers and scientists, we do not deny the importance of these questions as they are the subject of much work and effort, but we assert that many of these questions have been adequately addressed through the development of this protocol. We feel that planners and managers (or their staff) with some background in statistics and statistical software will find the protocol's analytic step manageable. Furthermore, the authors of this report are happy to answer any questions about analysis and implementation of this protocol.

2.1. Step 1: Consider the National Forest Planning and Management Context

In general, considering the context and intended purpose of any research is critical, but it is particularly important for implementing this protocol. Depending on the problem being addressed, the completion of each step within the protocol may vary. For instance, if the focus of the research is regarding a decision of wilderness designation within a national forest, then the subsequent steps are likely to be completed differently than in the case of a decision about completing a restoration project, or in the case of informing the forest plan revision process.

2.1.1. Three Planning and Management Contexts Where This Protocol has Been Applied

This protocol has been implemented in three different planning and management contexts. Irey (2014) implemented this approach to support wilderness management on the Frank Church – River of No Return Wilderness in Idaho ("wilderness application"). The specific goal of the wilderness application was to help society (both managers and the public) understand the full range of benefits provided by wilderness lands, and the various drivers of change that could potentially influence the provision of those benefits. Even though the Wilderness Act of 1964 does not mandate the management of wilderness for the provision of the full spectrum of ecosystem services relevant to human well-being (Dawson and Hendee 2009), Irey (2014) suggests that such knowledge can inform management decisions that protect quintessential wilderness benefits (e.g., solitude, unconfined recreation), while also building awareness for the suite of ecosystem services provided by wilderness that in general support human well-being, both within and outside of wilderness.

The second application of this protocol was in support of water resource management and planning within the Wind-Bighorn Basin in Wyoming and Montana ("water application") (Armatas 2013). Water resources on the Shoshone National Forest, which occupies a large area of the Wind-Bighorn Basin, were identified as particularly vulnerable during a biophysical assessment of the forest (Rice et al. 2012). This finding highlighted the importance of better understanding how water supports human well-being, as well as the potential drivers of change influencing water-based ecosystem services, both for Forest Service decisionmaking within the administrative boundaries of Federal land, and for fostering relationships with private, local government, and State government partners.

The third application of this protocol (and the primary example used in this document) was within the forest plan revision process on the Gila National Forest ("forest plan revision application"). The revised forest plan on the Gila National Forest "guides resource management on the Gila National Forest within the context of the broader landscape" and "takes an integrated and holistic approach that recognizes the interdependence of ecological, social, cultural and economic systems" (U.S. Department of Agriculture, Forest Service 2017: 1). The forest plan revision application, which is detailed in Armatas et al. (2017a), aimed to support the core planning team in its public engagement activities, and provide valuable information for the actual planning document. Although the forest plan revision process is ongoing, the protocol provided foundational knowledge for the plan component focused on ecosystem services (Matt Schultz, Gila National Forest, Silver City, NM, personal communication, February 28, 2018).

These three applications are similar in their aim to document multiple stakeholder perspectives on the importance of a broad range of ecosystem services, and the drivers of change perceived to influence such ecosystem services. However, specifics related to the procedure and outcomes of the protocol applications are likely to vary.

2.1.2. An In-Progress Application of this Protocol, and Other Potential Applications

The three applications briefly described are those that have been completed up to this point, but a major reason for developing and disseminating this approach is to provide planners and managers with a tool that could be implemented in a variety of contexts. Therefore, it is worth briefly mentioning an ongoing application of this protocol and other potential applications that have been suggested.

Currently, the authors of this report are applying this protocol to the comprehensive river management planning process on the Flathead River System in northwest Montana. Comprehensive river management plans are the guiding documents for the administration of rivers designated as Wild and Scenic under the Wild and Scenic Rivers Act of 1968. During review of this protocol by a national forest planner, additional potential applications of this protocol were suggested, including broad, and relatively infrequent applications such as Recreation Site Analysis (RSA), and perhaps more focused and frequent applications such as community roundtables and collaborative efforts focused on forest health.

2.2. Step 2: Identify, to the Greatest Extent Practicable, all Ecosystem Services Relevant to the Planning and Management Context

The purpose of this step is to identify all ecosystem services that are relevant to the decisionmaking context. For instance, if this protocol is being implemented to inform decisionmaking about a proposal to construct a river impoundment, then identifying all ecosystem services and processes related to the state of the social-ecological system before and after construction is warranted. Relevant ecosystem services would be likely to include water quality and quantity, flood protection, aquatic habitat connectivity, several recreation and leisure benefits (e.g., fishing, boating, wildlife watching, and photography), provisioning ecosystem services such as hydropower and irrigation, and benefits related to cultural, spiritual, and religious heritage.

For this stage, there is no need to agonize over whether or not to include a particular process or service. If it might apply to the decisionmaking context, then make note of it. This initial list of ecosystem services is a starting point which, in subsequent steps, is pared down to a manageable number of ecosystem services for consideration by a diverse range of stakeholders. Therefore, there is no need to worry about overlapping ecosystem services, or those that may not seem all that relevant. Literature review, focus groups, brainstorming sessions, and consultation with experts are potential methods for identifying ecosystem processes and services for this step.

2.2.1. The Initial List of Ecosystem Services: Experience from Past Applications of the Protocol

For all three applications of this protocol, the initial list of ecosystem services was bounded by the general planning and management context. For the wilderness application, the initial list of ecosystem services was informed by a review of wilderness value literature and literature related to ecosystem services, which resulted in a list of 76 ecosystem services provided by the Frank Church – River of No Return Wilderness (Irey 2014). Many of the ecosystem services on this list were clearly associated with wilderness, such as "solitude, privacy and escaping crowds and noise," but because the benefits from wilderness can span large spatial and temporal scales, some extended well beyond the borders of wilderness (e.g., "climate and weather regulation") (Irey 2014: 326–330). Similar to the wilderness application of the protocol, the water application included a literature review of the study area (i.e., the Wind-Bighorn Basin). It was also supplemented with input from experts (e.g., Forest Service employees in the area) and two focus groups with a wide range of participants (Armatas 2013).

Generating the initial list of ecosystem services for the forest plan revision application was done differently from the water and wilderness applications. The initial list was primarily informed by a document developed for the forest plan revision process, which thoroughly documented the social, economic, and ecological resources on the forest (U.S. Department of Agriculture, Forest Service 2017). There were 148 ecosystem services on the initial list for this application (table 1). We provide this first list to highlight its rough nature; some may think, for example, that ecosystem service number 57 ("hiking and backpacking") has much in common with number 59 ("exploration"). While this is true, it is important to reiterate that step 2 is meant to be a free-flowing brainstorming session, as opposed to a deliberate and perfectly consistent writing exercise. Critical assessment of the initial list is the task to be completed in the next step.

Table 1—Initial list of ecosystem services for the forest plan revision application on the Gila National Forest.

The Gila National Forest provides raw materials for subsistence, personal (distinguished from subsistence use as it is not critical to survival), cultural, and recreational use	
1. Raw materials for subsistence use: firewood gathering for primary heat; lumber, posts, poles, and traditional building materials (e.g., latillas and vigas); harvesting house logs for construction needs; food; plant pigments; clothing; stone and minerals for tools; piñon nuts; game animals and fish taken for meat; drinking water	2. Raw materials for cultural use: traditional foods; medicinal herb gathering; botanical remedies and medicines; forest products (juniper, piñon, oak, and ponderosa pine)
3. Raw materials for personal use: decorative rock for personal use; Christmas trees; transplants/wildings	4. Raw materials for recreational use: prospecting and gold panning; mineral collection (e.g., rockhounding); drinking water for forest users
The Gila National Forest also provides raw materials for commercial use, in addition to other opportunities for on- and off-forest economic gains	
5. Landscaping and industrial materials such as sand and gravel	6. Energy and mineral production: the hardrock minerals mined and processed for metals (e.g., gold, silver, copper, zinc, tin, and some types of nonmetallic minerals)
7. Employment opportunities	8. Leasing of nonrenewable energy resources, including fossil fuels, such as oil, gas, and geothermal energy sources
9. Medicines such as penicillin and other antibiotics	10. Provision of renewable energy resources such as solar, wind, hydropower, biomass, and geothermal
11. Timber production and fiber for paper	12. Widespread salvage logging
13. Increased property values of nearby private land	14. Tourism industry related to the life of a cowboy by driving cattle, building fence, or branding
15. Outfitting and guiding for fishing	16. Adventure races and similar events such as boot camps, mud events, and endurance races
17. Outfitting and guiding for hunting	18. Wood pellet or chip production or creating material for biogenerator use
19. Outfitting and guiding for ecotourism, rafting, and backcountry skiing	20. Off-forest drinking water and water for household use
21. Economic growth from tourism from people outside of the community visiting the Gila National Forest	22. Permitted livestock grazing
23. Agricultural community (ranching culture/tradition in New Mexico)	24. Watering of livestock and access to perennial and intermittent streams
25. Preservation of species that may have future medicinal use	26. Off-forest commercial irrigation/ personal irrigation

(continued on next page)

Table 1 (continued)—Initial list of ecosystem services for the forest plan revision application on the Gila National Forest.

The Gila National Forest provides recreational benefits, leisure, and personal enrichment opportunities	
27. Hunting	28. Mountain-biking
29. Mental therapy	30. Exploring caves/spelunking
31. Getting closer to God	32. Geocaching
33. Inspiration, creativity, free-thinking	34. Climbing
35. Fitness, and mentally and physically challenging recreation	36. Camping in the backcountry
37. Sport fishing in general (both rivers and lakes)	38. Car camping
39. River rafting	40. Horseback riding
41. Backcountry skiing	42. Off-highway vehicle use
43. Sport fishing for the Gila trout specifically	44. Wildlife watching and photography
45. Motorized recreation	46. Sightseeing
47. Natural beauty/scenery/aesthetics	48. Night sky viewing
49. Being away from civilization (escape daily routines and obligations)	50. Driving for pleasure
51. Solitude and quiet	52. Recreational aviation
53. Spiritual connections (both for traditional and nontraditional users)	54. Enjoying wilderness values
55. Feeling of appreciation	56. Backcountry stock packing
57. Hiking and backpacking	58. Dog walking
59. Exploration	
The Gila National Forest provides natural benefits, regulating benefits, and supporting benefits that partially prevent the need for built infrastructure or human intervention to facilitate certain benefits	
60. Flood mitigation	61. Unique ecosystems and habitats
62. Erosion control and sediment retention	63. Forage for wild ungulates and domestic livestock
64. Landslide mitigation	65. In-stream flow (not a beneficial use under New Mexico law)
66. Biological control of crop pests and bioremediation of contaminants	67. Soil formation
68. Regulation of greenhouse gases	69. Nutrient cycling
70. Prevention of threatened, endangered, and otherwise at-risk species reaching extinction	71. Photosynthesis
72. Gradual discharge of stored water	73. Water cycling, purification, and filtration
74. Refuge for wildlife	75. Climate regulation
76. Wildlife habitat and connectivity	77. Evapotranspiration
78. Terrestrial biodiversity	79. Carbon sequestration
80. Aquatic biodiversity	81. Activities of soil micro-organisms
82. Riparian biodiversity	83. Primary production
84. Habitat for wildlife	85. The production of forage
86. System resilience	87. Eutrophication

(continued on next page)

Table 1 (continued)—Initial list of ecosystem services for the forest plan revision application on the Gila National Forest.

The Gila National Forest provides natural benefits, regulating benefits, and supporting benefits that partially prevent the need for built infrastructure or human intervention to facilitate certain benefits (continued)	
88. Clean water	89. Stream temperatures regulation
90. Instream flow	91. Energy flow
92. Clean air	93. Thermoregulation (shading and evaporative cooling)
94. Soil micro-organisms	95. Seed dispersal and pollination
96. Habitat for soil micro- and macro-organisms	97. Production of micro-climates
98. Healthy soil	99. Water retention & storage
100. Wetlands	101. Soil stabilization
102. Bird species abundance	103. Groundwater recharge
104. Bird breeding habitat	105. Maintenance of soil permeability
106. Fish abundance	107. Filtering of air
108. Fire as a natural, ecological process	109. Storage and recycling of organic & inorganic waste
110. Old-growth forest	111. Maintenance of genetic diversity
112. Bird-watching locations	113. Maintenance of biological diversity
114. Caves for wildlife habitat, most notably for bat populations	115. Natural-appearing landscape
116. Night sky	
The Gila National Forest provides cultural benefits	
117. Family/social bonding through outdoor activities	118. Sacredness
119. Connecting with ancestors	120. Not mediated or controlled by human intervention (wildness, untrammeled)
121. Development of national character	122. Understanding the meaning, history, and relevance of all public lands
123. A symbol of freedom and pride	124. Reputation as national hunting destination for trophy animals, especially elk
125. Demonstration and defense of democratic ideals	126. Sustaining and supporting Native American culture
127. Building social capital and cohesion	128. Sustaining and supporting Hispanic culture
129. Salvation of freedom	130. Sustaining and supporting Anglo and Euro-American culture
131. Place for pilgrimage	132. Employment opportunities
133. Benefits to human spirit, spiritual renewal	134. Connecting youth with cultural traditions
135. Relief and escape from society and commercialization	136. Connecting youth with nature, more generally
137. Sense of place, belonging	138. Self-discovery, introspection
139. Kinship with animal kingdom	140. Physical and mental challenge
141. Unknown benefits, a reservation to maintain future options	142. Bequest to future generations

(continued on next page)

Table 1 (continued)—Initial list of ecosystem services for the forest plan revision application on the Gila National Forest.

The Gila National Forest provides scientific and historical benefits	
143. Education	144. Archaeological resources for science
145. Research	146. Archaeological resources for tourism
147. Example of healthy functioning ecosystems	148. Historic/prehistoric experience

2.3. Step 3: Distill the Initial List of Ecosystem Services Into a List to be Rank Ordered by Participants

This step prescribes the paring down of the long list of ecosystem services developed in the previous step into a manageable number of ecosystem services to be prioritized by stakeholders. It is appropriate for this smaller list of ecosystem services (henceforth "ranking list") to be within the range of 25 to 50. This is likely to be an adequate number to ensure a broad representation of the benefits relevant to the decisionmaking context, while being small enough to not overwhelm the respondent with too many ecosystem services to sort. In any public engagement process, it is important to not confuse or tire out the participant. The benefits should be stated in clear and plain language, and if definitions are necessary, then those should also be as simplistic as possible. Regarding the wording of ecosystem services, an explanation ranging from a single word (e.g., hydropower) to a simple phrase (e.g., increased property values of nearby private land) should suffice.

The ranking list should be both broadly representative of the benefits relevant to the decisionmaking context and balanced. By "balanced," we mean that there should not be too many ecosystem services related to a particular aspect of the research question. In other words, there should be an even distribution across types of benefits. In the context of forest planning, for example, an unbalanced list might include many ecosystem services related to recreation and the importance of the forest resources for cultural identity, but only a few related to the importance of extracting forest products. Including similar numbers of ecosystem services within each category (e.g., supporting, provisioning, cultural, and regulating if using the categorization developed by Millennium Ecosystem Assessment (2003)) will facilitate the balancing of the ranking list. It is also important, however, to ensure a balance of ecosystem services within each of these categories. For example, including similar numbers of recreation-related benefits and information-related benefits (e.g., research, education, interpretation) within the cultural ecosystem services category is advisable. A balanced ranking list will both help to ensure that the benefits are broadly representative within the decisionmaking context, and provide an analysis that will not be biased toward a particular suite of ecosystem services. Creating a balanced ranking is, inherently, about "lumping and splitting" ecosystem services, where categories and subcategories of ecosystem services are combined or separated. For instance, should the ranking list have a single ecosystem service for "recreation," or separate ecosystem services for hiking, camping, kayaking, rafting, and snowmobiling?

Although there is no definitive or "correct" solution in this process, we recommend consideration of two criteria when narrowing the initial list into the ranking list through merging, splitting, and dropping ecosystem services: (1) the conflict criterion and (2) the management criterion. "Conflict criterion" refers to those situations where an ecosystem service may be defined in a way that can cause internal conflict for the respondent. For example, phrasing an ecosystem service as simply "hunting" as opposed to "hunting for elk and mountain lion" may be advisable, as the latter ecosystem services may cause internal conflict if the respondent enjoys hunting for elk, but not mountain lion. Within the context of survey research methodology, this criterion highlights the need to avoid "double-barreled" questions (Babbie 2010).

Regarding the second criterion, merging two seemingly similar ecosystem services may not be advisable if management and planning for those benefits is significantly different. For example, merging ecosystem services related to all renewable energy resources may be difficult if the forest provides opportunities for a broad range of renewable energy development such as wind, solar, and woody biomass energy. Providing opportunities for solar and wind power requires different management approaches than woody biomass energy. As a result, these ecosystem services could be separated in the final ranking list *if* understanding perceptions about their importance is relevant within the planning and management context. Different management contexts can have a significant impact on the ecosystem services chosen. For instance, if the context is timber management where optimizing harvest cycles is the focus, then timber production (i.e., the provision of commercially viable trees) is a clear ecosystem service. In a context such as the wildland-urban interface (WUI), fuels reduction might prevent areas in the suitable timber base from ever producing such trees; thus, timber production could not be included as a relevant ecosystem service.

If possible, the ranking list should be reviewed and pilot tested. It is important that the ranking list is reviewed by at least a few people who are knowledgeable about the area of interest (as local knowledge can suggest whether a technical detail of an ecosystem service is correct—such as examples of recreation that are particularly relevant to the area). Pilot testing the ranking list consists of asking several people to complete the Q-sort. Pilot testing does not necessarily need to be completed by somebody who is knowledgeable about the importance of the place. It is actually worthwhile to have people who are not necessarily thinking about these ecosystem services, or natural resources in general, complete the exercise. These pilot testers may provide insight into particular ecosystem services that do not make sense as they are initially defined, or they may suggest aspects of nature that improve their well-being that were not yet considered.

2.3.1. From the “Everything” List to the “Ranking” List: Experiences and Examples from Past Applications of the Protocol

In the case of the forest plan revision application, the list shown in table 1 was distilled into the final ranking list shown in table 2. Although the target number of ecosystem services for the ranking list is, as previously

Table 2—Ranking list of ecosystem services for forest plan revision application on the Gila National Forest (Source: Armatas et al. 2017a).

Provisioning services (extractive resources and uses)
1. Forest materials for personal use (e.g., firewood, Christmas trees, gems, food, traditional and medicinal plants)
2. Timber production
3. Oil and natural gas and minerals (e.g., gold, copper, gravel)
4. Woody biomass for energy (e.g., wood pellets, chip production)
5. Livestock grazing
6. Water for household and municipal use
7. Irrigation for agriculture
Cultural services (recreation, historical, scientific, community and cultural, and personal-enrichment benefits)
Recreation and leisure-related cultural benefits
8. Outfitting and guiding (e.g., hunting and fishing)
9. Hunting and fishing (non-outfitted)
10. Nonmotorized recreation (e.g., hiking, biking, horses, floating, bird watching)
11. Motorized recreation (e.g., off-highway vehicles, dirt bikes)
12. Driving for pleasure
13. Developed camping (areas with toilets, tent sites, and water)
14. Dispersed camping (areas without any services)
Other cultural benefits
15. Solitude, quiet, and a clear night sky
16. Native American cultural benefits (e.g., ceremonial sites and materials)
17. Traditional agricultural lifestyle (e.g., connection to ranching, and use of irrigation ditches [acequias])
18. Education and interpretation of the area and ecosystems
19. Research and science (e.g., ecology, forestry, and archaeology)
20. Places where human influence is substantially unnoticeable
21. Cultural and archaeological sites
22. Public ownership and access to public land
23. Scenic beauty, aesthetics, and inspiration
Regulating services (environmental benefits)
24. Flood and erosion control
25. Carbon absorption
26. Biodiversity and abundance of plants and animals (including threatened and endangered species)
27. Wildlife habitat and connectivity
28. Water quality
29. Air quality
30. Water quantity (water in rivers and streams)

mentioned, between 25 and 50, the participants for the forest plan revision application were restricted to 30 minutes (as this particular application of the protocol was implemented within public meetings). Therefore, the goal was to have between 25 and 30 ecosystem services that represented the broad range of ecosystem services important to people within the forest planning context.

This ranking list was finalized with input from the Forest Planning team on the Gila National Forest, as well as pilot testing by a variety of people in an academic setting (where the report authors are located). The final ranking list for the wilderness application and the water application both employed pilot testing, and reviews from people familiar with the relevant areas. The final ranking list for the water application is available in Armatas (2013: 201–203), and the ranking list for the wilderness application is available in Irey (2014: 169–172).

2.4. Step 4: Decide How to Incorporate the Drivers-of-Change Component

This step of the protocol requires a consideration of the drivers of change that may influence the provision of ecosystem services included in the ranking list. This step is perhaps the most flexible, and the exact approach is likely to be determined by both the forest planning and management context established in step 1 and the practical aspect of stakeholder engagement. For example, the planning and management context may lead to an implementation of this protocol that focuses on a single driver of change. As a result, this could change the nature of the protocol from asking participants which drivers of change they perceive as influencing their most important ecosystem services to asking participants to describe how a particular change may influence their most important ecosystem services. For instance, consider a scenario where a bill such as that introduced by Senator Mike Lee of Utah becomes law, thus providing discretion to local wilderness managers to decide whether, and where, nonmotorized biking will be allowed in wilderness (O'Donoghue 2018). Within this relatively specific management and planning context, wilderness managers may identify a broad range of ecosystem services relevant to wilderness, and then ask stakeholders how bicycles, and the associated management actions (e.g., additional signage, trail barriers, and visitor instructions), potentially influence the wilderness ecosystem services contributing to their well-being.

If, on the other hand, the decisionmaking context is more encompassing, such as in the case of all three previous applications of this protocol, implementation may require consideration of several different drivers of change.

2.4.1. Demonstrating the Flexibility of the Protocol with Regard to the Drivers-of-Change Component: Different Ways to Engage Stakeholders

The ways in which the protocol can be implemented to understand stakeholders' perceptions of drivers of change related to their most important ecosystem services may depend on practical constraints related to stakeholder engagement. For instance, the forest plan revision application of the protocol was implemented in "world café"-style facilitated meetings, where members of the public attended open meetings about the forest plan revision process and participated in three separate "stations." One of the stations implemented this protocol; however, each station lasted only 30 minutes, and up to 25 people were at each station. To adjust to these practical needs, several drivers of change (table 3) were preselected for presentation to participants. This list was developed much like the ecosystem services list in the forest plan application. The initial list of drivers of change was developed through review of the site-specific forest planning document on the Gila National Forest (i.e., U.S. Department of Agriculture, Forest Service 2017), and this list was then reduced to a "drivers list" through consultation with the Forest Planning team.

Full details of how the drivers-of-change component is implemented with regard to stakeholder engagement is provided later in step 6, but it is worth mentioning that this part of the protocol is implemented after participants have completed the Q-sort. For the forest plan revision, participants were asked to select the three drivers of change from table 3 (each of which was presented on a separate card) that are most influential to their relationship with the forest.

Table 3—Drivers of change that participants considered following prioritization of ecosystem services (Source: Armatas et al. 2017a).

Driver
1. Invasive species
2. Uncharacteristic fire
3. Woody encroachment of grasslands
4. Declining Forest Service budgets
5. Extended drought
6. Extreme weather
7. Streamflow alterations
8. Roads and trails (conditions, access, amount)
9. Land use restrictions
10. Lack of land use restrictions
11. Predators, including wolves
12. Unmanaged grazing (wildlife or livestock)

The drivers-of-change step for the wilderness and water applications was different from the forest plan revision application. In these instances, drivers were not preselected, but instead identified during follow-up discussions with participants. In both cases, this discussion was a free-flowing conversation without prompting. After the ecosystem services prioritization (described in step 6), people simply stated anything that came to mind with regard to factors or influences (i.e., drivers of change) related to the provision of their most important ecosystem services. This approach was practical within the context of both applications, as Armatas (2013) and Irey (2014) mostly engaged stakeholders in one-on-one situations. Time constraints were not typically an issue, and the nature of the interaction allowed for an exploratory conversation.

2.5. Step 5: Identify a Broad Range of Stakeholders to Provide Input

The fundamental goal of this protocol is to *understand* how a broad range of *people* are supported by a diversity of ecosystem services, and how such ecosystem services are *perceived* to be influenced by various drivers of change. Achieving this goal requires input from a variety of participants who are asked to complete: (1) the Q-sort, (2) the drivers-of-change component, and (3) three to five demographic questions.

The group of participants should be diverse in their opinions about the topic of interest. In other words, the goal is to develop a group of people which, to the greatest extent practicable, represents the spectrum of opinions about the importance of ecosystem services. There are no strict guidelines for how many people are needed to complete the protocol in order to ensure that the full range of opinions is gathered, but practitioners of the scientific approach underlying this protocol (i.e., Q-methodology) suggest 40 to 60 people as a rule of thumb (Stainton-Rogers 1995). This rule of thumb should not be followed too rigidly, as studies applying this method have gathered input from far fewer than 40 people, and all 3 applications of the protocol gathered input from more than 60 people. It is important to stress that this protocol is meant to explore and discuss the broad range of opinions about important ecosystem services and relevant drivers. It does *not* yield estimates of how these opinions are distributed across a population—an estimate that would require a random sample of several hundred participants. As Eden et al. (2005: 417) suggest, participants are chosen for “comprehensiveness and diversity, rather than representativeness or quantity.”

How can one implementing the protocol increase the possibility that a group of people is representative of the diversity of opinions about the topic of interest? Depending on the practical constraints of the stakeholder engagement process, we recommend a combination of dimensional sampling (Arnold 1970) and the snowball sampling method, also called the chain-referral method. Dimensional sampling provides a framework “for drawing a purposive sample representative of the universe to which one wishes to generalize” (Arnold 1970: 147). To implement dimensional sampling, there is a need to identify the "dimensions" that suggest a difference in opinion, as well as the different "types" in each dimension. For example, if the topic of interest is understanding varying opinions about important characteristics for consideration when purchasing a new home, we might sample across three dimensions, with types in parentheses: (1) income (Under $50,000 per year, $50,000–$100,000 per year, over $100,000 per year); (2) age (20–35 years old, 35–50 years old, 50–65 years old, 65+ years old); and (3) home-buying experience (first-time buyer, not first-time buyer). This framework yields 24 combinations, or the product of the number of types in each dimension: (3 types for income) × (4 types for age) × (2 types for home-buying experience) = 24 combinations. The goal of dimensional sampling would be to gather input from at least one person from each combination. In addition, the chain-referral method of sampling can be used, which consists of asking respondents to refer other people who may have an opinion different from their own to participate in the protocol.

To understand whether a diverse range of opinions are being gathered, it is worthwhile to ask participants to answer a few demographic questions. The dimensions identified for the sampling plan can provide a guide for developing demographic questions. Similar to the previous step focused on incorporating the drivers-of-change component, this step may also be partly determined by the circumstances of public engagement. In other words, identifying a broad range of participants (and subsequent recruitment) may not be necessary if the protocol is being integrated into an established public engagement process. For instance, for the forest plan revision application of the protocol, there was no need to develop a sampling plan before implementing the Q-sort as the protocol was incorporated into the public engagement process (see Armatas (2013) and Irey (2014) for different examples of sampling approaches). That is, we administered the protocol to all who attended the public meetings, which took place in five different locations over the course of a week. It was assumed that people with a broad range of opinions would attend the meetings and, in total, 122 people completed the Q-sort.

To assist the Forest Planning team in determining whether the group of people attending the public meetings were relatively diverse demographically, we asked the following questions to all who participated:

1. What is your age?
2. In which county do you reside?
   (If you live in this area seasonally, list the local county.)
3. How would you describe yourself (ethnicity, race)?
4. For how many *years* has the Gila National Forest been important to you (for any reason)?

The demographic "dimensions" for the forest plan revision application are reflected in these questions.

2.6. Step 6: Gathering Public Input

Gathering public input for this protocol is a process with three distinct components: (1) the fun, thought-provoking activity (Q-sort); (2) the drivers-of-change component; and (3) three to five demographic questions.

The first task is to have participants prioritize the ecosystem services established in step 3. In this process participants must be provided with both physical materials and instructions for the Q-sort. The necessary physical materials are a ranking board (fig. 2A) and a deck of cards (one card for each ecosystem service established in step 3). The ranking board guides the participant by clearly showing how many ecosystem services are to be placed in each column, and it should roughly represent a “normal” distribution, or bell-shaped curve. In practice, the number of ecosystem services being ranked may prevent a perfectly normal distribution. While the ranking board in figure 2A could have been constructed in a more bell-shaped way (by moving boxes from the outside of the ranking board toward the middle), we opted against this to allow participants to position additional ecosystem services on the edges of the ranking board. This approach provides more opportunity for respondents to express strong feelings (both positive and negative) about the importance of ecosystem services, which we think is appropriate within the context of management and planning of natural resources. Typically, those interested in natural resource stewardship are passionate about the process, and the ranking board in figure 2A maintains the opportunities to express such passion.

The number of ecosystem services being ranked may expand the scale. For example, if 40 ecosystem services are being ranked, the ranking board may span from –5 to +5. The numeric scale indicates salience with the right side of the board indicating positive salience, the left side of the board indicating negative salience, and the middle of the board indicating neutrality. Finally, including a brief set of instructions on the ranking board is advisable.

Ideally, the ranking board is constructed from poster board (fig. 2B), as it provides a clear structure for the participant to follow. The cards should show the ecosystem services in easily read font, be constructed of thick paper (i.e., cardstock), and be large enough for easy handling. Last, the physical space for completing the Q-sort should be spacious. If multiple people are completing the Q-sorts at the same time, our experience suggests a maximum of six people to a standard 8-foot table (three people on each side).

Regarding the instructions for the Q-sort, it is important to provide both a basic description of the task, and specific guidance on how to prioritize the ecosystem services. The following “script” provides the basic points that should be covered when introducing the Q-sort:

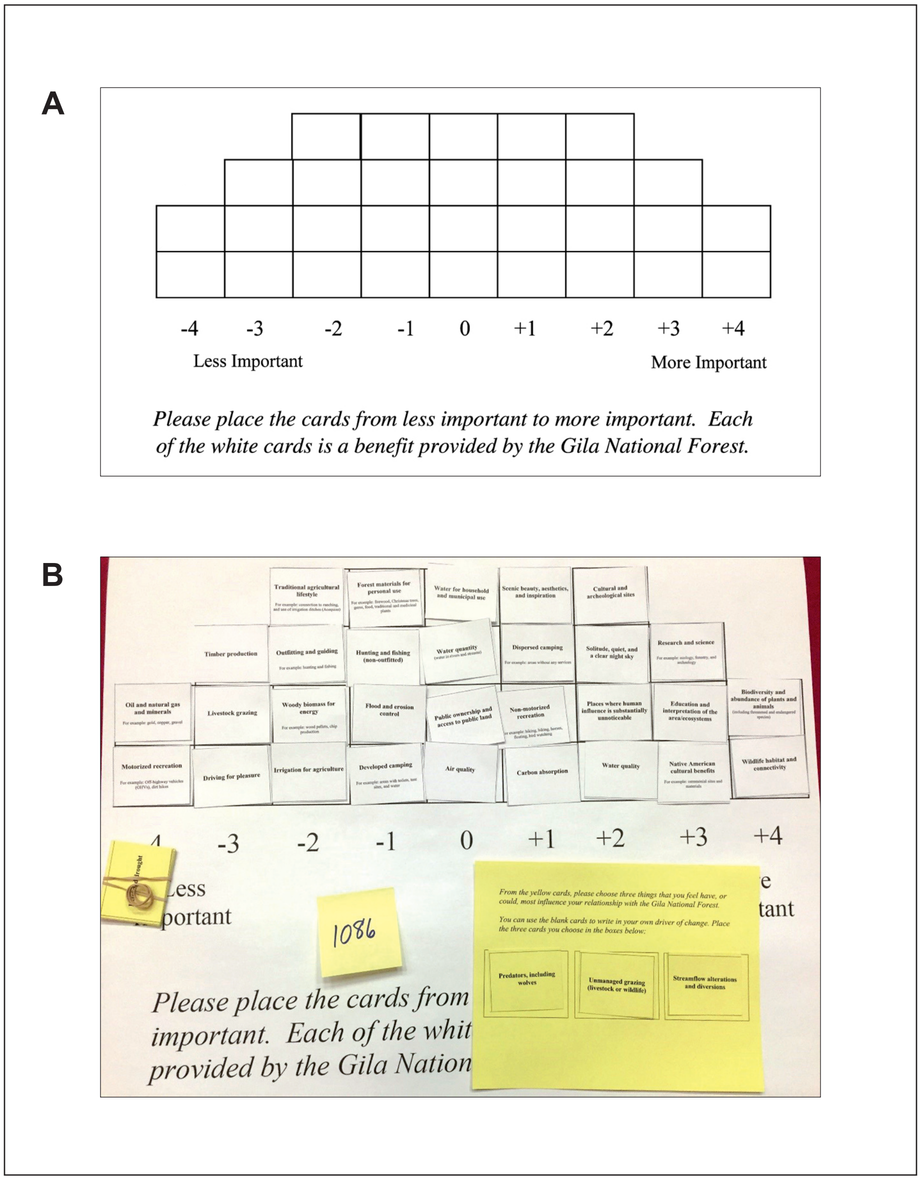


Figure 2—(A) Ranking board for forest plan revision application of the protocol; (B) completed Q-sort (photos: C. Armatas, USDA Forest Service).

> *Our objective is to understand which benefits provided by the [insert specific place—e.g., national forest, watershed] are most important to you. The ranking is your opinion—there are no right or wrong answers. Please arrange the benefits listed on the cards from "more important" on the right to "less important" on the left, from your perspective. This is certainly a difficult task as it requires that you think about tradeoffs among benefits that are important to a wide range of people. It is helpful to start by sorting the benefits into three piles. The first pile is a definitely important pile, or those that you might view positively, which will occupy the right side of the board.*

The second pile is an unimportant pile, or those you might feel strongly about in a negative way, which will occupy the left side of the board. Last, create a pile of benefits that you do not feel strongly about one way or another, which will occupy the more neutral middle part of the board. Once you have done that, continue arranging the benefits using the board as your guide. The rows are not different from one another, only the columns. So, you will need to choose your two most important benefits, then your next three more important benefits, and so on all the way over to the left side of the board.

After instructions are provided, and while the participant is completing the Q-sort, remain nearby to answer any questions that the participant may have. In our experience, 15 to 20 minutes is the average time for completing the Q-sort (some will take longer). Once the participant completes the Q-sort, record his or her input by taking a photograph of the Q-sort, giving each sort an identifying number.

Following the Q-sort, the drivers-of-change component can commence. In the case of the forest plan revision application of this protocol, where up to 25 people were providing input at a single time, the drivers-of-change component was structured. Each participant was provided with the preselected drivers (listed in table 3), each of which was printed on yellow cardstock. The following directions were given to participants regarding the drivers-of-change component for the forest plan revision application of the protocol:

We would like you to read through the yellow cards and think about how those factors may change your relationship with the forest. Just in case you would like to refer to it, the yellow piece of paper states the question that you should be thinking about as you read through the yellow cards. There are twelve factors that we preselected, but we have provided some blank cards for you to write in a different driver of change if you would like. Now, choose the three things that you think have in the past, or will in the future change your relationship with the Gila. The three choices you make can be from our preselected drivers of change, or from those you have written in. You do not need to put these three cards in any particular order, just choose the three things that you feel are the most influential, or most relevant to influencing your relationship with the Forest.

An example of a completed drivers-of-change component is shown in figure 2B. This exercise of choosing three drivers of change that were perceived to be most influential to the person's relationship with the Gila National Forest (as represented by the Q-sort) typically took around 5 minutes.

The final aspect of the public engagement process is to collect a limited amount of demographic information to ensure that a broad range of people are providing input. It is important to stress to participants that the demographic information is used only to provide this understanding, and not to connect their Q-sorts to them in any way. To reinforce this point with our actions, we deliberately separated the demographic pages from the Q-sorts. Emphasizing this point is meant to reassure participants who may be concerned that their Q-sorts will be connected to them. The questions asked to participants in this component of the public engagement process may vary depending on the forest planning or management context. In the forest plan revision application, the four questions listed in section 2.5 were asked. Similar questions were asked in the wilderness and water applications of the protocol, though in both applications several additional questions were asked. In our experience, there is limited benefit from asking additional demographic questions, which is why we recommend asking only three to five questions to determine whether a broad range of people are completing the exercise.

Before discussing how all of this public input can be analyzed, it is important to briefly discuss the management of public input. That is, how can this collected information be compiled in a way that is organized and ready for analysis? It is important to ensure that the input provided by each person is uniquely identified with a number (i.e., the Q-sort, drivers-of-change component, and demographic information are all labeled with the same number). Each person's Q-sort and drivers-of-change activity were photographed with a unique number, which also corresponded to the number attached to the demographic questions that were completed (fig. 2B). Although analysis will not focus on connecting demographic information with the associated Q-sort, keeping all the materials together will ensure that all of the public input is accounted for. In addition, the drivers-of-change component *will* be associated with the Q-sort, which reinforces the importance of keeping everything organized.

2.7. Step 7: Analyze Stakeholder Input

Analyzing the public input gathered in step 6 can be described in four separate phases: (1) organization, (2) analysis, (3) presentation, and (4) interpretation.

2.7.1. Organization of Public Input

"Organization" refers to preparing the public input for statistical analysis. First, the Q-sorts should be coded in preparation for entry into the chosen statistical software program. This requires assigning a number to each ecosystem service, and then entering those numbers on a ranking board for each person's Q-sort. If the drivers-of-change component is structured similarly to the forest plan revision application of the protocol, then the drivers of change can be coded (i.e., a number assigned to each driver of change) similarly to the coding of ecosystem services. The analyst can complete this task on her or his own after the public engagement. Each Q-sort and drivers-of-change selection would be re-created based on the photo documentation of the original, and then the numbers for each ecosystem service would be recorded on the ranking board; the drivers of change are recorded on the same piece of paper, which is uniquely numbered (fig. 3).

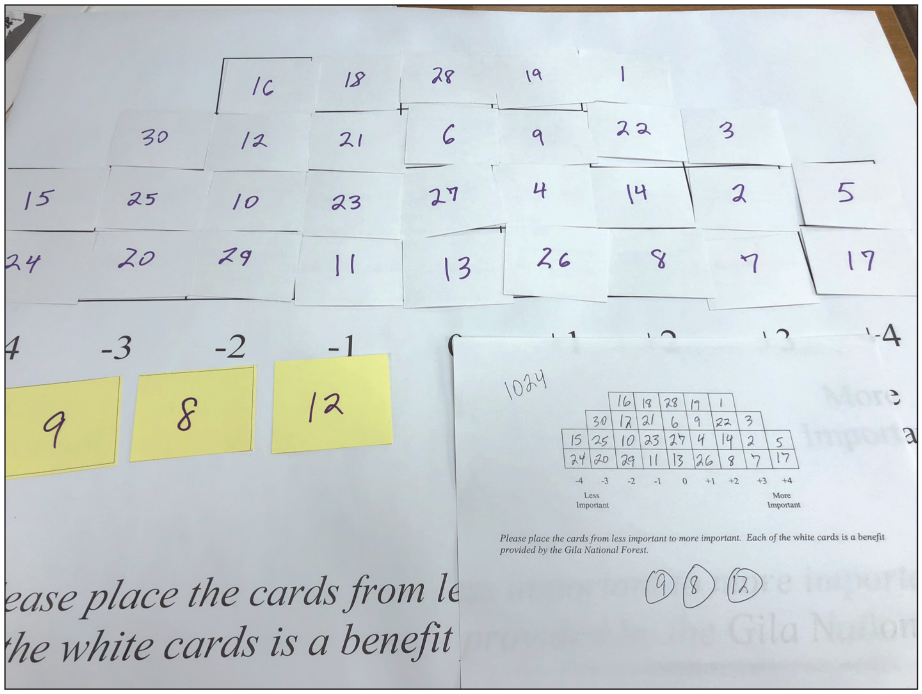


Figure 3—Process used for preparing Q-sort and drivers-of-change input for entry into statistical program.

This completes the preparation of the ecosystem service and drivers-of-change input. Last, demographic data can also be coded.

A brief discussion about the concept of coding may be worthwhile. If the variable of interest is numeric (e.g., open-ended question on age), then simply entering the age into a spreadsheet is best. If, on the other hand, the variable of interest is categorical (e.g., sex), then it may be helpful to code the answers with different numbers (e.g., male = 1, female = 2, and other = 3).

2.7.2. Analysis of Public Input

We use the term "analysis" loosely in this context, because particular components such as the demographic information are summarized only to understand the breadth of people providing input, and not analyzed using a formal statistical approach beyond computing means, medians, and ranges of the participants' demographics (e.g., average age of respondents).

The Q-sorts, however, are formally analyzed using factor analysis which, in this context, finds similarity between Q-sorts. We do not provide full details of how this analysis works so as not to burden the reader with too many technical details, but the basic factor analytic approach begins with a correlation between Q-sorts (which creates a correlation matrix). Factor analysis of this matrix then aims to find the best linear combinations of Q-sorts for explaining the variability in the data. For additional details, see Brown (1980) and Armatas (2013). By using this approach, a large number of Q-sorts (122 in the forest plan revision application of the protocol) are distilled into a limited number of typified Q-sorts or archetypes (four archetypes in the forest plan revision application) that represent the broad range of opinions about the importance of ecosystem services. These archetypes provide managers and planners with a nuanced understanding of the public's perspectives on which ecosystem services are important (fig. 4). Later, we will provide guidance on how these archetypes can be interpreted and may be useful for managers and planners, but we present an example now to illustrate the final product yielded from factor analysis. We now proceed with a step-by-step explanation of the analysis process from beginning (i.e., Q-sorts ready for entry into a statistical program) to end (i.e., archetypes similar to that illustrated in figure 4).

With Q-sorts ready for entry into a statistical program, there is a need to select a particular program for data analysis. Several programs or statistical packages are specifically designed to analyze Q-sorts (e.g., *PQMethod*, *PCQ*, *qmethod* package in *R*), and we recommend such a program. For this report, we present the process for data analysis using *PQMethod* developed by (Schmolck 2014), which is a free-software package that is user-friendly and easily available for download. PQMethod is a basic program that runs in DOS, which may feel antiquated and requires some adjustment as the program requires text commands without the use of a mouse. However, despite being reminiscent of a bygone era, the program is easily navigated and does not require writing any code. Just to reiterate, more contemporary software packages exist, such as the *qmethod* package in *R* (R Core Team 2018), and we encourage analysts to choose the package that they are most comfortable with; we provide our tutorial within the context of PQMethod.

The first prompt upon starting PQMethod requests the analyst to choose and enter a project name. What follows is the main menu (i.e., "home screen"), where nine options are provided to the analyst (fig. 5). For this protocol, we will describe operations 1, 2, 4, 6, 7, and 8, because analysis

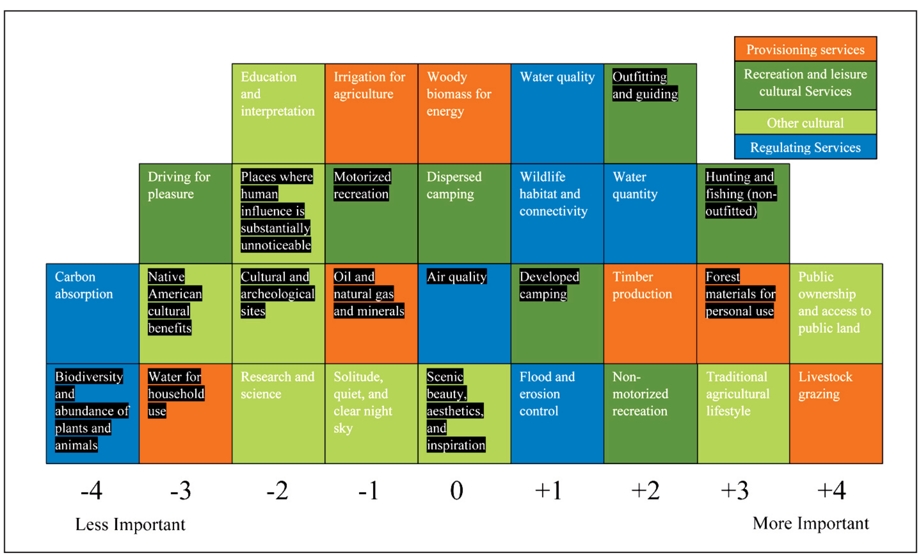


Figure 4—Representation of one of the four archetypes from the forest plan revision application of the protocol, labeled the "utilitarian" archetype.

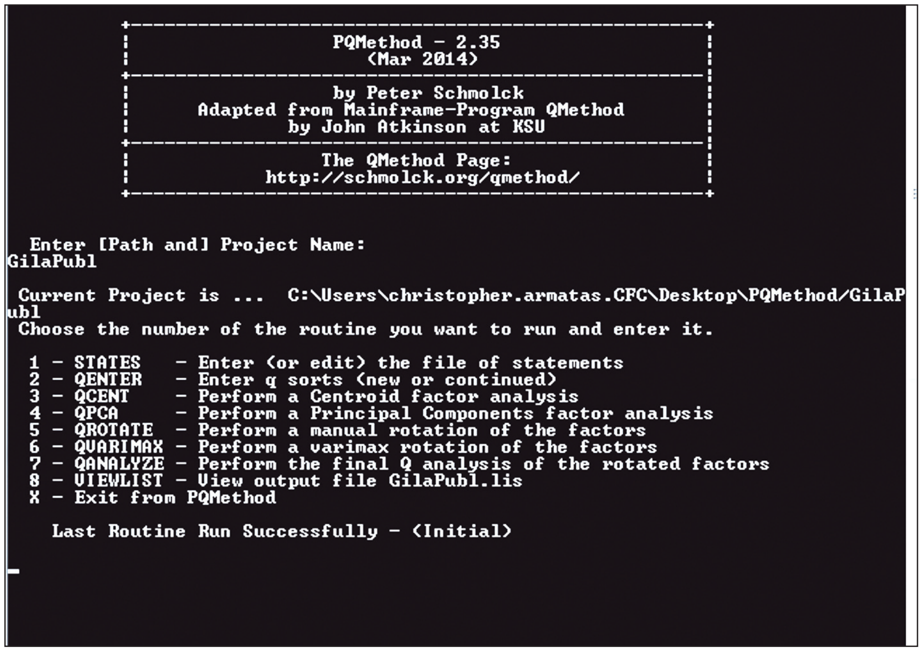


Figure 5—Main menu of PQMethod.

requires choosing either "centroid" factor analysis or principal components analysis (PCA), and we recommend PCA. Analysts may find PCA to be the most comfortable option, as it is a popular choice, perhaps because it seeks a single unique solution. In practice, factor analysis and PCA have been shown to yield very similar results. A similar analytic choice is between varimax rotation and manual rotation and, for the sake of simplicity, we recommend varimax rotation, which is a common and statistically rigorous approach to factor rotation.

The first step of analyzing the Q-sorts in *PQMethod* is to enter the "statements," which in the context of this protocol are the ecosystem services. The program guides the analyst through this process, but there is a character limit for each ecosystem service, which may require the analyst to create a truncated title. The second step requires that each Q-sort be entered into the program. This process is simple, and the program has a built-in quality control, which does not allow the analyst to incorrectly enter a Q-sort. For example, if an entered Q-sort is missing an ecosystem service, has a duplicate ecosystem service (same number entered twice), or has too many (or too few) ecosystem services in a column, then the program will prompt the analyst and immediately offer a solution.

Step 3 is the initial analysis, and, as mentioned, we suggest use of PCA. Therefore, once steps 1 and 2 are completed in PQMethod, the analyst chooses number 4 from the main screen. There is nothing more to do related to this step, as the program performs analysis and immediately provides the eigenvalues (a number reflecting the variance explained by each factor). The more substantive analytic step, both in terms of required decisions and interacting with the computer program, is the rotation of the factors.

We recommend rotating factors using “varimax” rotation, which is performed using the sixth operation on the PQMethod screen. Factor rotation has the largest implication for the final solution, and the subsequent interpretation of the archetypes. We do not detail the theoretical reasons for rotating factors, but we emphasize that factor rotation is standard in factor analysis. It offers a shift in perspective by changing the arrangement of factor loadings, but it does not change the data or alter the variance explained by the factors in any way (Brown 1980). Factor rotation facilitates identifying and interpreting factors and, for this protocol, the analyst needs to decide how many factors to rotate. That is, how many archetypes will represent all the Q-sorts? If a four-factor solution is chosen, then the analyst will present four archetypes. If a three-factor solution is chosen, then three archetypes are presented. There is no commonly used rule for deciding how many factors to retain and rotate for interpretation.

Consistent with the literature, we suggest that the analyst try several different rotations, specifically three, for the protocol. To decide which three rotated-factor solutions to consider, we recommend application of the common statistical criteria known as the “scree test.” To perform a scree test, the analyst simply enters the first 10 eigenvalues produced following completion of operation 4 (i.e., PCA) into a Microsoft® Excel spreadsheet to create a plot (fig. 6).

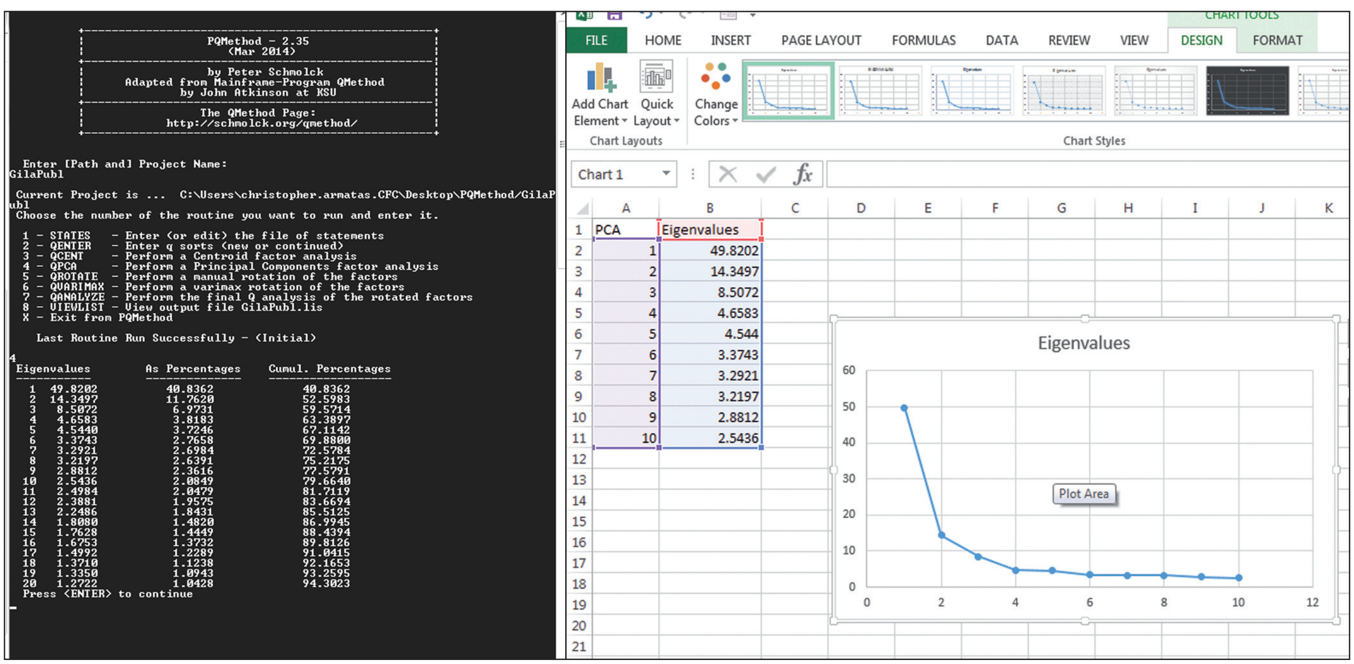


Figure 6—Developing a scree plot: screenshots from PQMethod and a Microsoft® Excel spreadsheet. The plot at bottom right is the scree plot. *Note:* In factor analysis, it is common for those factors with an eigenvalue greater than one to be retained, but when there are a large number of Q-sorts (variables) the size of the eigenvalues can all be greater than one. Thus, the common “eigenvalue” test in factor analysis is not particularly relevant when there are a large number of Q-sorts.

To decide how many factors to rotate, the analyst can search for where the slope of the line starts to level off (commonly called the elbow). One could argue that this happens at both the second and fourth factors, but we suggest that four factors is the point in the scree plot where the slope is more obviously leveling off. Therefore, we recommend rotating four factors to start, but also recommend inspection of two more factor solutions: a five-factor solution (one above the leveling-off point in the scree plot) and a three-factor solution (one below the leveling-off point in the scree plot). Before inspecting the three different solutions (and ultimately selecting a single final solution), one needs to complete the process of actually rotating the factors and creating the output for inspection.

This is a simple five-step process: (1) Perform varimax rotation of the factors (i.e., operation six on the PQMethod menu), (2) flag the cases to define each factor, (3) perform the final Q analysis of the rotated factors, (4) find and open the output file, and (5) save the output in a Microsoft Word or Adobe PDF file for inspection. This process is all quickly completed in PQMethod. Figure 7 illustrates the screens encountered by the analyst, and the process is as follows. **First**, after successfully completing “QPCA” (operation 4 on the main screen), the analyst should select operation 6 (“QVARIMAX”) and select the number of factors to be rotated. **Second**, after entering “Y” to the question “Do you wish to use the PQROT add-on program”, perform automatic flagging by selecting “F6”, then select “F8” to save the matrix (save all factors) and, last, select “F9” to quit the flagging screen. **Third**, perform the final Q-analysis of the rotated factors by running operation 7 (“QANALYZE”). **Fourth**, find and open the output file, which is stored in a “*.lis” file (thus requiring a text reading program like Windows® Notepad) at a location provided by PQMethod (as highlighted by the yellow box in figure 7). **Fifth**, copy all the output from the Notepad file, paste it into a Word file, and save (to enhance the appearance of this Word file, we recommend “no spacing,” size eight “Courier New” font, and “landscape” page layout).

This process should be done three times (once for each rotated solution), and it is important to note that every time operation 7 is run (i.e., “QANALYZE”) the “*.lis” file will change. Therefore, output should be saved to a Word file prior to completing the five steps just outlined for each rotation. Upon completion of this process for three factor rotations, the analyst should have three files saved for further inspection. In our example, the three files should be a three-factor solution, a four-factor solution, and a five-factor solution.

Each of these output files includes several components (table 4) pertinent to the factor analysis of the Q-sorts. Four of the components will be identical for all three rotated factor solutions (i.e., components 1, 2, 3, and 5 in table 4), and the remaining components will change as a result of factor rotation. The analyst does not need to thoroughly review every component when deciding which of the three rotated solutions to retain as the final

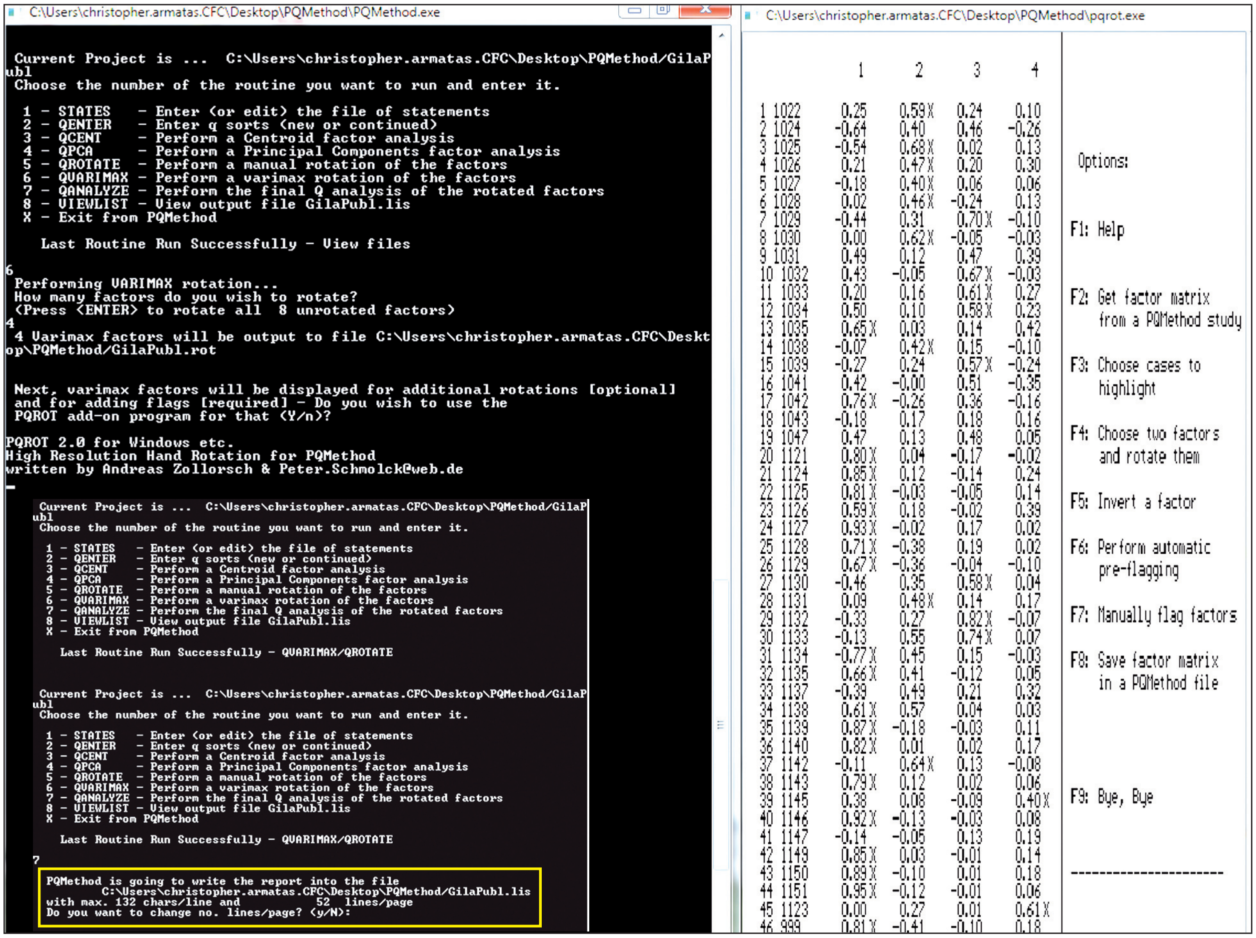


Figure 7—Screenshots illustrating the rotation process.

results for interpretation. As previously mentioned, there are no definitive rules for deciding which factor solution is the most appropriate but, in our experience, focusing on the following components in the following order provides an appropriate foundation for deciding on the final rotated solution: component 4 (factor matrix with an X indicating a defining sort), component 8 (factor scores (for each factor)), component 11 (factor Q-sort values for each statement), component 14 (distinguishing statements), and component 15 (consensus statements). Next we detail each of these components, and provide guidance on choosing a final rotated solution with examples from the forest plan revision application of the protocol.

Table 4—The output created by PQMethod, in the order it appears, following analysis of Q-sorts; and a brief description of the output.

Output component title	Output component description
1. Correlation matrix between sorts	The level of similarity, or correlation, between all Q-sorts. A value of 100 means two sorts are identical, a value of -100 means they are mirror opposites, and a value of 0 suggests no similarity.
2. Unrotated factor matrix	The factor loadings of each person (i.e., Q-sort) on the unrotated factors.
3. Cumulative communalities matrix	The cumulative variance explained by each unrotated factor for all Q-sorts.
4. Factor matrix with an X indicating a defining sort	The factor loadings for each person for all the rotated factors, and the "X" indicates whether a person is contributing to the definition of a particular factor.
5. Free distribution data results	The means and standard deviation of each person's Q-sort.
6. Factor scores with corresponding ranks	The factor scores of each ecosystem service for each factor, and the relative ranking of each score.
7. Correlations between factors scores	The level of interrelation between archetypes (i.e., typified Q-sorts).
8. Factor scores (for each factor)	The factor scores for each ecosystem service for each factor (this is the same information as presented in component 6, just in a different format).
9. Descending array of differences between factors	The difference in factor scores for each ecosystem service between the different factors.
10. Exact factor scores in Z-score and T-score units	Factor scores computed using a slightly different approach than factor scores computed in components 6 and 8.
11. Factor Q-sort values for each statement	The ranking-board value for each ecosystem service for all the factors.
12. Factor Q-sort values for statements sorted by consensus and disagreement	A ranking of ecosystem services from consensus to disagreement across all archetypes. In other words, this output shows which ecosystem services were subject to the greatest level of agreement and disagreement.
13. Factor characteristics	Several descriptive statistics for each factor (e.g., number of defining Q-sorts).
14. Distinguishing statements	A list of ecosystem services that are ranked notably different by a factor relative to all other factors.
15. Consensus statements	A list of ecosystem services that are not ranked notably differently by any pair of factors.

We selected a four-factor solution as the final results for interpretation for the forest plan revision application of the protocol. This four-factor solution is thoroughly detailed in Armatas et al. (2017a) but without the specific details of why a four-factor solution was chosen (as opposed to a three-factor solution or five-factor solution). The process for selecting that solution commenced with the same process outlined earlier. That is, a scree plot was developed to narrow the possible solutions (i.e., three-factor, four-factor, and five-factor).

Then for each of the three solutions, we focused on the output components previously listed, which can be grouped into two categories: (1) objective statistical components and (2) subjective qualitative components. Selecting the final solution can begin with a focus on an output component that provides statistical insight into the appropriateness of a given factor solution. This is the fourth component in table 4, or the "factor matrix with an X indicating a defining sort." To help explain the component more generally, figure 8 illustrates the first 42 people (or Q-sorts) of a four-factor rotated solution. Column 1 shows the order in which the Q-sorts were entered (i.e., 1, 2, 3…) and the corresponding unique Q-sort number assigned during the public meetings (i.e., 1022, 1024, 1025…). The remaining columns represent the loadings of each Q-sort on the four different factors. In this case, factor loadings indicate the level of similarity that each Q-sort has

Factor Matrix with an X Indicating a Defining Sort

		Loadings			
QSORT		1	2	3	4
1	1022	0.2457	0.5928X	0.2356	0.0953
2	1024	-0.6352	0.3981	0.4584	-0.2619
3	1025	-0.5398	0.6844X	0.0242	0.1305
4	1026	0.2061	0.4706X	0.2008	0.2992
5	1027	-0.1828	0.4000X	0.0633	0.0616
6	1028	0.0157	0.4572X	-0.2391	0.1269
7	1029	-0.4433	0.3075	0.7045X	-0.1018
8	1030	0.0040	0.6151X	-0.0457	-0.0342
9	1031	0.4861	0.1206	0.4740	0.3890
10	1032	0.4349	-0.0481	0.6727X	-0.0305
11	1033	0.2012	0.1641	0.6096X	0.2720
12	1034	0.5044	0.0951	0.5832X	0.2322
13	1035	0.6454X	0.0254	0.1361	0.4166
14	1038	-0.0653	0.4189X	0.1487	-0.1006
15	1039	-0.2654	0.2429	0.5718X	-0.2353
16	1041	0.4244	-0.0005	0.5064	-0.3530
17	1042	0.7621X	-0.2559	0.3611	-0.1558
18	1043	-0.1819	0.1725	0.1761	0.1639
19	1047	0.4656	0.1282	0.4816	0.0504
20	1121	0.7985X	0.0390	-0.1743	-0.0238
21	1124	0.8514X	0.1246	-0.1359	0.2415
22	1125	0.8117X	-0.0314	-0.0539	0.1422
23	1126	0.5919X	0.1754	-0.0175	0.3855
24	1127	0.9336X	-0.0200	0.1738	0.0159
25	1128	0.7114X	-0.3782	0.1941	0.0198
26	1129	0.6673X	-0.3566	-0.0377	-0.1027
27	1130	-0.4597	0.3461	0.5823X	0.0397
28	1131	0.0934	0.4764X	0.1362	0.1748
29	1132	-0.3262	0.2667	0.8163X	-0.0717
30	1133	-0.1337	0.5460	0.7373X	0.0667
31	1134	-0.7715X	0.4517	0.1452	-0.0302
32	1135	0.6568X	0.4064	-0.1203	0.0535
33	1137	-0.3880	0.4947	0.2072	0.3188
34	1138	0.6130X	0.5692	0.0374	0.0342
35	1139	0.8748X	-0.1808	-0.0303	0.1050
36	1140	0.8233X	0.0143	0.0155	0.1696
37	1142	-0.1111	0.6366X	0.1315	-0.0797
38	1143	0.7854X	0.1204	0.0227	0.0587
39	1145	0.3764	0.0805	-0.0885	0.3951X
40	1146	0.9195X	-0.1309	-0.0291	0.0822
41	1147	-0.1356	-0.0540	0.1341	0.1860
42	1149	0.8468X	0.0334	-0.0057	0.1403

Figure 8—Component 4 of the output from PQMethod.

with the four different factors (or archetypes). For example, Q-sort 1022 has a statistically significant loading on factor 2, and insignificant loadings on factors 1, 3, and 4. As a result, Q-sort 1022 has been flagged (with an X) for factor 2, which means that this person's prioritization of ecosystem services (or Q-sort) will contribute to defining the archetype represented by factor 2. On the other hand, Q-sort 1024 has not been flagged and, therefore, this person's Q-sort does not contribute to defining any of the archetypes. There is a specific decision rule for auto-flagging, which can be found in the PQMethod manual (Schmolck 2015), but is not discussed any further herein.

Now we will discuss what the analyst should look for in this component. The analyst's primary consideration for component 4 is the number of defining Q-sorts on each factor (i.e., number of Xs in each column). This number indicates how many people's Q-sorts will be used to define each archetype. In the case of the forest plan revision application of this protocol, the five-factor solution had zero defining Q-sorts on the fifth factor, which suggested that no people shared this viewpoint. This observation led to the quick and obvious conclusion that the appropriate factor solution was either a three-factor solution or a four-factor solution. In other words, inspection of component 4 quickly led to ruling out one of the factor solutions.

There are a few other aspects of component 4 that could indicate one factor solution is perhaps more appropriate than another. For example, a single defining Q-sort is not indicative of a shared viewpoint, which is the purpose of Q-methodology; therefore, we would rule out retaining factor solutions if there is a factor with only one defining Q-sort. Although a factor with two defining Q-sorts is technically a shared viewpoint, we would recommend a minimum of three defining Q-sorts for all factors in a particular factor solution. An analyst may encounter a situation where there are an adequate number of defining Q-sorts on all factors for multiple-factor solutions. For example, table 5 shows the number of defining Q-sorts on each factor in the forest plan revision application of the protocol (this information can be found by counting the Xs for each factor or, more simply, by referring to component 13, or factor characteristics, in the output file). In a case such as that in table 5, factor 4 has eight defining Q-sorts, which is a robust number of defining Q-sorts for creating an archetype. In this situation, after ruling out the five-factor solution, the analyst could proceed with a four-factor solution. However, consider a situation where there were only three defining Q-sorts for the fourth factor. Would the analyst proceed with exploring and discussing a four-factor solution? Although the occurrence of three defining Q-sorts does suggest a legitimate shared perspective, the

Table 5—Defining Q-sorts in the case of the forest plan revision application.

	Factor 1	Factor 2	Factor 3	Factor 4
Three-factor solution	77	25	13	N/A
Four-factor solution	69	18	12	8

analyst may have less confidence in it. Perhaps one of the three people was not really engaged in the activity, and sorted the ecosystem services in a haphazard way. In these more borderline situations, the analyst should proceed to the remaining components to decide whether exploring the additional viewpoint is warranted. Generally, it is better to maintain as many factors as can be usefully and confidently identified.

The four remaining output components that the analyst should investigate when selecting the final factor solution are 8, 11, 14, and 15. We call these components subjective qualitative components, not because they are qualitative per se (that is, they still present the information in a quantitative way with factor scores and numeric values), but because they provide a picture of the different archetypes, and the analyst must decide whether the archetypes created make sense. In other words, these components do not provide any objective guidance for deciding on the best factor solution. The analyst needs to spend time with the different archetypes created from the different factor solutions, and decide, based on his or her knowledge and judgment, whether the archetypes make sense and are worthy of full interpretation and exploration.

Inspection of the four “subjective qualitative components” is, in essence, the start of interpreting the public input gathered. For example, figure 9 shows the output from component 8 (factor scores or z-scores) for the first factor in the forest plan revision application of this protocol. This factor is the archetype labeled the “environmental archetype” in Armatas et al. (2017a). Component 11 (factor Q-sort values for each statement) provides this same list with the values from the ranking board. For example, the ecosystem

Factor Scores -- For Factor 1

No.	Statement	No.	Z-SCORES
24	biodiversity and abundance	24	1.571
25	wildlife habitat and connectivity	25	1.548
29	public ownership and access	29	1.123
26	water quality	26	1.098
20	places where human influence	20	1.066
10	non-motorized recreation	10	1.023
15	solitude quiet and clear night sky	15	0.881
30	scenic beauty aesthetics and inspiration	30	0.799
28	water quantity	28	0.765
27	air quality	27	0.722
19	research and science	19	0.662
14	dispersed camping	14	0.518
23	carbon absorption	23	0.451
21	cultural and archeological sites	21	0.239
16	Native American cultural benefits	16	0.219
18	education and interpretation	18	0.166
22	flood and erosion control	22	0.135
9	hunting and fishing nonoutfitted	9	-0.061
13	developed camping	13	-0.451
8	outfitting and guiding	8	-0.649
1	forest materials for personal use	1	-0.685
6	water for household use	6	-0.753
17	traditional agricultural lifestyle	17	-0.952
4	woody biomass for energy	4	-0.972
12	driving for pleasure	12	-1.072
7	irrigation for agriculture	7	-1.183
2	timber production	2	-1.270
5	livestock grazing	5	-1.476
11	motorized recreation	11	-1.568
3	oil and natural gas and minerals	3	-1.895

Figure 9—Factor scores created for each archetype.

services for “biodiversity and abundance” and “wildlife habitat and connectivity” are considered as +4 importance on the ranking board by the environmental archetype, because they correspond to the ecosystem services with the two highest z-scores (as shown in figure 9). Before selecting a final factor solution, and fully interpreting and exploring it, the analyst can think about these different factors and ask such questions as: Does my experience interacting with the public support this archetype? Are there interesting insights that can be gleaned from this archetype? Is it possible that this archetype resulted from someone doing the ranking incorrectly (in other words, did someone misinterpret the directions for how to complete the Q-sort)?

It is difficult to provide definitive guidance on what factor solution to choose for full interpretation and exploration, but following the preceding basic guidelines and thoroughly exploring the output components of several factor solutions are likely to provide clarity on the most appropriate solution. Furthermore, there is a tight-knit and extremely helpful online community of researchers and practitioners who are passionate about the method underpinning this protocol (i.e., Q-methodology), which can be found at https://qmethod.org/community/mailing-list/. The Q-methodology listserv, run by Kent State University, includes discussions about the method ranging from purely theoretical issues to the most practical aspects of analysis. In our experience, many of the world’s experts in this method provide detailed responses to questions in a very timely manner, and it is not uncommon for such experts to review full analyses and provide feedback.

Once a final factor solution is chosen, the drivers-of-change component needs to be integrated prior to a holistic interpretation of the results. In the forest plan revision application of the protocol, where multiple people provided input at the same time and the drivers-of-change component consisted of people selecting 3 of the 12 preselected drivers that they perceived as most influential to their important ecosystem services, analysis included a formal, but basic, statistical approach. We applied simple linear regression, which Armatas et al. (2017a: 10) concisely describe:

> Linear regression analysis is a commonly used statistical technique that aims to model the relationship between a dependent variable and one or more explanatory variables. Although relatively straightforward in a statistical sense, an in-depth discussion of regression analysis is beyond the scope of this report. Such discussions are widely available, and DeVeaux et al. (2012) present one which is accessible to readers who may not be familiar with the approach.

Instead of discussing the mechanics of the approach, a brief discussion of the purpose of regression analysis, and the possible conclusions that can be drawn from it, are provided. Regression analysis is often used for the purposes of prediction and/or explanation. For example, one could use regression analysis to predict whether it will rain on a given day based upon information such as temperature, humidity, season, and any other explanatory variable found to be relevant (e.g., altitude, proximity to a mountain). For the purposes of explanation, regression analysis could be used to understand the influential factors that lead someone to graduate from college. For example, are gender, household income, race, and state residence associated with the probability that someone graduates from college? In order to answer these questions, whether for prediction or explanation, one needs information related to both the dependent and explanatory variables.

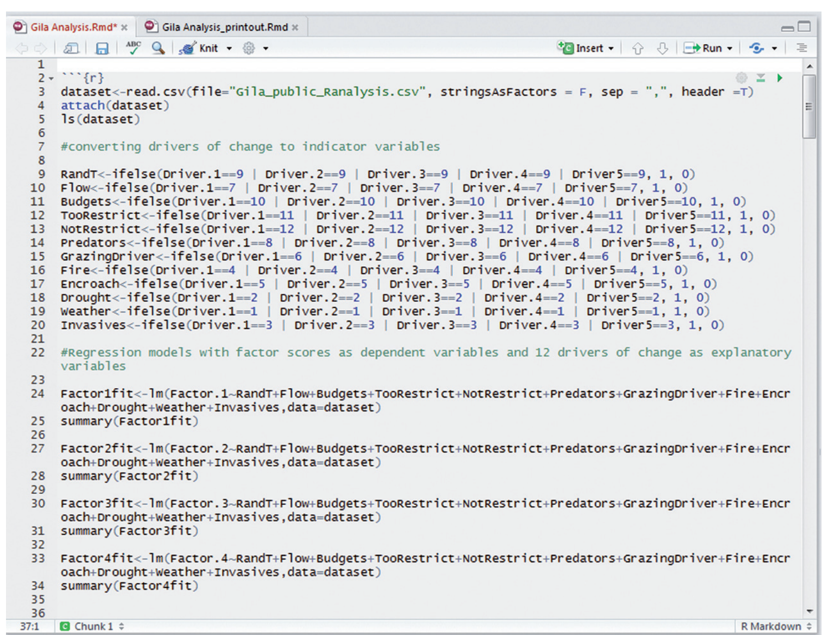
In the forest plan revision application of the protocol, there is interest in understanding whether the selection of particular drivers of change can highlight which archetype one may align with. Therefore, we completed four separate regression analyses (one for each archetype), where the dependent variables in the regression analyses were the "loadings" that each person (122 people total) had with relation to the 4 archetypes (i.e., the loadings listed in figure 8), and the explanatory variables were the 12 drivers of change listed in table 3 (represented as indicator, or dummy, variables—using a value of 1 if that driver was selected as one of three most influential, otherwise a value of 0).

How, exactly, was this analysis executed? First, an Excel spreadsheet was created, where each row is a person (or Q-sort) and the columns show the associated factor loadings and coded drivers. Figure 10 is a screenshot of a portion (only 31 of the 122 Q-sorts) of the spreadsheet used for the forest plan revision application of the protocol and, as shown, the columns for the factors correspond to the loadings for each Q-sort in figure 8. The columns for driver 1, driver 2, and driver 3 show the drivers selected by each person; however, these drivers have been coded. The numbers between 1 and 12 were used to code the preselected drivers (e.g., a "5" in the drivers column corresponds to "woody encroachment of grasslands" in table 3), and the three-digit numbers were used to code any driver of change that was written in by respondents. Once this spreadsheet is developed, regression analysis is performed using a suitable software program (e.g., SPSS, Stata®, *RStudio*).

We used the freely available program, *RStudio* (a "front-end" of *R*), to perform this analysis. The first step was converting all the drivers-of-change variables to indicator variables. Then, four simple regressions were completed, the code for which is reflected in figure 11.

	A	B	C	D	E	F	G	H	I
1	ID	Sort Num	Factor 1	Factor 2	Factor 3	Factor 4	Driver 1	Driver 2	Driver 3
2	1	1022	0.24566	0.59276	0.23555	0.09531	5	11	108
3	2	1024	-0.63519	0.39812	0.45835	-0.26187	9	8	12
4	3	1025	-0.53984	0.68444	0.02419	0.13054	8	5	11
5	4	1026	0.20611	0.47059	0.20081	0.29923	8	9	11
6	5	1027	-0.1828	0.40003	0.06331	0.0616	8	9	
7	6	1028	0.01573	0.45718	-0.23912	0.12687	9	5	109
8	7	1029	-0.44327	0.30753	0.70451	-0.10184	11	5	2
9	8	1030	0.00399	0.61513	-0.04573	-0.03416	109	9	11
10	9	1031	0.48611	0.1206	0.47404	0.389	5	2	4
11	10	1032	0.43495	-0.04813	0.67274	-0.03046	2	8	10
12	11	1033	0.20124	0.16415	0.60959	0.27204	8	5	6
13	12	1034	0.50435	0.09507	0.5832	0.23223	9	6	4
14	13	1035	0.64539	0.02543	0.13611	0.41662	1	7	9
15	14	1038	-0.06528	0.41892	0.14869	-0.10065	8	11	2
16	15	1039	-0.26543	0.24294	0.57181	-0.23533	11	4	9
17	16	1041	0.42443	-0.00052	0.50637	-0.35299	10	2	110
18	17	1042	0.76212	-0.25591	0.36109	-0.15581	9	10	111
19	18	1043	-0.1819	0.17249	0.17605	0.16392	9	10	11
20	19	1047	0.46556	0.12821	0.48156	0.05036	10	4	7
21	20	1121	0.79854	0.03897	-0.17427	-0.02385	7	12	9
22	21	1124	0.85136	0.12457	-0.13594	0.24152	7	8	9
23	22	1125	0.81167	-0.03136	-0.05392	0.14216	10	6	7
24	23	1126	0.59194	0.17538	-0.01752	0.38546	10	12	12
25	24	1127	0.93359	-0.01995	0.17376	0.01591	7	6	4
26	25	1128	0.7114	-0.3782	0.19406	0.01977	9	10	11
27	26	1129	0.66727	-0.35658	-0.03769	-0.10267	113	114	115
28	27	1130	-0.45972	0.34612	0.58226	0.03975	11	9	4
29	28	1131	0.09341	0.47643	0.1362	0.17482	9	11	12
30	29	1132	-0.3262	0.2667	0.81629	-0.07168	2	5	11
31	30	1133	-0.1337	0.54602	0.73735	0.06674	11	5	8
32	31	1134	-0.77148	0.45168	0.14518	-0.03022	116	117	118

Figure 10—Initial spreadsheet for drivers-of-change analysis.



```
```{r}
dataset<-read.csv(file="Gila_public_Ranalysis.csv", stringsAsFactors = F, sep = ",", header =T)
attach(dataset)
ls(dataset)

#converting drivers of change to indicator variables

RandT<-ifelse(Driver.1==9 | Driver.2==9 | Driver.3==9 | Driver.4==9 | Driver5==9, 1, 0)
Flow<-ifelse(Driver.1==7 | Driver.2==7 | Driver.3==7 | Driver.4==7 | Driver5==7, 1, 0)
Budgets<-ifelse(Driver.1==10 | Driver.2==10 | Driver.3==10 | Driver.4==10 | Driver5==10, 1, 0)
TooRestrict<-ifelse(Driver.1==11 | Driver.2==11 | Driver.3==11 | Driver.4==11 | Driver5==11, 1, 0)
NotRestrict<-ifelse(Driver.1==12 | Driver.2==12 | Driver.3==12 | Driver.4==12 | Driver5==12, 1, 0)
Predators<-ifelse(Driver.1==8 | Driver.2==8 | Driver.3==8 | Driver.4==8 | Driver5==8, 1, 0)
GrazingDriver<-ifelse(Driver.1==6 | Driver.2==6 | Driver.3==6 | Driver.4==6 | Driver5==6, 1, 0)
Fire<-ifelse(Driver.1==4 | Driver.2==4 | Driver.3==4 | Driver.4==4 | Driver5==4, 1, 0)
Encroach<-ifelse(Driver.1==5 | Driver.2==5 | Driver.3==5 | Driver.4==5 | Driver5==5, 1, 0)
Drought<-ifelse(Driver.1==2 | Driver.2==2 | Driver.3==2 | Driver.4==2 | Driver5==2, 1, 0)
Weather<-ifelse(Driver.1==1 | Driver.2==1 | Driver.3==1 | Driver.4==1 | Driver5==1, 1, 0)
Invasives<-ifelse(Driver.1==3 | Driver.2==3 | Driver.3==3 | Driver.4==3 | Driver5==3, 1, 0)

#Regression models with factor scores as dependent variables and 12 drivers of change as explanatory variables

Factor1fit<-lm(Factor.1~RandT+Flow+Budgets+TooRestrict+NotRestrict+Predators+GrazingDriver+Fire+Encroach+Drought+Weather+Invasives,data=dataset)
summary(Factor1fit)

Factor2fit<-lm(Factor.2~RandT+Flow+Budgets+TooRestrict+NotRestrict+Predators+GrazingDriver+Fire+Encroach+Drought+Weather+Invasives,data=dataset)
summary(Factor2fit)

Factor3fit<-lm(Factor.3~RandT+Flow+Budgets+TooRestrict+NotRestrict+Predators+GrazingDriver+Fire+Encroach+Drought+Weather+Invasives,data=dataset)
summary(Factor3fit)

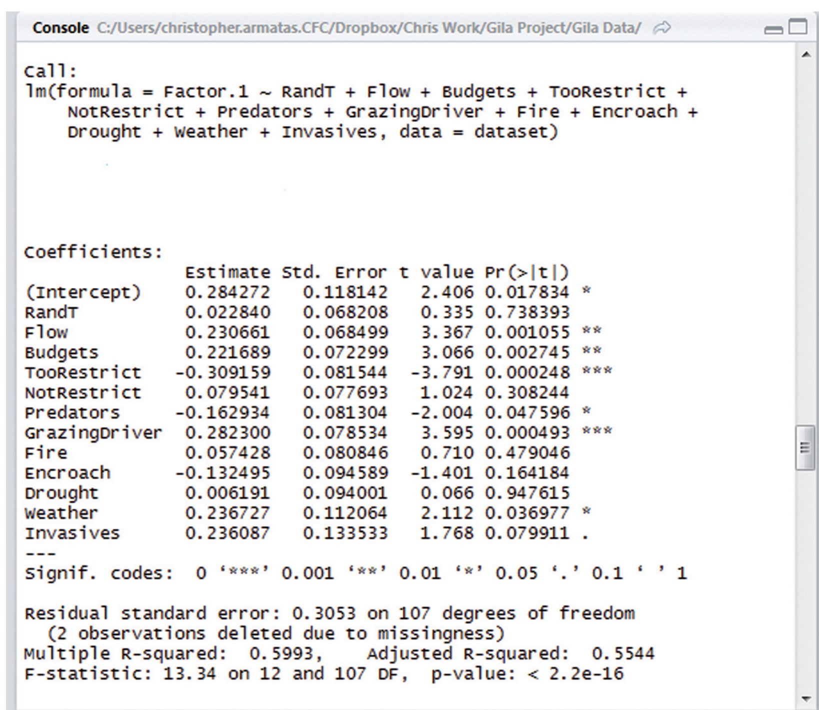
Factor4fit<-lm(Factor.4~RandT+Flow+Budgets+TooRestrict+NotRestrict+Predators+GrazingDriver+Fire+Encroach+Drought+Weather+Invasives,data=dataset)
summary(Factor4fit)
```

Figure 11—Screenshot of code used for regression analysis.
```

For each regression, the analyst is provided with output such as that shown in figure 12. We will elaborate on how this information can be interpreted within the context of the protocol more generally later but, to prevent confusion, we will first provide a basic interpretation of this output. Only those explanatory variables (e.g., Flow, Budgets) with asterisks indicate a statistically significant association between driver of change selected and factor loading. In cases where an asterisk is not present, there is not enough evidence to conclude that there is a relationship between the driver of change and the corresponding archetype. For example, this output suggests an association between "TooRestrict," which represents the driver of change "land use restrictions" in table 3, and the factor loading that a person has with factor 1. To be more precise, this variable would be interpreted as follows: Selecting the driver of change "land use restrictions" is associated with a decrease of 0.309 in a person's factor loading on factor 1, all else constant. More interpretation-related details about this particular drivers-of-change component follows.

2.7.3. Presentation of Public Input

Before discussing interpretation of the public input gathered, we review how an analyst would present the final results derived from the Q-sort analysis and the drivers-of-change component. That is, what does the analyst do with the following: the final factor solution as it is expressed in the PQMethod output file, the information gathered from the preselected drivers exercise (i.e., the drivers-of-change component for the forest plan revision application), and the linear regression output shown in figure 12?



```
Console C:/Users/christopher.armatas.CFC/Dropbox/Chris Work/Gila Project/Gila Data/

Call:
lm(formula = Factor.1 ~ RandT + Flow + Budgets + TooRestrict +
    NotRestrict + Predators + GrazingDriver + Fire + Encroach +
    Drought + Weather + Invasives, data = dataset)

Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)    0.284272   0.118142   2.406 0.017834 *
RandT          0.022840   0.068208   0.335 0.738393
Flow           0.230661   0.068499   3.367 0.001055 **
Budgets        0.221689   0.072299   3.066 0.002745 **
TooRestrict   -0.309159   0.081544  -3.791 0.000248 ***
NotRestrict    0.079541   0.077693   1.024 0.308244
Predators     -0.162934   0.081304  -2.004 0.047596 *
GrazingDriver  0.282300   0.078534   3.595 0.000493 ***
Fire           0.057428   0.080846   0.710 0.479046
Encroach      -0.132495   0.094589  -1.401 0.164184
Drought        0.006191   0.094001   0.066 0.947615
Weather        0.236727   0.112064   2.112 0.036977 *
Invasives      0.236087   0.133533   1.768 0.079911 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.3053 on 107 degrees of freedom
  (2 observations deleted due to missingness)
Multiple R-squared:  0.5993,    Adjusted R-squared:  0.5544
F-statistic: 13.34 on 12 and 107 DF,  p-value: < 2.2e-16
```

Figure 12—Regression output from drivers-of-change component of forest plan revision application of the protocol.

For presentation of the PQMethod output, "factor arrays" must be created. We recommend completing this process, as explained next, for one archetype first. Then, simply repeat the process for each archetype by modifying the initial creations (i.e., copy and paste the first archetype, and modify as needed for the remaining archetypes).

Creating the factor arrays for each archetype is a simple process of filling in a ranking board with the ecosystem services for each archetype, highlighting those ecosystem services that are statistically distinguishable, creating a name for the archetype, and color coding the ecosystem services by category type. Filling in the ranking board draws from output component 11 in table 4 (factor Q-sort values), and the analyst simply inserts the ecosystem service in the appropriate box on the ranking board. For instance, ecosystem services 24 and 25 (i.e., "biodiversity and abundance" and "wildlife habitat and connectivity") both have a value of +4 in figure 13 (for factor 1) and, as such, are occupying those positions on the ranking board in figure 14.

Distinguishing statements are provided for each factor in PQMethod output (component 14). While it is important to consider each archetype holistically, it may be helpful to be particularly mindful of the distinguishing ecosystem services as they highlight areas of significant differentiation between the archetypes. Figure 15 shows the distinguishing ecosystem services for factor 1 of the forest plan revision application (as listed in component 14 of the output file and highlighted with black in figure 14).

Factor Q-Sort Values for Each Statement

			Factor Arrays			
No.	Statement	No.	1	2	3	4
1	forest materials for personal use	1	-1	3	1	-1
2	timber production	2	-3	2	2	-3
3	oil and natural gas and minerals	3	-4	-1	0	0
4	woody biomass for energy	4	-2	0	-1	-2
5	livestock grazing	5	-3	4	4	1
6	water for household use	6	-2	-3	2	3
7	irrigation for agriculture	7	-3	-1	2	0
8	outfitting and guiding	8	-1	2	0	-2
9	hunting and fishing nonoutfitted	9	-1	3	1	1
10	non-motorized recreation	10	2	2	-3	-3
11	motorized recreation	11	-4	-1	-4	4
12	driving for pleasure	12	-2	-3	-3	2
13	developed camping	13	-1	1	-2	-2
14	dispersed camping	14	1	0	-2	-1
15	solitude quiet and clear night sky	15	2	-1	-2	3
16	Native American cultural benefits	16	0	-3	-1	0
17	traditional agricultural lifestyle	17	-2	3	3	1
18	education and interpretation	18	0	-2	0	-3
19	research and science	19	1	-2	1	-1
20	places where human influence	20	3	-2	-4	-4
21	cultural and archeological sites	21	0	-2	-1	-1
22	flood and erosion control	22	0	1	3	0
23	carbon absorption	23	1	-4	-3	-4
24	biodiversity and abundance	24	4	-4	1	-2
25	wildlife habitat and connectivity	25	4	1	0	2
26	water quality	26	3	1	3	2
27	air quality	27	1	0	2	1
28	water quantity	28	2	2	4	2
29	public ownership and access	29	3	4	-1	4
30	scenic beauty aesthetics and inspiration	30	2	0	-2	3

Figure 13—Ranking board position of each ecosystem service for factor array development.

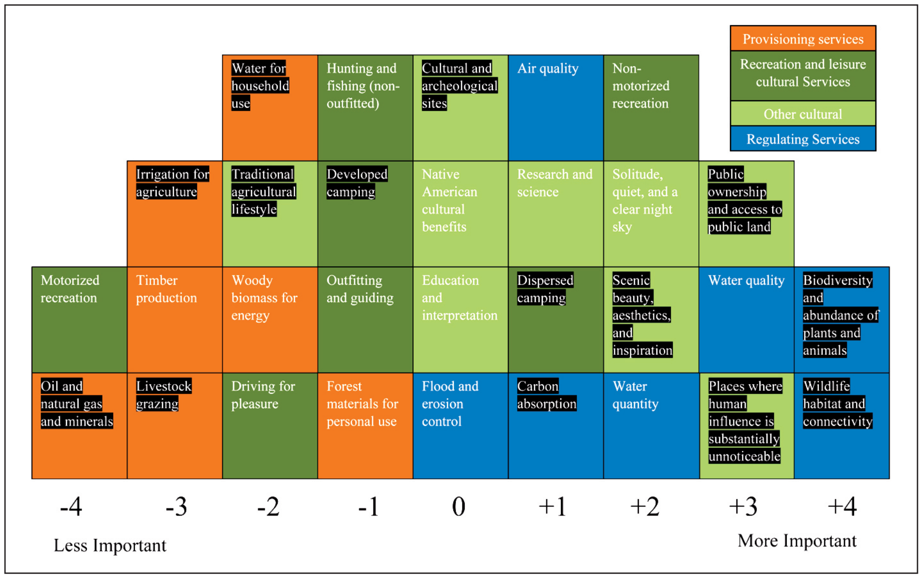


Figure 14—Factor array for environmental archetype from the forest plan revision application of the protocol.

Distinguishing Statements for Factor 1

(P < .05 ; Asterisk (*) Indicates Significance at P < .01)

Both the Factor Q-Sort Value (Q-SV) and the Z-Score (Z-SCR) are Shown.

			Factors 1		2		3		4	
No.	Statement	No.	Q-SV	Z-SCR	Q-SV	Z-SCR	Q-SV	Z-SCR	Q-SV	Z-SCR
24	biodiversity and abundance	24	4	1.57*	-4	-1.70	1	0.35	-2	-0.69
25	wildlife habitat and connectivity	25	4	1.55*	1	0.27	0	0.11	2	0.78
29	public ownership and access	29	3	1.12*	4	1.79	-1	-0.61	4	1.89
20	places where human influence	20	3	1.07*	-2	-0.84	-4	-1.54	-4	-1.42
30	scenic beauty aesthetics and inspiration	30	2	0.80	0	-0.18	-2	-0.83	3	1.36
14	dispersed camping	14	1	0.52*	0	0.01	-2	-0.74	-1	-0.33
23	carbon absorption	23	1	0.45*	-4	-1.34	-3	-1.52	-4	-2.11
21	cultural and archeological sites	21	0	0.24	-2	-0.97	-1	-0.42	-1	-0.27
13	developed camping	13	-1	-0.45	1	0.17	-2	-1.18	-2	-1.00
6	water for household use	6	-2	-0.75*	-3	-1.30	2	0.86	3	0.87
17	traditional agricultural lifestyle	17	-2	-0.95*	3	1.17	3	1.37	1	0.60
7	irrigation for agriculture	7	-3	-1.18*	-1	-0.19	2	1.03	0	0.09
5	livestock grazing	5	-3	-1.48*	4	1.72	4	1.71	1	0.46
3	oil and natural gas and minerals	3	-4	-1.90*	-1	-0.56	0	0.12	0	0.18

Figure 15—Statements to be highlighted in black in factor array for factor 1.

Although naming each archetype is not necessary, we find it helpful for communicating the results because, instead of referring to "factor 1" in discussions with the public and other decisionmakers, we can refer to the "environmental archetype." Similarly, categorizing the ecosystem services by color may enhance communication, as it can quickly highlight an important aspect of the archetype. For instance, figure 14 illustrates easily how the environmental archetype generally considers provisioning services to be of lesser importance. Regarding presentation of the drivers-of-change component, we recommend presenting both summary analysis of the drivers-of-change component in aggregate (i.e., the public's suggestions about drivers in general), as well as the analysis of drivers of change for each archetype individually. Presenting the aggregate information for the drivers-of-change component of the forest plan revision application of the protocol simply involved tabulating, in a spreadsheet, the times particular preselected drivers were chosen, and the number of times different drivers of change were written in by respondents. Table 6 illustrates how this information was presented in this application.

Table 6—Presentation of drivers-of-change component (in aggregate) for the forest plan revision application (Source: Armatas et al. 2017a: 29).

	Number of times chosen as one of the three most influential drivers of change to ecosystem services that are important to respondent
Preselected drivers of change provided to respondents	
Roads and trails (conditions, access, amount)	56
Streamflow alterations and diversions	44
Declining Forest Service budgets	40
Land use restrictions	37
Lack of land use restrictions	34
Predators, including wolves	27
Unmanaged grazing (wildlife or livestock)	27
Uncharacteristic fire	25
Woody encroachment of grasslands	14
Extended drought	14
Extreme weather	12
Invasive species	8
Drivers of change “written in” by respondents	
Public land transfer	2
Climate change	2
Inability of local managers to manage local forests and conflicts	2
Fuelwood collection	2
Long-term restoration following wildfire	1
Travel management restrictions	1
Fire management	1
Balancing multiple use and wilderness designation	1
Local timber and livestock production as tools for management	1
2012 Forest Planning legislation	1
Gila trout protection	1
Loss of natural night sky	1
Restrictions to livestock	1
Lack of trail maintenance, mapping, and development	1
Restricting multiple use instead of using it as a management tool	1
Tree management selective harvest	1
Public relations	1
Managed grazing (livestock)	1
Cuts to ranching allotments	1
Jeeping availability and trails	1
Four-wheel drive access to all lands	1

Presenting the drivers-of-change component in relation to each archetype individually will depend on how the component is integrated (again, see Armatas (2013) and Irey (2014) for different examples of how the drivers-of-change component was completed and interpreted). For the forest plan revision application, we created a table where all the archetypes are listed with the corresponding coefficients from the regression analysis. For example, table 7 is how we presented the results of the drivers-of-change component. As can be seen, all 12 preselected drivers of change are listed, and the association (or lack of association) with each archetype is reflected by the asterisks and the signs on the coefficients.

2.7.4. Interpretation of Public Input

What can (and cannot) be said about the factor arrays, the tables related to the drivers-of-change component, and the demographic information collected? In other words, how do we interpret all this public input as new knowledge that can inform decisionmaking and support a variety of management and planning needs?

In general, the protocol provides nuanced and detailed "archetypes," "typified relationships," or "general perspectives" (all parallel terms) about the importance of ecosystem services, unimportance of ecosystem services, tradeoffs among ecosystem services, and the drivers of change considered influential to the continued provision of nature's benefits. These archetypes

Table 7—Coefficients from linear regression analysis between drivers of change (independent variables) and archetypes (dependent variables) (Source: Armatas et al. 2017a).

	Archetypes (typified relationships)			
Drivers of change	**Environmental**	**Utilitarian**	**Water**	**Motorized**
Roads and trails (conditions, access, amount)	0.02	-0.06	0.07	0.10**
Streamflow alterations and diversions	0.23***	-0.14***	-0.02	-0.04
Declining Forest Service budgets	0.22***	-0.10*	0.07	-0.02
Land use restrictions	-0.31***	0.21***	0.10	-0.01
Lack of land use restrictions	0.08	0.04	-0.04	0.03
Predators, including wolves	-0.16**	0.06	0.15**	0.03
Unmanaged grazing (wildlife or livestock)	0.28***	-0.13**	0.01	-0.03
Uncharacteristic fire	0.06	0.12*	0.06	0.07
Woody encroachment of grasslands	-0.13	0.20***	0.16**	0.03
Extended drought	0.01	-0.10	0.21***	-0.04
Extreme weather	0.24**	-0.23***	0.08	-0.05
Invasive species	0.24*	-0.11	0.04	0.06

Note: Levels of statistical significance denoted as: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

represent shared perspectives that are defined by multiple people and, as such, we would expect public participants who review these archetypes to perhaps react by noting: "That one is not exactly how I feel, but it is close." This approach provides confidence that a broad range of general perspectives have been captured, and the demographic information collected can help the analyst see whether a broad range of people have completed the Q-sort. However, the protocol does not allow for any claims about the distribution of these perspectives across the population, nor should the demographic information be used to suggest anything about a particular archetype. For example, the forest plan revision application of this protocol found four primary archetypes ("environmental," "utilitarian," "water," and "motorized") (Armatas et al. 2017a), and we can assert that these four archetypes are likely to capture the general sentiments relevant to forest plan revision on the Gila National Forest. However, we cannot assert that, for example, 25 percent of stakeholders interested in the forest plan revision adopt the utilitarian perspective, that 90 percent adopt the water perspective, or that the motorized perspective is more likely to be held by older people. Such general statements of representativeness would require further polling or survey work.

By making explicit the spectrum of public opinion on the topic, this protocol provides an understanding that belies the general statement, for instance, that "biodiversity conservation is a universally important ecosystem service." Instead, the approach may highlight perspectives that consider biodiversity conservation to be an important ecosystem service, and other perspectives that view biodiversity conservation as a competing ecosystem service. The forest plan revision application illustrates this point nicely, as the utilitarian archetype (shown in figure 4) and the environmental archetype (shown in figure 14) place "biodiversity and abundance of plants and animals" on opposite ends of the board.

The Q-sorting process requires that each individual completing the process engage with *all* ecosystem services in the ranking list, and it requires difficult decisions about tradeoffs (the same types of decisions made by planners and managers). Therefore, the analyst can think of each factor array as highlighting those ecosystem services that are considered to be positively salient (occupying the right of the ranking board), negatively salient (occupying the left of the ranking board), and more neutral (occupying the middle of the ranking board). For instance, the utilitarian archetype (fig. 4) considers several provisioning services (forest materials for personal use, livestock grazing) as positively salient, and several regulating and cultural services (carbon absorption, Native American cultural benefits) as negatively salient.

The drivers-of-change component of the protocol highlights, in general, the influential factors that the public is concerned about with regard to the continued provision of important ecosystem services. For instance, table 6 provides an overview of the drivers of change that the public selected during the implementation of the forest plan revision application of the protocol.

A total of 122 people provided input, which means that the numbers in table 6 can easily be interpreted as proportions. For example, 56 people, or nearly half of the participants, selected "roads and trails (conditions, access, amount)" as one of the three most influential drivers of change to their important ecosystem services.

When the factor arrays are accompanied with the input derived from the drivers-of-change component, the understanding of each archetype becomes more detailed. For instance, considering the utilitarian archetype, and those ecosystem services that are positively and negatively salient, the drivers of change selected can potentially highlight perceived tradeoffs between different ecosystem services. As shown in table 7, selecting the driver of change "land use restrictions" is associated with an increase in the possibility that someone will align with the utilitarian archetype. This suggests that those who align with this archetype may view land use restrictions as a management approach for increasing the provision of carbon absorption and biodiversity. Framed differently, this archetype may perceive a tradeoff between particular provisioning services and particular regulating services.

Finally, the drivers-of-change component can give forest planners and managers additional confidence that the factor arrays represent robust conclusions. For instance, the forest plan revision application identified and explored a "water" archetype, which prioritized several benefits that are tied to water, including livestock grazing, water quantity, water quality, traditional agricultural lifestyle, irrigation for agriculture, and flood and erosion control. All of these benefits were positioned on the right side of the ranking board for the water archetype. As shown in table 7, the three drivers of change associated with this archetype were "predators, including wolves," "woody encroachment of grasslands," and "extended drought." Although one would not necessarily be surprised that these three drivers of change were of concern to people who valued the aforementioned ecosystem services, the logical connection between the drivers and the benefits should provide confidence in the validity of the results.

2.8. Step 8: Communicate Results to Participants and Receive Feedback About the Validity of the Viewpoints Identified and Summarized

It is important, to the greatest extent practicable, to communicate the various relationships identified, as well as the drivers of change highlighted, back to the participants who completed the exercise. This communication could take place during public meetings or presentations or via an established email list. In reference to the typified relationships identified, the primary question for those who completed the Q-sort is: "Do any of these relationships capture the essence of your relationship with the national forest?" We would expect most, though not all, participants to identify with at least one relationship. Some may not identify with the exact ecosystem service prioritization, but it should be generally representative of their feelings. This step is valuable for two reasons. First, it reinforces (or raises concerns) about the analysis and final relationships interpreted. Second, it could provide the foundation for productive discussions about why particular drivers of change threaten relationships, or about the meaning of the different relationships (i.e., why are particular ecosystem services important?).

For practitioners who may be considering implementation of this protocol, there is a need to highlight how this nuanced understanding of public perceptions about the importance of ecosystem services and relevant drivers of change can support forest planning and management activities. That is, what are the management implications?

3. Management Implications

Two broad, interrelated benefits may result from applying this protocol within the context of various planning and management needs: (1) facilitation of public relations and (2) support of natural resource decisionmaking.

3.1. Public Relations

Forest planning and management is a process that requires not only making difficult decisions about the stewardship of natural resources, but also fostering relationships with the public. As public land is jointly owned by all U.S. citizens, those administering such land are inherently serving the public. This protocol, through an understanding of public perceptions of ecosystem services and drivers of change, provides managers and planners with a nuanced and visually appealing picture of the different perspectives held by the public. As a reminder, these perspectives are derived from the opinions of a diverse range of people, which allows one to understand the variety of existing viewpoints; however, the archetypes do not provide *any* information about how the perspectives are distributed across the population. Gaining this information requires another, completely different, approach.

One potential benefit of the archetypes generated by this approach is that they serve as constant reminders of the broad range of opinions on the topic. These constant reminders may help forest planners and managers align their priorities with those of the public, and potentially highlight differences in concern related to the drivers of change. For example, the water application of the protocol found that particular perspectives were not concerned with climate change. According to Armatas (2013), the agricultural archetype (who assigned high importance to commercial irrigation, preserving agricultural lifestyles, and water for stock) was not necessarily concerned about climate change because of the capacity for water storage in the study area. This lack of concern, however, may be misplaced as climate trends show earlier runoff and reduced snowpack. The mismatch in priorities between land managers and the public can highlight areas where discussion and education may be warranted.

Another benefit of the protocol, according to Armatas et al. (2017a: 33), is that it provides a "cognitively manageable way" for managers to visualize the public and it provides an inclusive picture of the different types of people interested in land management and planning decisions without "prioritizing the interests of some over the interests of others." This is important in that the loudest voices (or most "successful" interest groups) do not completely dominate the public input process. It also reminds managers about the diversity of viewpoints, which may not be oppositional or divergent. This protocol does not represent a vote by the people, as the results do not yield estimates of each archetype in terms of population distribution. We see this as a strength of this approach, because it can facilitate communication between natural resource decisionmakers and the public by highlighting the difficulty of the job. In other words, there are several different viewpoints about the important benefits provided by public lands, and managers and planners are charged with accommodating and considering *all* of these viewpoints. While this may be obvious to decisionmakers, it may not be central to the public's thinking. The different archetypes can also serve as communication tools when planners and managers make decisions; even if a portion of the public disagrees with a particular decision, the archetypes can facilitate communication as to why those decisions were made (recognizing the perspectives that may underlie decisions).

The clear representation of diverse viewpoints may also help decisionmakers facilitate civil discourse between members of the public. The protocol process can facilitate such discourse because it is an individual activity, which both allows all individuals to submit their input and prevents dominant personalities from monopolizing the discussion. The fact that every individual interacts with every ecosystem service in the ranking list can also help members of the public understand benefits that they may not have previously considered. We have observed participants discussing their Q-sorts (after the exercise), genuinely intrigued by their own and others' tradeoffs. The "diverse archetypes can potentially give legitimacy to viewpoints that differ from one's own. If one is no longer skeptical about the existence of a different viewpoint, then perhaps acceptance of that different viewpoint and subsequent civil discourse can commence" (Armatas et al. 2017a: 34). The protocol may foster empathy among members of the public for different perspectives.

Also related to the "legitimacy" of these perspectives, the protocol provides a clear and structured process for arriving at the different archetypes. The inclusion of all interested parties, the statistical analysis of the Q-sorts, and the supporting evidence provided by the drivers-of-change component may lend credence to the perspectives, thus supporting discussions between the public and the natural resource decisionmakers by reducing the potential for public skepticism about the different archetypes. That is, the scientific structure and rigor allow the archetypes to be viewed, perhaps, as more legitimate, thus rising above accusations that particular attitudes and opinions are not serious or worth consideration.

3.2. Decisionmaking

Forest planners and managers are confronted with a variety of decisions in their day-to-day activities. Those decisions undoubtedly require numerous considerations, which suggests that no single body of knowledge, such as that provided by this protocol, will authoritatively direct decisionmaking. However, the understanding of multiple stakeholder perspectives yielded by this protocol can support decisionmaking by highlighting how particular decisions may impact the public. Understanding perceived tradeoffs between ecosystem services can help decisionmakers understand "winners" and "losers" in decisions. For example, the forest plan revision application of this protocol found that an increase in livestock grazing is "likely to be beneficial to the water and utilitarian archetypes, whereas the environmental archetype may be negatively impacted" (Armatas et al. 2017a). This understanding helps to highlight which archetypes are sensitive to changes in the provision of particular ecosystem services. One potential use of these archetypes is in the development of different land management alternatives.

The ability to understand perceived tradeoffs is potentially beneficial for assessing how increasing the provision of one ecosystem service may influence the provision of another ecosystem service. The forest plan revision application of this protocol was carried out recently, and a preliminary draft plan for the Gila National Forest integrated the knowledge gained from the protocol into a specific management approach for ecosystem services. Within the context of the ecosystem services approach, the preliminary draft plan stated that "management balances the complex interrelationships and tradeoffs between these services so that the sustainability of one is not compromised by a focus on another" (U.S. Department of Agriculture, Forest Service 2018: 64), and the plan used the factor arrays from the protocol to highlight which benefits provided by various ecosystem components (e.g., riparian and aquatic ecosystems, soils) were important to a broad range of stakeholders. In addition, the protocol can help planners and managers navigate an uncertain future that is likely to experience rapidly changing conditions. This adaptation planning is where the Gila National Forest plan revision team implemented the understanding derived from the drivers-of-change component of the protocol. Specifically, the preliminary draft plan applied the protocol to manage change and uncertainty related to vulnerabilities that may result from weather-related events (U.S. Department of Agriculture, Forest Service 2018).

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