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forest policy

Implementing the 2012 Forest Planning Rule: Best Available Scientific Information in Forest Planning Assessments

C.M. Ryan, L.K. Cerveny, T.L. Robinson, and D.J. Blahna

National forests and grasslands in the United States are governed by land and resource management plans that should be updated every 15 years to reflect changing social, economic, and environmental conditions and to address new priorities. A new forest planning rule finalized in 2012 introduces new planning approaches and requirements, and several forests have completed the forest assessment phase of their planning process. Using document analysis and interview data, we analyzed four completed forest assessments to gain insights into early forest planning efforts under the 2012 rule. We found that forest assessments address the required topics, although the organization and depth of treatment varies across cases; government sources and academic publishers are relied on most often as sources of scientific information; and approaches to best available scientific information rely on peer-reviewed information, agency technical reports and syntheses, and personal expertise and judgement.

Keywords: early adopter, expertise, US Forest Service

Management of the 154 national forests and 20 grasslands in the United States is governed by land and resource management plans (also called forest plans), as required by the National Forest Management Act of 1976 (NFMA; 16 U.S.C. 1604). The forest plan functions as a guiding document that outlines goals, objectives, and strategies for management of the unit. Periodically, the rule related to forest planning is revised to reflect societal changes, new approaches and technologies, and scientific discoveries. For many years the US Forest Service (USFS), which manages the system of national forests and grasslands, has operated under a planning rule finalized in 1982 (47 FR 43026) despite several efforts (2000, 2005, and 2008) to revise and improve the rule (Schultz et al. 2013). A new planning rule issued in April 2012 (77 FR 21161) introduces several significant changes, including a renewed emphasis on collaboration, improved transparency, and a strengthened role for public involvement throughout the planning process. Of interest for our study is the requirement to use the best available scientific information (BASI) to inform the assessment, plan revision decisions, and monitoring program.

To date, little research has addressed implementation of the 2012 planning rule. Schultz et al. (2013) examined approaches to wildlife conservation planning under the new rule, raising concerns regarding potential extirpation of species. Another study analyzed public participation processes in 12 national forests (University of Montana 2015), and Schembra (2013) explored the role of standards and guidelines and how they are used in planning activities. Forest planning under the 2012 rule consists of three phases (assessment, plan development, and monitoring). The assessment phase is important, as it assembles relevant scientific information that planners will rely on to make decisions on forest management in the plan development phase. Our study contributes to this growing body of knowledge by examining the assessment phase of the forest planning process.

Eight "early adopter" national forests, along with several other forests, are currently developing their forest plans using the 2012

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rule. These forests were designated as early adopters because they provide important benefits, had strong existing collaborative networks in place, and needed to revise their forest plans (USDA Forest Service 2012a). The eight early adopter forests are: Cibola (NM), Chugach (AK), El Yunque (PR), Nez Perce and Clearwater (ID), and three forests that are coordinating planning on a regional basis: Inyo, Sequoia, and Sierra (CA).

Although implementation is still in early stages, several of the early adopter forests have completed their forest assessments and draft forest plans, which presents an opportunity to study implementation of the planning process under the new rule. One forest (the Francis Marion in SC) has completed the full plan revision process as of this writing. We examined four forests that have completed their assessments, including three forests identified by the agency as early adopters and one forest that is keeping pace with this group. The study explored three questions: 1) What does the 2012 planning rule require regarding the structure, content, and process for forest assessments? 2) How have forests implemented the directives related to forest assessments under the 2012 planning rule? 3) How are forests approaching the requirement for the use of best available scientific information in their assessments?

Forest Planning under the 2012 Rule

The 2012 planning rule suggests an adaptive approach to forest planning, instructing managers to 1) *assess* forest conditions; 2) *revise or amend* plans if the assessment indicates a need for change; and 3) *monitor* plan implementation (36 CFR 219.5). The process is cyclical, with monitoring data feeding back into the assessment of conditions in the management unit (USDA Forest Service 2012b). During the assessment phase, planners are expected to "rapidly evaluate existing information about relevant ecological, economic, and social conditions, trends, and sustainability, and their relationship to the land management plan within the context of the broader landscape" (36 CFR 219.5(a)(1)). The second phase of the planning process is plan development, amendment, or revision, where planners use the results of the assessment to establish a need for change and generate planning alternatives (36 CFR 219.5(a)(2)), and the public has the greatest opportunity for input. The plan development phase includes environmental impact assessment, public input, and plan publication (36 CFR 219.5(a)(2)). The third phase (monitoring) is an opportunity to track and measure management effectiveness over time (36 CFR 219.5(a)(3)). The planning *process* under the 2012 rule is similar to the process specified under the 1982 rule, but differs in terms of the specific elements required for the *assessment* (2012 rule) and the *analysis of the management situation* (the assessment's counterpart in the 1982 rule).

We focused our study on the assessment phase of the planning process. The assessment phase is important because it requires the forest to assemble and synthesize the most recent, relevant, and highest-quality science on social, ecological, and economic conditions to inform the plan development. Not only does this provide planners an opportunity to evaluate changes in biophysical and socio-economic conditions based on the latest monitoring data, it also represents a chance to reflect on new concepts, models, and methods that result in new scientific information about the local forest environment. Under the 2012 planning rule, the assessment phase identifies existing conditions, trends, risks, uncertainties, and information gaps that are relevant to land and resource management issues in the unit (36 CFR 219.5–219.6). In the assessment phase, the planning unit is not required to generate new studies or information, but is expected to obtain pre-existing information that is publicly available or voluntarily provided (36 CFR 219.6). Information can come from government and nongovernment sources, and the rule instructs the Forest Supervisor to provide opportunities for stakeholders to provide information for the assessment (36 CFR 219.6). The primary product of the assessment phase is an assessment document that evaluates existing information for 15 specific topic areas (Figure 1). Although the general topic areas are mandated by the 2012 rule, the Forest Supervisor has discretion to determine the scope, scale, and timing of the assessment, assuming the other requirements in the planning rule are followed (36 CFR 219.6).

Role of Science in Natural Resource Management

Historically, natural resource management in the United States was guided by the idea of scientific management and Progressive-era approaches (Taylor 1896). In particular, Samuel Hays's "gospel of efficiency" relied on a rational and scientific method of making decisions through a single, central authority. The thought was to avoid conflict via a scientific approach to social and economic issues (Hays 1959, p. 267). The US Forest Service exemplifies the approach of technical rationality and empirical science as the basis for sound resource management practices (Wellman 1987; Kaufman 1960). Foresters and natural resource managers

Management and Policy Implications

Although implementation of the US Forest Service's 2012 planning rule is still in the early stages, several national forests have completed the assessment phase and moved on to the next phase of forest planning. Our analysis of forest assessments from several "early adopter" forests illustrates that forest planners are making serious efforts to address required topics and rely on the best available scientific information. Assessment reports were disproportionately heavy in science related to terrestrial and aquatic ecosystems, and more limited in treatment of infrastructure, land ownership and access patterns, cultural heritage, and areas of tribal importance. Ensuring that assessment teams include broad and diverse disciplinary experts will help address this challenge, recognizing that some forests may not have access to necessary disciplinary specialists. It is also possible that some of the topics (e.g., ecosystem services, tribal and cultural resources, land status and use patterns) simply do not have as much relevant and available information as other topics. Assessment teams may want to consider additional ways to interact with scientists and others to create functioning communities of practice related to science exchange for forest planning. In the same way, agency scientists may consider forging new and enduring relationships with planners and managers that could generate new science that is of immediate relevance. We found similarities across all forests in the most common approaches to identifying BASI in addition to other approaches such as data sharing meetings, a wiki review site, and requests for a science synthesis. Information from non-peer-reviewed sources was more difficult for planners to assess and evaluate. Sharing best practices, along with revised guidance for planning rule implementation, may help national forest planners improve the utility, efficiency, and quality of forest assessments.

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- Terrestrial ecosystems, aquatic ecosystems, and watersheds
- Air, soil, and water resources and quality
- System drivers, including ecological processes, disturbance regimes, and stressors
- Baseline carbon stocks
- Threatened, endangered, proposed and candidate species; potential species of concern
- Social, cultural, and economic conditions
- Benefits people obtain from the planning area (ecosystem services)
- Multiple uses and their contributions to economies
- Recreation settings, opportunities, and access, and scenic character
- Renewable and nonrenewable energy and mineral resources
- Infrastructure (recreational facilities, transportation and utility corridors)
- Areas of tribal importance
- Cultural and historic resources and uses
- Land status, ownership, use, and access patterns
- Existing designated areas including wilderness and wild and scenic rivers; need and opportunity for new designations

Figure 1. Topics for forest plan assessments (36 CFR 219.6)

are expected to incorporate state-of-the-art scientific knowledge to manage public lands (Lachapelle et al. 2003). However, the role of science in natural resource decision-making has become much more complex (Mills and Clark 2001). Recent literature acknowledges that no important policy issue or decision is purely technical, that established practices are problematic, and that politics are unavoidable (Brunner et al. 2005). In spite of this, numerous policies reflect the scientific management paradigm in their calls for best available science.

In the United States, many policies and statutes contain references to best available science, including the Marine Mammal Protection Act of 1972, the Endangered Species Act of 1973, and the Safe Drinking Water Act of 1974. Despite references to the concept of best available science, these policies do not include specific definitions of its properties, standards, or practical application in the decision-making process (Doremus 2004; Smallwood et al. 1999), leading to different definitions of what it means. Ryder et al. (2010) identify attributes of best available science from published literature that span topics such as endangered species legislation, protection of conservation areas, forest management, water resource management, and ocean fisheries. The paper highlights the diversity of attributes assigned to best available science, and demonstrates that no single attribute is common to all studies, suggesting that best available science is context specific (Ryder et al. 2010). Moreover, as Lowell and Kelly (2016) observe, the ability to use best available science may be inhibited by institutional constraints within particular agencies limited by time or organizational capacity. Other literature has attempted to assign descriptors to the concept. For example, "best" often connotes scientific information with the greatest degree of excellence and authenticity based on sound logic (Moghissi et al. 2010), or that there is no better scientific information, and suggests the use of the most relevant and contemporary data and methods (National Research Council 2004). "Available" connotes scientific information that is accessible and attainable (Moghissi et al. 2010), or that decisions can be consistent with the scientific information that is available even though data gaps exist (National Research Council 2004). "Science or Scientific information" is defined as knowledge that emerges from a process of observation, identification, description, and testing of explanatory hypotheses about fundamental principles that govern cause-and-effect (National Research Council 2004). The National Research Council report includes guidelines for effectively using best available science, including concepts of relevance, inclusiveness, objectivity, transparency and openness, timeliness, and peer review. Finally, Charnley et al. (2017) analyzed a science synthesis for three national forests and suggest criteria for evaluating "best available *social* science," which may be different from the criteria used to evaluate best available biophysical science.

A key aspect of the 2012 planning rule is that it requires the planning process to draw on the best available scientific information (36 CFR 219.3). The preamble to the planning rule notes that there is a range of information that can be considered BASI, stating:

> In some circumstances, the BASI would be that which is developed using the scientific method, which includes clearly stated questions, well-designed investigations and logically analyzed results, documented clearly and subjected to peer review. However, in other circumstances the BASI for the matter under consideration may be information from analyses of data obtained from a local area, or studies to address a specific question in one area. In other circumstances, the BASI also could be the result of expert opinion, panel consensus, or observations, as long as the responsible official has a reasonable basis for relying on that scientific information as the best available. (77 FR 21192 [April 9, 2012])

Planning Directives are agency guidance documents that direct implementation of rules such as the 2012 planning rule, and directives for assessments are in Chapter 10 of the Land Management Planning Handbook (USDA Forest Service 2015a). The definition of BASI is contained in the "zero code" chapter of the handbook and specifies three primary criteria for determining BASI: accuracy, reliability, and relevance (FSH 1909.12.07.12), in addition to referencing the Data Quality Act (PL 106–554) for guidance on evaluating available information (Figure 2). Available is defined as information that currently exists in a form useful for the planning process without further data collection, modification, or validation (FSH 1909.07.01).

The directives also provide guidance regarding sources of scientific information. The sources mentioned in the guidance include peer-reviewed articles, scientific assessments, other scientific information (expert opinion, panel consensus, inventories, or observational data), data prepared and managed by the Forest Service

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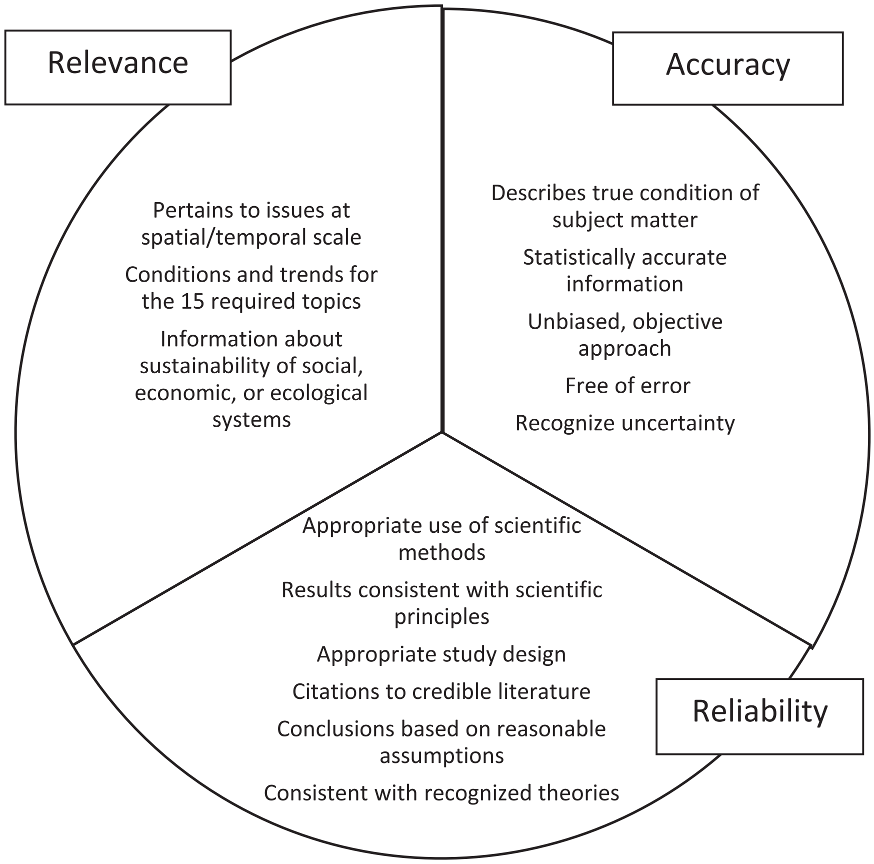

Figure 2. Criteria for determining best available scientific information (BASI). Source: Forest Service Handbook 1909.12.07.12

or other federal agencies, information prepared by universities, national research networks, and other reputable scientific organizations, and data or information from public and governmental participation (FSH 1909.12.07.13).

At the US Forest Service, two regional science synthesis efforts were initiated to assist forest planners in identifying BASI for their assessments. The first synthesis included the Sierra Nevada, southern Cascades, and Modoc plateau areas of California, and informed plan revisions on three national forests (Long et al. 2014). The second synthesis is currently underway as part of the Northwest Forest Plan area planning process, which covers 17 national forests and five Bureau of Land Management units across parts of the Cascade and coastal ranges of Washington, Oregon, and northern California. Once drafted, the synthesis report underwent independent third-party peer review, in addition to public review, and is currently under revision (Spies et al. 2017). Science synthesis efforts represent a noteworthy approach to developing BASI for use in forest assessments, creating a role for public engagement, and for employing a bioregional approach to assembling the latest science for use by multiple forests.

Methods

We used an exploratory case study approach to examine four national forest planning units that were revising their forest plans under the 2012 rule. Information on the USFS website helped us determine the planning status of each national forest as of spring 2015. The primary selection criterion was completion of the assessment process by spring 2015. We also strove to select national forests from different regions. Based on these criteria, we selected the Chugach National Forest (Alaska), Cibola National Forest (New Mexico), Inyo National Forest (California), and the Nantahala and Pisgah National Forests (North Carolina). Table 1 displays characteristics of each national forest planning unit in our sample.

Our research approach relied on content analysis of documents and interview data. We began by conducting a chapter-by-chapter analysis of each forest's assessment report to identify and characterize the information presented. We recorded page counts for each of the 15 assessment topics specified in the 2012 rule. In some cases, the chapters directly aligned with the required topics (Figure 1). In other cases, we had to make a more subjective characterization of the chapter contents. We also noted and analyzed any references to the use of best available science.

Second, as part of the document review, we analyzed data sources used in the assessment. For each assessment report, we identified all of the items cited in the reference section. We then coded each cited item according to the type of publishing entity and the type of document. Every cited item was placed in one category for each coding exercise. For each cited item, we determined the appropriate categories by examining the information in the citation entry and (when necessary) directly reviewing the item or gathering information on the publishing entity. We grouped publishing entities into five types: government; non-government; scientific, scholarly, or peer-reviewed; universities; and unknown or other (Table 2). This categorization approximates the rigor of scientific review, but there is overlap in categories. Most scholarly journals require a double-blind peer-review process, where reviewers and authors are

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Table 1. Characteristics of national forests in the study.

Management unit(s)	Geography	Total acreage* (millions of acres)	Notes on use and resources	Designated early adopter?	Most recent previous plan revision	Notes on current plan revision
Chugach National Forest Alaska Region (R10)	Southcentral Alaska: major geographic areas are Cooper River, Prince William Sound, and eastern Kenai Peninsula	6.26	Subsistence, timber, recreation, mining. Human use concentrated in Kenai area. Very limited road coverage and use in other areas. Habitat for all 5 Pacific salmon species	Yes	2002	Managed by a planning team housed within unit
Cibola National Forest Southwest Region (R3)	West-Central New Mexico: Eight noncontiguous parcels organized around distinct mountainous areas known as "sky islands"	2.11	Recreation, timber, cultural heritage, range. Surrounding region experiencing population growth and demographic changes. Pinyon-juniper & ponderosa pine are predominate vegetation types	Yes	1985	Managed by a planning team housed within unit. Does not include 4 associated national grasslands
Inyo National Forest Pacific Southwest Region (R5)	Eastern California & West Nevada: Two noncontiguous parcels at intersection of Sierra Nevada, Great Basin, and Mojave Desert areas	2.07	Water supply, hydroelectricity, recreation, timber, range. Nearly 47% of total area is wilderness. Focus on wildland fire management. Substantial variation in vegetation type, habitat, and elevation	Yes	1988	One of three early adopters in R5. Coordination through a regional planning team, with separate planning teams for each unit. Each unit releases its own assessment & forest plan. Joint EIS for 3 units
Nantahala & Pisgah National Forests Southern Region (R8)	Western North Carolina: Blue Ridge region of Appalachian Mountains	2.48	Timber, recreation, cultural/historical heritage, water development. Located in Blue Ridge National Heritage Area. Hardwood forest with high species diversity	No	1987	Both units will use same revised plan. Managed by planning team housed at NF in NC headquarters

*Total acreage includes NFS-owned land and acreage under other ownership within each unit. Source: USDA Forest Service 2015b.

Table 2. Categories for coding type of publishing entity.

Publishing entity	Description of coding criteria
Government	Federal, tribal, state, or local governments in the United States; foreign governments; international intergovernmental groups such as the United Nations and affiliates. Includes peer-reviewed and non-peer-reviewed materials
Non-government	Materials not published by a government agency, university, or peer-reviewed entity. Includes businesses, consulting firms, and advocacy groups
Scientific scholarly or peer reviewed	Associations, societies, journal publishers, university presses, or other entities that produce peer-reviewed scientific or scholarly material
Universities	Materials from universities that may or may not be subject to rigorous academic peer review. Includes university or college departments, programs, laboratories, and centers, and theses and dissertations from universities
Unknown or other	News organizations or other undefined groups; disposition of publisher could not be determined

unknown to each other. University and government agency scientific documents often require peer review, but the level of rigor of the review may be variable. It was not possible to discern the level or type of peer review or scientific rigor for each category.

For the type of document, we sorted the references into 12 categories: academic book; non-academic book; conference proceeding; correspondence; database; scientific journal; news; technical report; statute or regulation; thesis or dissertation; website; and unknown (Table 3).

Our final data collection activity was qualitative interviewing with members of the planning teams at three of the forests in our study. We conducted nine semi-structured interviews (nine people in total; three interviews each from three forests). Unfortunately, we were not able to recruit interview participants from the Cibola planning effort. Potential interview participants were identified through the list of preparers included in each assessment document. Interviewees were subject matter experts who had contributed material to the assessment reports, along with planning staff officers or coordinators. Interview questions explored the overall structure of the assessment process, the role of the planning directives, the overall organization of the forests' plan revision efforts, and approaches to identification and use of best available science. Interviews were audio-recorded, transcribed, and analyzed using content analysis with a coding framework developed by the study team. Content analysis is a method that uses codes, or labels that assign meaning to descriptive or inferential data collected during a study (Miles et al. 2014). The codes are used to retrieve and organize similar data and aid the researcher in relating data to research questions, theoretical concepts, and themes (Araujo 1995; Miles et al. 2014).

Results

We present results of our analysis in three sections: 1) required topics; 2) sources and types of information; and 3) identifying and using BASI.

Required topics in the forest assessment

The number and percent of pages devoted to each required topic is presented in Table 4. We did not include introductory front matter in the page counts. A 0* entry means that the assessment report did not

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Table 3. Categories for coding type of document.

Document type	Description of coding criteria
Academic book	An item printed, bound, distributed as a book, or released as an e-book by a peer-reviewed/scholarly entity
Non-academic book	An item printed, bound, distributed as a book, or released as an e-book by an entity whose primary orientation is not peer reviewed/scholarly
Conference proceeding	Papers, abstracts, and talks presented at a conference and published in a conference proceeding collection
Correspondence	Letters or emails written by individuals of any affiliation
Database	Raw data or data analysis tools/software; online databases
Scientific journal	A peer-reviewed article in a scholarly journal
News	Articles in newspapers (print or online) and news magazines
Technical report	Technical and research reports, white papers, policy papers, fact sheets, briefings
Statute, regulation, and planning documents	Federal, state, or local laws and rules; EISs; management plans; strategic plans
Thesis or dissertation	Advanced degree projects and papers
Website	One or more webpages on a non-database website, including encyclopedias with narrative entries
Unknown	The type of document could not be discerned

Table 4. Page counts and percentages of total pages for 15 required assessment topics.

		Number of pages (pct. of total pages in report)				Pct.
Topic #	Assessment topics (per 36 CFR 219.6)	Chugach	Cibola	Inyo	N&P	Avg.
1	Terrestrial ecosystems, aquatic ecosystems, and watersheds	66 (22.9%)	51.5 (11.2%)	38.5 (21.0%)	29 (15.7%)	**17.7**
2	Air, soil and water resources and quality	17 (5.9%)	88 (19.2%)	9 (4.9%)	19 (10.3%)	**10.1**
3	System drivers (processes, disturbance regimes, and stressors)	40 (13.9%)	21 (4.6%)	15 (8.2%)	7 (3.8%)	**7.6**
4	Baseline carbon stocks	7 (2.4%)	6 (1.3%)	4 (2.2%)	7 (3.8%)	**2.4**
5	Threatened, endangered, candidate species; potential species of conservation concern	12 (4.2%)	36 (7.9%)	24 (13.1%)	4 (2.2%)	**6.8**
6	Social, cultural, and economic conditions	21 (7.3%)	71 (15.5%)	14 (7.7%)	8 (4.3%)	**8.7**
7	Benefits obtained by people (ecosystem services)	49 (17.0%)	0* (0.0%)	2.5 (1.4%)	4 (2.2%)	**5.1**
8	Multiple uses and their contributions to economies	0* (0.0%)	26 (5.7%)	15 (8.2%)	17 (9.2%)	**5.8**
9	Recreation settings, opportunities, and access, and scenic character	29 (10.0%)	39 (8.5%)	15.5 (8.5%)	21 (11.4%)	**9.6**
10	Renewable and nonrenewable energy and mineral resources	17 (5.9%)	18 (3.9%)	3.5 (1.9%)	8 (4.3%)	**4.0**
11	Infrastructure	2 (0.7%)	12 (2.6%)	9.5 (5.2%)	10 (5.4%)	**3.5**
12	Areas of tribal importance	2 (0.7%)	13 (2.8%)	4.5 (2.5%)	3 (1.6%)	**1.9**
13	Cultural and historical resources and uses	3.5 (1.2%)	40 (8.7%)	7 (3.8%)	23 (12.4%)	**6.6**
14	Land status and ownership, use, and access patterns	8 (2.8%)	17 (3.7%)	7 (3.8%)	9 (4.9%)	**3.8**
15	Designated areas, potential/need for new designations	15 (5.2%)	20 (4.4%)	14 (7.7%)	16 (8.7%)	**6.5**
	TOTAL	**288.5**	**458.5**	**183**	**185**	**100**

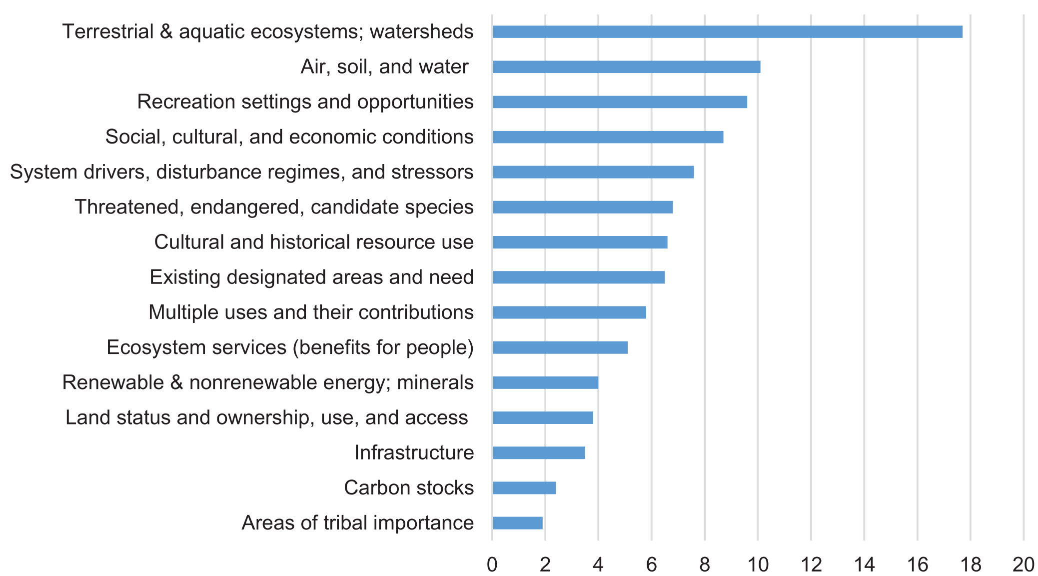

Figure 3. Average percentage of pages devoted to each topic in each forest assessment for all forests combined

have any pages that were specifically devoted to the topic, but references to the topic were instead interspersed throughout the report and it was too difficult to separate them from other topic page counts.

Two of the national forests (Inyo and Nantahala-Pisgah) published assessment reports that consisted of 15 chapters that directly reflected each of the required topics. Meanwhile, the Chugach and Cibola took a different approach; some of the chapter topics aligned with the topic requirements in the 2012 rule, but other required topics were broken up and distributed among multiple chapters. For example, the Chugach had one chapter for areas of tribal importance and one chapter for land status and ownership, but divided the terrestrial and aquatic ecosystems and watersheds

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Table 5. Percent allocation of predominant topics among four forest assessments.

Rank	Chugach topics	Pct.	Cibola topics	Pct.	Inyo topics	Pct.	N&P topics	Pct.
1	Terrestrial and aquatic ecosystems	23%	Air, soil, and water	19%	Terrestrial and aquatic ecosystems	21%	Terrestrial and aquatic ecosystems	16%
2	Benefits obtained by people (ecosystem services)	17%	Social, cultural, and economic conditions	16%	Threatened and endangered species	13%	Cultural and historic resources	12%
3	System drivers, disturbance regimes, and stressors	14%	Terrestrial and aquatic ecosystems	11%	Recreation settings and opportunities	9%	Recreation settings and opportunities	11%
4	Recreation settings and opportunities	10%	Cultural and historic resources	9%	System drivers, disturbance regimes, and stressors	8%	Air, soil and water	10%
5	Social, cultural, and economic conditions	7%	Recreation settings and opportunities	9%	Multiple uses	8%	Multiple uses	9%
Total		71%		63%		59%		59%

into five chapters, one each for watersheds, fish, wetlands, vegetation, and wildlife, and these chapters were integrated with material discussing soils and carbon stocks. Two forests did not have any pages specifically devoted to one required topic each (benefits obtained by people for the Cibola, and multiple uses for the Chugach), but these subjects were still referenced in the context of the other topics.

For all four assessments combined, the required topic with the largest average percentage of pages was terrestrial and aquatic ecosystems and watersheds (17.7%), followed by air, soil, and water resources (10.1%) and recreation opportunities (9.6%) (Figure 3).

Terrestrial and aquatic ecosystems and watersheds comprised the largest section of the assessment for three of the four forests. Air, soil, and water was especially prominent for the Cibola National Forest, and all of the forest assessments covered recreation evenly. In contrast, the three required topics with the smallest page counts, on average, were areas of tribal importance (1.9%), carbon stocks (2.4%), and infrastructure (3.4%). Benefits obtained by people (ecosystem services) had the most variable coverage, with one of the shortest sections for three of the four forest assessments, but the second longest topic for the Chugach National Forest. In all four assessment documents, benefits obtained by people were mentioned throughout the document in sentences or paragraphs at too fine a scale for this analysis to count.

We found some variation among the forest assessments in terms of the extent to which a forest focused on a particular topic (Table 5).

For the Chugach National Forest, the top five topics comprised more than 70% of the assessment, with the bulk emphasizing terrestrial and aquatic ecosystems, which reflects the importance of salmon habitat. The Chugach was the only forest to emphasize ecosystem services as a predominant framework to capture benefits obtained by people. However, other forests may have captured this topic under the category of multiple uses. Disturbance regimes (fire and invasive species) were also important for the Chugach. The Cibola National Forest was unique in their emphasis on air, soil, and water as well as social, cultural, and economic conditions and cultural and historic sites. Because water access is very important in the southwest, the predominance of this topic is not surprising. For the Inyo National Forest, the topic of threatened and endangered species was prominent, while topics related to recreation and disturbance regimes (fire, invasive species, and other ecosystem stressors) were also important. Meanwhile, cultural and historical resources were prominent in the Nantahala and Pisgah National Forests, along with recreation.

Although the 2012 rule provides a list of 15 distinct required topics, these topics overlap and are not discussed in complete isolation from one another. As we found in our analysis, it is difficult to discuss multiple uses without also discussing benefits obtained by people; air, soil, and water resources; recreation; and terrestrial and aquatic ecosystems and watersheds. In our analysis, we often found that an assessment chapter devoted to a required topic also contained information that closely resembled material discussed elsewhere. In particular, we found the chapters on multiple uses and benefits obtained by people to be largely redundant, given the other topics that were also included in the report.

Sources and types of information in the forest assessment

To understand the sources and types of information used in the assessments, we conducted a systematic examination and tally of citations by publication source and type. Overall, government sources were the most commonly cited information source (51.8%), followed by scientific scholarly publications (30.7%) (Table 6).

Table 6. Citations based on information source for forest assessments.

	Count (Percent)				
Publishing entity	Chugach	Cibola	Inyo	Nantahala & Pisgah	TOTAL (Mean)
Government	239 (53.6%)	159 (49.8%)	131 (49.8%)	109 (54.0%)	**638 (51.8%)**
Scientific scholarly or peer reviewed	155 (34.8%)	82 (25.7%)	82 (31.2%)	63 (31.2%)	**382 (30.7%)**
Non-government	21 (4.7%)	39 (12.2%)	24 (9.1%)	18 (8.9%)	**102 (8.7%)**
Universities	30 (6.7%)	39 (12.2%)	19 (7.2%)	11 (5.5%)	**99 (7.9%)**
Unknown or other	1 (0.2%)	0 (0%)	7 (2.7%)	1 (0.5%)	**9 (0.9%)**
TOTAL	446	319	263	202	**1230**

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Table 7. Citations based on document type for forest assessments.

Document type	Count (Percent)				
	Chugach	Cibola	Inyo	Nantahala & Pisgah	**TOTAL**
Technical report	174 (39.0%)	121 (37.9%)	108 (41.1%)	73 (36.1%)	**476 (38.5%)**
Scientific journal article	129 (28.9%)	47 (14.7%)	63 (24.0%)	48 (23.8%)	**287 (22.8%)**
Academic book	28 (6.3%)	36 (11.3%)	20 (7.6%)	15 (7.4%)	**99 (8.2%)**
Statute, regulation, or planning document	43 (9.6%)	26 (8.2%)	23 (8.8%)	12 (5.9%)	**104 (8.1%)**
Website	33 (7.4%)	42 (13.2%)	3 (1.1%)	13 (6.4%)	**91 (7.0%)**
Database	17 (3.8%)	25 (7.8%)	17 (6.5%)	18 (8.9%)	**77 (6.8%)**
Conference proceeding	10 (2.2%)	3 (0.9%)	6 (2.3%)	18 (8.9%)	**37 (3.6%)**
Non-academic book	4 (0.9%)	9 (2.8%)	10 (3.8%)	0 (0.0%)	**23 (1.9%)**
Correspondence	0 (0.0%)	7 (2.2%)	5 (1.9%)	4 (2.0%)	**16 (1.5%)**
Thesis or dissertation	8 (1.8%)	2 (0.6%)	2 (0.8%)	1 (0.5%)	**13 (0.9%)**
News	0 (0.0%)	1 (0.3%)	3 (1.1%)	0 (0.0%)	**4 (0.4%)**
Unknown	0 (0.0%)	0 (0.0%)	3 (1.1%)	0 (0.0%)	**3 (0.3%)**
TOTAL	446 (100.0%)	319 (100.0%)	263 (100.0%)	202 (100.0%)	**1230 (100.0%)**

A large portion of the government sources included US Forest Service publications (average of 28%), which were more commonly cited than other federal government sources (average of 12%) or state and local governments (average of 11%). Some variation exists among the forests in our sample, but the trends were consistent in terms of reliance on government sources and scholarly peer-reviewed publishers for the majority of citations (82.5% combined average for both categories). The Chugach relied to a greater degree on scholarly publications than other forests. The Cibola had the highest proportion from non-governmental organizations and trade groups (12.2%). The Inyo and the Nantahala and Pisgah mirrored the group average.

Next, we explored citations by the type of document referenced. We found that technical reports were the most common type of document cited in the assessments, with an average of 38.5% (Table 7).

The technical report classification is broad and includes technical and scientific reports, policy briefings, white papers, and other types of information (sometimes referred to as gray literature). All four forests were consistent in the ratio of technical reports cited. The second most common document type was the scientific journal article, with an average of 23%, although the Cibola assessment featured far fewer than the other forests. All of the forests cited a wide variety of regulations, statutes, and planning documents, (e.g., water quality regulations, county comprehensive plans, environmental impact statements, state resource management plans, and forest plans). The Cibola assessment featured the greatest variety of document types, relying on websites and academic books more than the other forests. The Nantahala and Pisgah assessment relied more heavily on conference proceedings. The least commonly cited document types, on average, were news articles (0.4%), theses or dissertations (0.9%), and correspondence (1.5%). Although there is a separate category for websites, documents in many of the other categories were readily available online.

Table 8. Approaches to identifying and using BASI from interview data.

BASI approach	Chugach	Nantahala/ Pisgah	Inyo
Literature review (e.g. Google Scholar for scholarly literature)	x	x	x
Forest Service reports, monitoring data	x	x	x
Personal expertise/training/judgement	x	x	x
Existing dataset/database	x		x
Nearby Forest Service research station		x	x
Nearby university		x	
Host data sharing meeting (partners and stakeholders)		x	
Meet with scientists		x	
Post draft documents on wiki site for public review/editing			x
Other public review opportunity		x	
Gray ("non-peer-reviewed") literature, traditional knowledge			x

Identifying and using best available scientific information in the forest assessment

In interviews, respondents were asked how they identified and obtained BASI for their assessment. Table 8 displays the different approaches used by three of the four forests.

Literature reviews and searches, Forest Service reports and datasets, and personal scientific expertise were mentioned by all nine respondents as primary ways that they identified and obtained BASI. Literature reviews focused on identifying peer-reviewed journals, conference proceedings, or agency reports. Existing datasets and nearby Forest Service research stations and universities were also relied upon. The Sierra Nevada science synthesis effort, which informed the Inyo National Forest assessment, took nearly 18 months to complete (Long et al. 2014). The Inyo also posted draft documents on a wiki site for public review and editing. All nine interviewees stated that their assessment team used the Draft Planning Directives, but also mentioned that the directives were not clear, save for the focus on organizing around the 15 topics. No respondent mentioned specific guidance beyond the draft directives on how to identify BASI. The final directives do specifically address the definition of BASI, as discussed above (Figure 2). Gray literature and traditional knowledge presented challenges, as it at times conflicted with peer-reviewed information. Two respondents mentioned that they wanted to incorporate this type of information, but were unsure how to do so.

Assessments must document what information was determined to be BASI, explain the basis for that determination, and explain how the information was applied to the issues considered (36 CFR

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219.3). Our analysis of the assessment documents reveals that all documents discuss the use of high-quality and valid scientific information, citing criteria such as clearly defined and well-developed methodology; standardized methodology; logical conclusions; and reasonable inferences (Chugach National Forest 2014; Inyo National Forest 2014; Nantahala and Pisgah National Forests 2014; Cibola National Forest and National Grasslands 2015). The assessments for all forests mention their reliance on information relevant to their specific forests and issues. Only the Nantahala-Pisgah assessment presented a hierarchy of information sources, with peer-reviewed journal articles the highest, followed by government documents and reports, monitoring datasets, theses and dissertations from universities, and expert opinion where facts were not known through the other sources.

Discussion

The 2012 forest planning rule requires that each national forest or grassland conduct a scientific assessment to guide plan development. We found that assessment reports were disproportionately heavy in science related to terrestrial and aquatic ecosystems, and more limited in treatment of infrastructure, land ownership and access patterns, cultural heritage, and areas of tribal importance. Recreation was the only topic to receive consistent attention across all four forests, although the topic was overshadowed by terrestrial and aquatic ecosystems. We may only speculate about why terrestrial and aquatic ecosystem information was the most prevalent in all four forests, but it is consistent with agency administrative hiring practices since the 1980s that have emphasized recruitment of ecologists, biologists, and other biophysical scientists, compared to social scientists, for example (Thomas and Mohai 1995). The abundance of agency specialists in these topic areas may reinforce the relative importance of terrestrial and aquatic ecosystems compared to other topic areas, such as recreation, social science, or cultural resource management. This has been confirmed by a national assessment of interdisciplinary planning team composition (Cerveny et al. 2011). Ensuring that assessment teams include broad and diverse disciplinary experts will help address this challenge, recognizing that some forests may not have access to necessary disciplinary specialists. It is also possible that some of the topics (e.g., ecosystem services, tribal and cultural resources, land status and use patterns) simply do not have as much relevant and available information as other topics.

The benefits obtained by people (ecosystem services) topic received little or no explicit coverage in all but one assessment. The limited coverage of ecosystem services may make sense because it was not even considered an area of research until the late 1990s, so there would be less existing information on certain important ecosystem service topics (e.g., pollination, stormwater attenuation, medicinal resources, and spiritual and historical significance) compared to recreation, threatened and endangered species, and other traditional assessment topics (Blahna et al. 2017). Previously, "forest benefits to people" were considered elements of "multiple use" and planners might have addressed these benefits under the "multiple use" topic. Ecosystem services (ES) are often categorized into four classes: provisioning, regulating, cultural, and supporting. Timber, recreation, wildlife, and other traditional forest planning topics all fall into one of these four classes. Another reason for lack of coverage of ecosystem services may be that planners could not differentiate the normal assessment topics from the ecosystem service classes. Efforts to help planning team members understand ecosystem services approaches and how they can be used to inform the planning process may be warranted, and the rule's current requirement for only using existing data in assessments may need to be revisited (Blahna et al. 2017). For example, implementation teams working on ecosystem services may consider the benefits of providing specific tools, frameworks, and guidelines for integrating ecosystem services models into the forest planning process. In addition, critical issues and topics (e.g., newly listed threatened or endangered species, or changing recreation behaviors) that forest plans need to address may change from one planning cycle to the next.

The specific required topics may not be universally appropriate for every planning unit. Planners felt obligated to address all 15 topics, but the lack of coverage for some topics suggests that the topic was not deemed relevant or meaningful for their plan, there was no available data on the topic, or it was unclear how the topics could be covered. Variability in application of the directives, and acknowledgment of local context and conditions, is consistent with the overall Forest Service approach toward decentralized decision-making (Kaufman 1960; Tipple and Wellman 1991; Koontz 2007) and localized interpretation by planning teams, similar to "street-level" bureaucrats who create de facto policy through everyday practice (Sabatier et al. 1995; Lipsky 2010; Trusty and Cerveny 2012). Kaufman (1960) observes the traditional Forest Service practice of maintaining control of heterogeneous and geographically dispersed management units by issuing centralized directives that provide parameters (or "side boards") within which line officers have some leeway to make decisions. This tendency toward uniformity and "pre-formed" decisions may result in some inefficiencies and omissions. The implied obligation to cover all 15 topics may have resulted in some assessments that distract from the most important management issues for the unit. This will be especially important during the next stage of planning—revision or amendment—where the assessment data will be used to analyze different management scenarios. Approaches for identifying and analyzing the most relevant assessment data that address the key environmental problems or social conflicts that confront each planning unit will be needed (Blahna et al. 2017). This is especially important for topics like human benefits (ecosystem services) and multiple uses, which cut across all of the other topical areas and are not as easily categorized in assessments. Recent efforts to engage the public in science synthesis efforts in support of forest planning suggest that there may be an important role for the public to help prioritize forest assessment topics.

The most common sources of information were government sources, followed by scholarly academic sources. Many of the agency sources were peer-reviewed scientific studies, which appear to be especially useful because of the topical specificity or geographic focus (relevance). Although not all technical reports are peer reviewed, they may be more accessible and usable compared to scholarly journal articles, which may require planning team members to interpret the findings and make inferences for relevance to local conditions. This finding is consistent with previous research examining the information needs and sources of Forest Service fire managers (Ryan and Cerveny 2011) and recreation managers (Ryan and Cerveny 2010). Fire managers relied heavily on agency information sources. Although managers in the study noted the availability of high-quality, relevant information, they faced significant barriers in terms of time, funding,

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and personnel to access and use that information. Similarly, recreation managers also relied on agency information sources, but indicated strong preferences for enhanced interactions with agency scientists, including collaborative research, conferences, and a desire for agency researchers to reach out more directly to managers to ensure their research was relevant and useful. With regard to forest assessments, engagement with scientists is particularly important for topics where little research is available. Assessment teams may want to consider additional ways to interact with scientists and others to create functioning communities of practice related to science exchange for forest planning. In the same way, agency scientists may consider forging new and enduring relationships with planners and managers that could generate new science that is of immediate relevance.

The 2012 planning rule and its directives provide criteria for BASI, and we found similarities across all forests in the most common approaches to identifying BASI, in addition to other approaches, such as data sharing meetings, a wiki review site, and requests for a science synthesis. Information from non-peer-reviewed sources was more difficult for planners to assess and evaluate, and it is not clear how this information was incorporated into each assessment. Teams may not have the capacity to separately evaluate and assess the many different types and sources of information, and so they rely on hierarchical ranking approaches (peer-reviewed sources being highest rank) to streamline the evaluation. Planning teams clearly value peer-reviewed and agency-generated information, and it may be that they are simply identifying information that is "available" and using the "best" of that based on their judgments. This may result in situations where the science expertise on each team could influence BASI decisions. As discussed above, consideration of the makeup and membership of the assessment team is important here, as well as increased transparency regarding the process for determining science relevance and quality.

Conclusion

Implementation of the US Forest Service 2012 planning rule is still in its early stages. Our study illustrates that forest planners use a variety of approaches to address required topics, and do rely on BASI as they develop their forest assessments. While each national forest assessment included the 15 required topics, we found considerable variation in coverage, which suggests that planners may emphasize topics most relevant to their forest, or that variation exists in terms of what science or planning team expertise is available or deemed desirable. The predominance of science related to terrestrial and aquatic ecosystems in the assessments compared to other topics warrants further inquiry in order to learn whether this asymmetry is based on policy, availability of information, existing expertise, or other factors. Efforts to include the public in the process of prioritizing topics for the assessments could also be evaluated. The reliance on government sources for scientific information suggests that agency-supported science is either more accessible or more relevant to the planning team. It also suggests that there may be benefits to bolstering "communities of practice" for key topical areas covered by forest assessments that bring together university and agency scientists with managers.

The appearance of science in an assessment report is important, but the actual *use* of science in planning may be more important. Although our findings are not generalizable to all national forests, they do provide an understanding of plan assessment activities for those in the early phases of forest planning, whose efforts are likely to inform and influence other national forests. Our goal was to provide an early glimpse of plan revision efforts in order to highlight important lessons learned and create a foundation for future research. For example, do planners find that the required topics provide useful guidance for developing their assessments? How can planners become more confident in knowing what BASI is, and how to identify and use it? Is additional guidance needed for incorporation of traditional knowledge and other information? Of particular interest is whether the "science synthesis" information is useful to forest planners in addressing their forest assessment needs, given the significant agency resources devoted to developing science syntheses. Finally, how is information from the assessment used in forest plan revision (development and selection of management options) and monitoring efforts? While draft environmental impact assessment (EIS) reports are available in various stages, as of this writing only one final Record of Decision (ROD) has been issued for a forest plan undergoing revision under the 2012 rule. Thus, it remains to be seen how scientific information will be incorporated in development of alternatives, impact statements, and final management decisions.

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