

Developing A Framework for the U.S. Forest Service Broader-Scale Monitoring Strategy: Processes and Outcomes

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Executive Summary

The 2012 U.S. Forest Service (USFS) Planning Rule requires “the development of a broader-scale monitoring strategy [BSMS] for plan monitoring questions that can best be answered at a geographic scale broader than one plan area.” The Southwest Ecological Restoration Institutes (SWERI) in partnership with the USFS Southwestern (Region 3) and Rocky Mountain (Region 2) Regions developed a framework for a regional broader-scale monitoring strategy. The project included a multi-step process designed to capture input from stakeholders, USFS staff, other agency partners, and other monitoring experts to best meet the intent and requirements of the 2012 Planning Rule. A BSMS framework was synthesized from four state-based workshops in 2016 (AZ, NM, CO, WY), and more than 90 interviews.

The following recommendations and observations capture the major findings from this process. Additionally, a set of example potential broader-scale monitoring questions, indicators, and datasets were developed and can be found in Appendix C.

Primary recommendations for a broader-scale monitoring strategy:

- 1) Increase efficiency. The planning rule directs the USFS to increase efficiencies, while also addressing stressors and threats at the landscape scale. Suggested mechanisms to increase efficiency include:
 - Develop a common set of broader-scale monitoring questions at the regional level.
 - Identify existing monitoring that meets BSMS criteria.
 - Aggregate existing data from forest-level monitoring.
 - Standardize the monitoring indicators and data collection protocols within and across national forests.
 - Utilize existing corporate data and analytical capacity.
 - Support and share USFS innovations developed at forest and regional levels.
 - Share lessons learned, including processes, collaboration, and monitoring resources between and across partners and landscapes.
 - Coordinate data sharing and data management within and across agencies and partnerships.
- 2) Build Capacity. A BSMS requires capacity at regional or sub-regional levels for implementation. The planning rule states the need for a BSMS to occur within existing funding levels; no new funding was allocated for a BSMS. We suggest additional capacity gains may be accomplished from utilizing existing staff, USFS corporate and partner resources, as well as increasing monitoring efficiencies across forests.
 - Dedicate technical expertise to assist with question and protocol development and integration, data roll-up, and assessment.
 - Plan for technical training and education for USFS staff.
 - Work with high capacity partners (state and federal agencies, non-profits, tribes) strategically and efficiently to fill BSMS monitoring gaps.
 - Dedicate regional staff for coordination, communication, and adaptive management recommendations.
 - Engage line officers and forest staff in BSMS development.

- 3) Capitalize on existing opportunities. The planning rule suggests multiple broad-scale monitoring strategies and sub-strategies can be developed to meet the BSMS requirement. This allows a flexibility to be opportunistic across the forests in a region.
 - Capture BSMS needs for each forest as opportunities arise through forest planning.
 - Link monitoring to forest plan assessment through the forest planning process.
 - Utilize national-level reviews of forest-level monitoring plan development.

To achieve these recommendations, participants also recommended specific communication needs and partnership engagement opportunities:

BSMS communication:

- 1) Identify opportunities to work closely with other land and wildlife management agencies to better understand key stressors and threats across boundaries.
- 2) Identify efficient and effective strategies for collecting BSMS data and communicating BSMS results and information back to forests and other audiences. Clear articulation of the audiences for BSMS data delivery, and the appropriate time intervals for that communication are needed.
- 3) Formal communication methods are recommended given the high level of turn-over within USFS positions. Similar to sharing innovations, in-person workshops are preferred; report delivery or web delivery are less effective for information dissemination.

BSMS partner engagement:

- 1) USFS regional and forest leadership should work together to identify partnership opportunities and develop partnership strategies prior to engaging partners in the process.
- 2) Technical workshops with USFS resource professionals (at regional and forest levels) and corporate analysts will clarify existing BSMS strategies already in place, and allow for more strategic engagement with partners.
- 3) Use third-party facilitation to strategically engage partners with technical expertise prior to public engagement.

An over-arching recommendation across four workshops and 90 interviews is that a BSMS can build on current monitoring efforts. Existing data and existing monitoring that meets BSMS criteria should be leveraged, and monitoring indicators and data collection protocols should be standardized within and across national forests and surrounding landscapes. Increased coordination and understanding across agencies will support an “all-lands” approach to land management and engage partners in monitoring across land management jurisdictions.

Introduction

In order to meet the requirements and goals of developing a Broader-Scale Monitoring Strategy (BSMS) under the 2012 USFS Planning Rule (hereafter, the Planning Rule), the USFS Southwestern (Region 3) and Rocky Mountain (Region 2) Regions, with the Southwest Ecological Restoration Institutes (SWERI)¹, identified and tested a process to collaboratively design a BSMS framework for the USFS Southwestern and Rocky Mountain Regions. In addition to the process, the project goals included identifying potential BSMS monitoring questions, indicators, and associated parameters (scale, databases, and potential governance approaches). Products from this project also should inform the development of a BSMS in other National Forest System regions. This report discusses the statewide workshops conducted during the second year of the project and includes final project recommendations for developing a BSMS. This project was developed and conducted by SWERI and the USFS Southwestern Region (Region 3) and the USFS Rocky Mountain Region (Region 2), with support from and in partnership with the USFS Washington Office (National Forest System and State and Private Forestry), and the Rocky Mountain Research Station (RMRS).

Project Objectives and Timeline

This project was governed by a steering committee composed of line officers and leadership from USFS Southwestern and Rocky Mountain Regions, the RMRS, the Ecosystem Management Coordination group, the Inventory, Monitoring and Assessment (IMA) group, State and Private Forestry, State Forestry, and SWERI. To develop the project process and ensure deliverables are met, a core project team was developed composed of planners from the Southwestern and Rocky Mountain Regions, RMRS researchers, IMA staff, and SWERI researchers.

The BSMS project included the following phases:

1. **Interviews conducted with stakeholders, USFS staff, other agency partners, and other monitoring experts.** The goals of this phase were to inform the development of a BSMS by gaining a better understanding of the opportunities, barriers, and gaps relevant for developing a BSMS. A report based on this phase was completed in late fall 2015 and is available at: <http://sweri.eri.nau.edu/BroadscaleMonitoring.html>.
2. **Statewide workshops to further develop the BSMS strategy.** These workshops took place in Arizona, New Mexico, Colorado, and Wyoming during spring 2016 and brought together USFS staff, USFS and other subject-matter experts, and key partners to develop the BSMS.
3. **Summary report and recommendations on the process and framework for the BSMS in the Southwestern and Rocky Mountain Regions.** This report serves as the final report, consolidating findings and recommendations based on the previous two phases of work. It was completed in September of 2016.

¹ Southwest Ecological Restoration Institutes (SWERI) include the Ecological Restoration Institute, Northern Arizona University; the Colorado Forest Restoration Institute, Colorado State University and the New Mexico Forest and Watershed Restoration Institute, New Mexico Highlands University.

Overview of Broader-Scale Monitoring Under the 2012 Planning Rule

Monitoring is one of three critical components of the 2012 USFS Planning Rule framework. The monitoring section of the rule calls for monitoring at the unit (i.e., national forest) level and also at a broader scale. All monitoring is meant to “enable the responsible official to determine if a change in plan components or other plan content that guide management of resources on the plan area may be needed” (77 FR 21161). The monitoring program will include specific monitoring questions and indicators (77 FR 21161).

The rule requires “the development of a broader-scale monitoring strategy [BSMS] for plan monitoring questions that can best be answered at a geographic scale broader than one plan area.” Specifically, the planning rule section on “Broader-scale monitoring strategies” at 36 CFR 219.12 (a) and (b) states:

a. Plan monitoring program: The plan monitoring program should be coordinated and integrated with relevant broader-scale monitoring strategies to ensure that monitoring is complementary and efficient, and that information is gathered at scales appropriate to the monitoring questions.

b. Broader-scale monitoring strategies:

- (1) The regional forester shall develop a broader-scale monitoring strategy for plan monitoring questions that can best be answered at a geographic scale broader than one plan area.
- (2) When developing a monitoring strategy, the regional forester shall coordinate with the relevant responsible officials, USFS State and Private Forestry, and USFS Research and Development, partners, and the public. Two or more regional foresters may jointly develop broader-scale monitoring strategies.
- (3) Each regional forester shall ensure that the broader-scale monitoring strategy is within the financial and technical capabilities of the region and complements other ongoing monitoring efforts.
- (4) Projects and activities may be carried out under plans developed, amended, or revised under this part before the regional forester has developed a broader-scale monitoring strategy.

Several other points are worth noting from the Planning Rule preamble. The expectation is that “over time, the two-level approach to monitoring is expected to increase monitoring efficiencies and decrease the cost of other planning related activities” (77 FR 21161). Addressing the “all-lands” approach, first described by Secretary of Agriculture Tom Vilsack, is a key component and purpose of the Planning Rule.

The monitoring requirements of the Planning Rule are intended to help the agency use the best available science, incorporate new information, adapt to changing conditions, and keep plans up-to-date in order to meet current and future needs. The **forest-level** monitoring plans are directed to inform forest management and contain monitoring questions and associated indicators for eight key areas identified in the Planning Rule:

- I. The status of select watershed conditions (219.12(a)(5)(i))
- II. The status of select ecological conditions (including key characteristics of terrestrial/aquatic ecosystems) (219.12(a)(5)(ii))
- III. The status of Focal Species to assess ecological conditions (219.12(a)(5)(iii))
- IV. The status of select ecological conditions that contribute to the recovery of T&E species, conserve proposed and candidate species, and maintain a viable population of species of conservation concern (219.12(a)(5)(iv))
- V. The status of visitor use, visitor satisfaction, and progress toward meeting recreation objectives (219.12(a)(5)(v))
- VI. Measureable changes on the plan area related to climate change and other stressors (219.12(a)(5)(vi))
- VII. Progress toward meeting desired conditions and objectives (including those for multiple uses) (219.12(a)(5)(vii))
- VIII. The effects of management systems so that they do not substantially and permanently impair the productivity of the land (219.12(a)(5)(viii) and 16 U.S.C. 1604(g)(3)(C) – NFMA)

Additionally, Planning Rule authors and implementers readily recognize the importance of social and economic monitoring and refer to this direction in the USFS Handbook:

FSH 1909.12 sec 32.13(f) Indicators addressing the plan contributions to communities, social and economic sustainability of communities, multiple use management in the plan area, or progress toward meeting the desired conditions and objectives related to social and economic sustainability.

Not all forest plan monitoring questions will have application at the broader-scale; conversely, to meet all-lands opportunities and work across regions, not all BSMS questions will tier to specific forest plan monitoring questions.

Broader-Scale Monitoring Goals and Strategies

To better inform the BSMS project deliverables, the BSMS project team developed the goals and strategies that would be associated with a BSMS in the Southwestern and Rocky Mountain Regions.

The project team outlined the goals of a BSMS, based on language in the rule at 36 CFR 219.12, as being:

1. To help determine if management adjustments are needed as guided by Land Management Plans (LMPs; adjustments may or may not require plan amendment):
 - Test relevant assumptions of LMPs.
 - Measure management effectiveness in order to assess progress toward achieving or maintaining desired conditions in LMPs.
 - Track relevant changes, including, but not limited to: risks, stressors, and conditions beyond unit boundaries.
 - Assess the interrelationship between planning area(s) and the larger landscape.

2. To improve coordination and communication of monitoring efforts:
 - Identify questions best answered at geographic scales greater than one forest.
 - Create a more systematic and unified monitoring approach to test management effectiveness, test relevant assumptions, and track relevant changes.
 - Leverage resources via multi-party monitoring resources including all USFS branches, other government agencies, non-government agencies, and the public.
 - Identify a feedback mechanism (i.e., a process of adaptive management) to improve effectiveness and efficiency of broader-scale monitoring, collaboration with partners, and communication to LMP decision-makers.
 - Provide opportunities to communicate broad trends across National Forest System lands to a variety of stakeholders.

The project team also clarified that strategies for collecting broader-scale monitoring data to meet above goals could include:

1. Providing data that may not be collected by the forest but may inform decisions or plan direction, e.g., measures of ecosystem function or connectivity from regional or national datasets that are not typically used or accessed by forests; metrics of climate change (such as regional precipitation and temperature data). Portions of this are already occurring and can be found in existing forest plans.
2. Providing data that is relevant for forest resources and may be collected by the forest but analyzed in a unique way at regional or multi-forest scales, e.g., population trend or abundance; forest structure, composition, and potential vegetation data layers; data on natural disturbance processes (fire, insects, and disease).
3. Providing aggregated data from multiple forests that forests otherwise would not have access to or capacity to aggregate on their own, e.g., measures of ecosystem structure and composition (land cover, land use, and shifts associated with climate change); spring and stream quality; air quality; demographics and visitation use data. These data may inform cumulative effects analysis.
4. Drawing upon broader-scale monitoring programs or portions of programs developed by partners.

What is Monitoring?

Monitoring is the collection of regular observations through time to inform the status and trends of environmental conditions and other parameters. For the USFS, monitoring is intended to inform management decisions; continuous monitoring is necessary to capture the effect of management, and any management changes through time. Monitoring should be based on the best available science, include appropriate questions for the variable of interest, and utilize appropriate data to answer the questions at relevant scales and timeframes.

In addition to forest-level monitoring, the BSMS, which is to be developed and overseen at the regional level, is meant for questions that address conditions and trends at scales greater than one forest unit but also inform forest-level management decisions and progress toward meeting forest management plan desired conditions. The Planning Rule recommends national forests work

toward consistent indicators and consistent monitoring methods to measure progress on desired conditions across national forest and all-lands. This would allow the USFS to synthesize information in a consistent manner across spatial and temporal scales. When warranted, monitoring should be broader than one region (e.g., sage grouse range-wide efforts). The Planning Rule states that where appropriate, the BSMS should draw upon existing monitoring efforts but also address any critical information gaps. Monitoring and evaluation are fundamental to providing data on project implementation and effectiveness, improving decision making, allowing for accountability to stakeholders, identifying needed changes in management, and informing trends and the direction of the system or other variables of interest.

To address these Planning Rule requirements, there are a range of monitoring-related activities that are relevant to a BSMS (Figure 1). The National Forest System’s responsibilities are to conduct monitoring of the conditions of resources and effects of management actions; research is the responsibility of other deputy areas. The results from our evaluation of other federal monitoring strategies and from the interview phase suggest the differences between monitoring and research are not always black and white and that any potential broader-scale strategies require integrating different types of monitoring information. Based on those assessments, we found broader-scale monitoring should be informed from components of inventory, management reporting, and research (Figure 1).

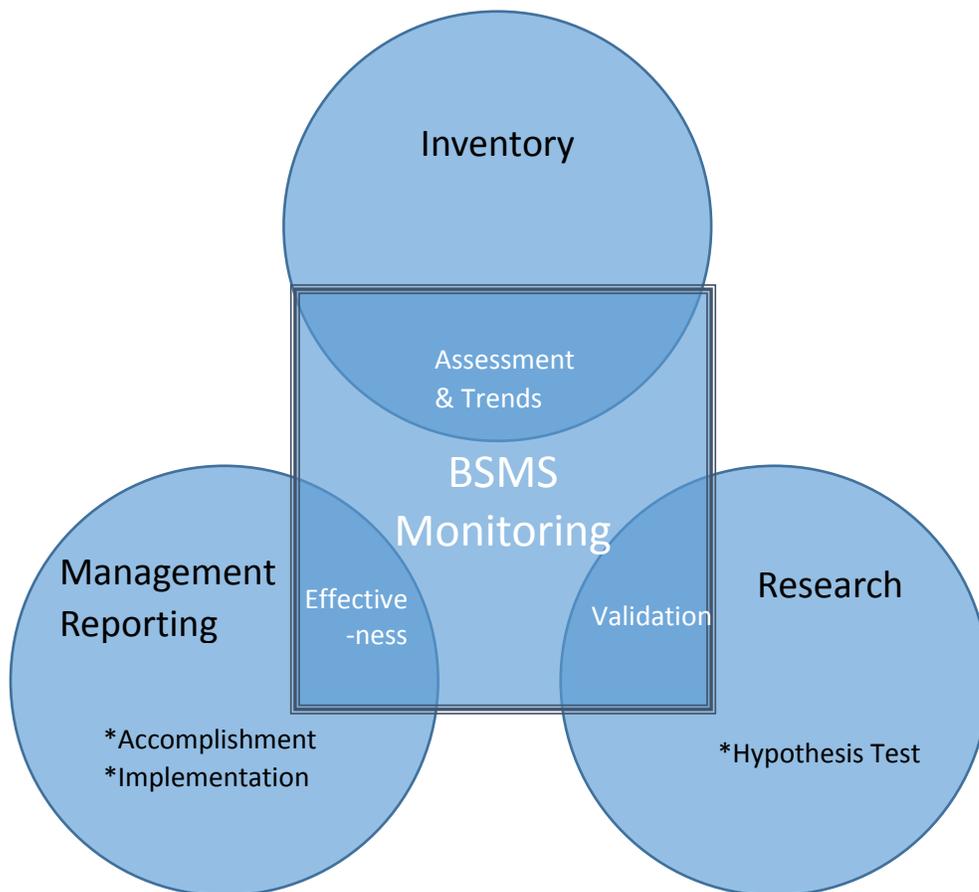


Figure 1. BSMS monitoring captures components of Inventory, Management Reporting, and Research.

- Inventory
 - The collection of basic inventory data through time allows assessment of the long-term trends and conditions of resources without reference to specific management actions. The FIA survey plots (surveillance monitoring dataset) is an example of this. **Application to a BSMS: This monitoring is useful for landscape-scale assessments of trends, such as ecosystem dynamics or regional trends in tree growth or mortality.**
- Management Reporting
 - Effectiveness monitoring evaluates whether specific management actions have been successful in achieving desired goals or objectives. Rigorous effectiveness monitoring requires replication, controls, baseline data, and long-term monitoring. **Application to a BSMS: Evaluate if landscape is trending toward, or meeting, desired conditions.**
 - Accomplishment reporting and implementation monitoring are both important to forest-level administrative accounting of outputs and activities, and the degree to which projects adhered to forest plan guidelines, best management practices, or project design. **Application to a BSMS: Accomplishment reporting is a key component, and available for use by a BSMS to assess regional targets by aggregating forest-level accomplishments.**
- Research
 - Validation monitoring is used to investigate assumptions of causality associated with management actions and ecological conditions and trends, or between ecological trends of different resources. It asks: Is the observed or assumed relationship between resources or management valid? **Application to a BSMS: Validation monitoring may be necessary to justify the use of key monitoring indicators, such as focal species as indicators of ecological integrity.**
 - Hypothesis testing often requires sophisticated measurement protocols and sampling designs — including experimentation and replication of treatments — to infer causal mechanisms with sufficient statistical power (Busch et al. 2003; Larson et al. 2013). **Application to BSMS: Links directly to regional management questions concerning the science and practice of resource management.**

Finally, modeling is often used across all monitoring, and also may rely on different datasets available from inventory, research, and management applications. Using both remotely sensed spatial data in tandem with ground-based data often yields the greatest efficiencies in logistical investments.

Summary of Interview Findings

We developed our workshops based on findings from the interview phase. An overview of those findings are provided here. Interviews were conducted with USFS staff, other federal and state agencies, and non-profit partners. We found that developing a BSMS could:

- Improve consistency and coordination in goals, planning, and monitoring efforts across USFS units.
- Increase efficiency and quality of monitoring efforts by increasing consistency of data collected and understanding of broad-scale trends across USFS units.
- Increase coordination and understanding across land management jurisdictions, supporting an “all-lands” approach to land management.
- Provide opportunities for increased data sharing and transparency, facilitating more effective partnerships.
- Be an effective communication tool, enhancing the ability of the USFS to inform the public and Congress about the condition of the National Forest System.

Based on the interviews, we developed recommendations for the successful development of a BSMS, including:

In the short-term:

- Link plan revision processes to broader-scale monitoring through clear communication and designated point staff.
- Review existing LMP monitoring plans in order to inform broader-scale monitoring and understand the current consistencies and gaps across units.
- Engage partners active in monitoring to identify efficiencies across land management jurisdictions.

In the long-term:

- Increase capacity and availability of resources for broader-scale monitoring.
- Develop a network of monitoring specialists at national and regional nodes to work with each other, USFS staff, and non-USFS partners.

Resources that could be used to help develop a BSMS include:

- Other broader-scale monitoring programs, including the Bureau of Land Management (BLM) Assessment, Inventory and Monitoring (AIM) program, the U.S. Fish and Wildlife Service (USFWS) Inventory and Monitoring (I&M) Program, the National Park Service (NPS) Inventory and Monitoring (I&M) Program, USFS Northwest Forest Plan Monitoring, and others.
- Existing USFS sources of broad-scale data, such as FIA, MTBS, and IDS.
- Existing datasets from government or non-profit partners, like U.S. Geological Survey (USGS) LiDAR data and Environmental Protection Agency (EPA) water and air quality data.
- State Heritage programs and NatureServe.

Please see Appendix B for further results from the interview phase, including a review of additional agency broader-scale monitoring efforts.

Workshop Overview: Goals and Process

Workshop Goals

Workshops were designed to bring together USFS regional planning and renewable resource staff, forest-level planning and monitoring staff, subject-matter experts, and partners who bring significant capacity around monitoring and have an interest in or history of coordinating with the USFS on monitoring. Each workshop's stated goal was to explore an all-lands approach to identify shared opportunities for efficient and effective inventory and monitoring techniques. Detailed workshop objectives were to:

- Foster learning about:
 - Broader-scale monitoring for forest plans — intent and goals.
 - Perceptions of broader-scale monitoring (BSMS R2/R3 project interview results).
 - Partner initiatives, efforts, and data.
- Identify potential questions, indicators, and metrics with partner land management agencies and stakeholders that could inform a broader-scale monitoring framework.
- Gather input for criteria to refine a broader-scale monitoring framework that would prioritize draft questions, indicators, and metrics.
- Identify partnership gaps, needs, and opportunities.
- Outline a collaborative approach, structure, steps, and timeline for refining broad-scale monitoring opportunities.

Workshop Scope, Structure, and Invitees

The workshop scope, invitee list, and structure was developed by the project team based on information collected during the interview phase of the project. The interview results acknowledged that partnerships and collaboration can provide additional capacity and tools to the broad-scale monitoring process. It was also acknowledged that communication among USFS managers and their partners can be a challenge. To help bridge the communication gap, several interviewees, both within and outside the USFS, suggested that partner agencies and organizations should be engaged in planning for broader-scale monitoring on the front end, not just after a framework has been developed. We proceeded to design the workshops to be state-wide, specifically because many of the USFS partner agencies and stakeholders are organized by state (e.g., state forestry, state wildlife, BLM state offices, and several non-governmental organizations).

Workshop invitees were chosen based on interview findings and project team recommendations to cover a range of staff from the national forests and regional offices, as well as key partner agencies and non-government organizations (Table 1). For each state-wide workshop, we invited staff members from USFS RMRS, FIA, BLM, U.S. Fish and Wildlife Service, and National Park Service. State forestry agencies and state wildlife agency staff were also invited. Non-government organizations invited included high capacity, technical resources that the USFS had a history of contracted monitoring work.

Table 1. Workshop attendees.

Attending Organization	Workshop attended
Arizona Game and Fish Dept.	AZ
Arizona Game and Fish Dept. - Natural Heritage program	AZ
Arizona State Forestry	AZ
Bird Conservancy of the Rockies	CO, NM, WY
BKS Environmental Association, Inc.	WY
Black Hills Forest Resource Association	WY
Bureau of Land Management	AZ, CO, NM
Bureau of Land Management National Operations Center	CO
Cochiti Pueblo	NM
Colorado Forest Restoration Institute	CO, NM, WY
Colorado Natural Heritage Program	CO
Colorado Parks and Wildlife	CO
Colorado Plateau Research Station/Northern Arizona University	AZ
Colorado State Forest Service	CO
Colorado State University	CO, WY
Dept. of Interior - Southwest Climate Science Center	AZ
Dept. of Interior - North Central Climate Science Center	CO
Desert Landscape Conservation Cooperative	AZ
Ecological Restoration Institute	AZ, CO, NM, WY
Environmental Protection Agency Region 8	CO
EnviroSystems Management	NM
Grand Canyon Trust	AZ
Little Snake River Conservation District	WY
National Park Service	CO, NM
National Parks Service - Valles Caldera National Preserve	NM
Natural Resource Ecology Laboratory	CO
Nebraska National Forest and Grasslands	WY
New Mexico Department of Agriculture	NM
New Mexico Department of Game & Fish	NM
New Mexico Forest and Watershed Restoration Institute	NM
New Mexico State Forestry	NM
Pueblo of San Felipe	NM
Pueblo of Tesuque	NM
Ruckelshaus Institute, Haub School of Environment and Natural Resources, University of Wyoming	WY
The Nature Conservancy	AZ, CO, NM, WY
The Wilderness Society	CO
Trout Unlimited	WY
University of New Mexico	NM
University of Wyoming	WY
US Fish and Wildlife Service	NM
US Geological Survey	AZ, CO, NM, WY

USDA - Natural Resources Conservation Service	CO, WY
USDA – Agricultural Research Service, Rangeland Resources Research Unit	CO
United States Forest Service (USFS)	AZ, CO, NM, WY
USFS Geospatial Technology and Applications Center (GTAC)	NM, CO
USFS Apache-Sitgreaves National Forests	AZ
USFS Arapaho-Roosevelt National Forest	CO
USFS Bighorn National Forest	WY
USFS Black Hills National Forest	WY
USFS Bridger-Teton National Forests	WY
USFS Carson National Forest	NM
USFS Cibola National Forest & National Grasslands	NM
USFS Coconino National Forest	AZ
USFS Coronado National Forest	AZ, NM
USFS Gila National Forest	NM
USFS Grand Mesa, Uncompahgre and Gunnison	CO
USFS Kaibab National Forest	AZ
USFS Lincoln National Forest	NM
USFS Medicine Bow/Routt NFs & Thunder Basin NG	WY
USFS Prescott National Forest	AZ
USFS Region 1 Office	CO
USFS Region 2 Office	AZ, CO, WY
USFS Region 3 Office	AZ, CO, NM
USFS Region 4 Office	CO
USFS Rio Grande National Forest	CO
USFS Rocky Mountain Research Station	AZ, CO, WY
USFS Remote Sensing Applications Center (RSAC)/RedCastle Resources contracted to USFS (RSAC is now GTAC)	CO, NM
USFS San Juan National Forest	CO, WY
USFS Santa Fe National Forest	NM
USFS Tonto National Forest	AZ
USFS Washington Office	AZ, CO, NM
USFS White River National Forest	CO
USFS Forest Inventory and Analysis	AZ, NM, WY
Western New Mexico University	NM
Wyoming Department of Agriculture	WY
Wyoming Game & Fish Dept	WY
Wyoming Natural Diversity Database, University of Wyoming	WY
Wyoming Office of the Governor	WY
Wyoming State Forestry Division	WY

Key interview results and a pre-workshop survey

(http://sweri.eri.nau.edu/PDFs/BSMS_InterviewReportFinal122115.pdf) informed the structure of the workshop. Resource professionals both internal and external to the USFS were interested in learning more about the USFS broader-scale monitoring requirements, USFS corporate datasets and data analyses, for example, FIA and the Remote Sensing Application Center (RSAC), as well as partner datasets (e.g., the state heritage program data). Therefore, we dedicated time to presentations and information sharing by USFS and partner professionals with expertise in these areas.

At some workshops, partners from other state and federal agencies shared information about other broader-scale monitoring efforts. The remainder of the workshop was then spent in smaller, break-out groups based on resource areas. A total of five resource areas were determined from interviews and the Planning Rule and included: 1) forest structure and fuels; 2) grassland and range; 3) wildlife; 4) watershed; and 5) social, economic, cultural, and recreation. Participants self-selected for one of the five resource areas at the beginning of the workshop, allowing facilitators to better understand the distribution of resource expertise in workshop audiences and adjust group facilitation as needed. Climate change was not brought out as separate resource area; anticipated climate change impacts are multidisciplinary, and we predicted questions incorporating climate change effects would be proposed in each resource area. Finally, additional break-out groups were initiated at the end of the workshop. The groups answered a set of questions to capture existing opportunities for partnerships and USFS institutional needs for implementation of a broader-scale monitoring strategy.

Workshop Process and Modifications

The beginning of each workshop included front-end information sessions. The key working components of the workshop were conducted in smaller, breakout groups. For sample agenda and facilitator instructions, see Appendix A. Breakout sessions were developed to meet the goals and intent of the workshop and project, which were to collect recommendations for the appropriate 1) questions, 2) indicators, and 3) appropriate datasets for a USFS BSMS that informs forest planning.

Workshop participants were divided into the aforementioned five resource groups to answer the following question: What are your most crucial resource questions that need longer-term, broader-scale monitoring? While the same breakout question was used to initiate the sessions, there were key challenges found at the first two workshops that prompted process changes to better capture the questions, associated indicators, and data recommendations from workshop attendees. For comparison, Appendix A includes the workshop process used at the first workshop (Phoenix, AZ) and the fourth workshop (Laramie, WY), with agenda and facilitator instructions. The key challenges noted at the first workshop included:

1. Developing questions for the appropriate broader scales.
2. Appropriately linking questions and indicators.
3. Appropriately linking indicators and datasets.

To address these issues, we made several modifications (see Appendix A, facilitator instructions from Arizona and Wyoming included).

1. **Scaling:** At the first workshop, the breakout question was phrased without a clear emphasis on the broader-scale component. Although it was in the question itself, there were difficulties in defining the broader scale. Participants were more comfortable with the questions they were addressing at project, forest, or other smaller-scale units. By workshop two, we structured the flip-chart note taking to visually represent three nested scales: 1) forest-level, 2) two forests or more, and 3) two forests and broader landscape (see Appendix A for figure). This visualization allowed participants to list their question and critically assess the appropriate scale it was best suited for. We also added a plenary session, “What is Broader-Scale Monitoring,” after the information sharing session and before the break-out sessions to capture the participants’ understanding and to help clarify their thinking to the broader group.
2. **Linkages, Indicators:** Also at the first workshop, we collected potential indicators in a separate session after developing a question list. This resulted in indicators that were not directly tied to questions. This was modified to continue work on the larger, scaled diagram and solicit potential indicators directly related to the questions. Different “sticky” note colors were used to distinguish questions from indicators.
3. **Linkages, Data:** At the first two workshops, we solicited a list of available datasets for each resource, but in a separate session from the question/indicator exercise. These stages were all combined by the third workshop to generate a large figure with questions, indicators, and data.

Other key modifications including added flexibility to collect USFS institutional recommendations and partnership recommendations in plenary or breakout groups, based on total workshop size and other factors. At the first workshop, this was also done in breakouts; however, the second workshop (New Mexico) had cross-breakout group conversations that contributed to a plenary discussion, which we easily accommodated and modified subsequent workshops to include the same plenary discussion.

All four workshops met the objectives and intent of the project, while also raising new questions and challenges for the development of a regional broader-scale monitoring strategy. Please see the final recommendations portion of this report for recommendations specific to workshop processes.

Workshop Outcomes

Technical Information Transfer

Exchanging knowledge to foster learning was a primary goal of the BSMS workshops. Based largely on interview findings, we planned the workshops to share knowledge on existing corporate capacity for a BSMS, partner efforts that may provide valuable lessons learned, and data-sharing opportunities (Table 2). The workshops served to fill some knowledge gaps, create contacts and establish follow-up needs.

Table 2. Subset of technical transfer presentations across all workshops.

ORGANIZATION	TOPIC	WORKSHOPS (STATES)
USFS Washington Office, and USFS Regions 2 and 3	Planning Rule, USFS Monitoring & IMA	AZ, CO, NM, WY
USFS Forest Inventory and Assessment	Multiple: Basic design, Wildlife Habitat Applications, Region-specific Applications, Needs Assessment.	AZ, CO, NM, WY
Desert Landscape Conservation Cooperative	DLCC overview, and Conservation Atlas Planning Tool	AZ
AZ Department of Game and Fish Monitoring	Research Monitoring	AZ
Southwest Climate Science Center	Climate Science Center Overview and data availability	AZ
AZ Natural Heritage Program	Overview of Natural Heritage Database	AZ
US Fish and Wildlife Service	USFWS Inventory and Monitoring Program	NM
The Nature Conservancy	Rio Grande Waterfund Monitoring Plan	NM
Bird Conservancy of the Rockies	Overview of organization and sampling	CO, NM
NM Natural Heritage Program	Project partnerships with the USFS	NM
Remote Sensing Application Center (now part of GTAC)	Overview of repeated products, and availability for proposed projects and analyst capacity	CO, NM
NM highland Forest & Watershed Restoration Institute	Monitoring partnerships with the USFS	NM
Colorado State Forestry	State of Colorado Issues and Monitoring Needs	CO
National Park Service	NPS Inventory and Monitoring – Overview and Lessons Learned	CO
Bureau of Land Management	BLM Assessment, Inventory and Monitoring Program – Overview and Lessons Learned	CO
USFS Rocky Mountain Research Station	Rangeland broader-scale monitoring	CO
WY Office of the Governor	State of Wyoming Forestry Task Force	WY
Wyoming Natural Diversity Database	WY Heritage Database Program	WY
US Geologic Survey	WY Landscape Conservation Initiative	WY
Colorado State University	Invasive Species Inventory & Mapping	WY

We asked regional planners or Washington Office staff (Ecosystem Management Coordination (EMC)) to share key introductory presentations providing the overview of the Planning Rule direction and intent. USFS Region 2 was also able to share their monitoring transition work and potential contributions from transition planning to a BSMS. These presentations were intended for our partner audience members, but we received feedback that the other USFS staff appreciated the opportunity to discuss the Planning Rule intent, and regional work to date, in a workshop setting. We highlight below the presentations we organized across all workshops to set the stage for a BSMS.

Across all four workshops, we asked USFS Research Station FIA staff to present. The interview results and our project team discussions indicated that FIA was highly suited for broader-scale monitoring. Our workshop audience often included forest-level resource staff more familiar with project-level, or sub-forest-level monitoring. Therefore, we invited FIA staff to introduce the basic sampling and data availability of FIA data and highlight some of the many applications of FIA data toward core Planning Rule monitoring needs. In addition, the FIA team shared their mandate and staff availability for analytical assessments in addition to data requests. Questions for the FIA presenters focused on understanding their analytical capacity, the cost and process for any data collection intensification projects, and their availability to assess and help craft BSMS questions for appropriate utilization of existing FIA data. **Key takeaways included:** the need to better integrate National Forest Systems (NFS) with FIA in Regions 2 and 3, specifically:

- Utilize FIA for regional BSMS development (see “Recommendations” section).
- Follow-up for integration of FIA plot grids with partner landscape monitoring (e.g., Bird Conservancy of the Rockies).
- Follow-up for cost estimates for specific regional needs, particularly for non-forest vegetation inventory (e.g., all condition inventory in Region 2).
- Share innovations (e.g., Region 1 vegetation data analysis tools).

At two workshops (NM and CO), the Remote Sensing Applications Center (RSAC) provided an overview of data analyses and availability. RSAC is now part of the Geospatial Technology and Applications Center (GTAC). Discussions at the workshops were similar to FIA discussions and included questions about the availability of GTAC staff to answer more regionally specific questions with remote-sensing data. GTAC takes proposals each year for special projects from USFS units; for example, the RSAC helped develop a process and technique for Region 3’s Four Forest Restoration Initiative (4FRI) to utilize remotely sensed data and measure a spatial heterogeneity question. A common question from participants was how well remote sensing could answer management effectiveness questions, or how to better use ground-based data collection as validation for remote sensing data analyses. Additional examples of remote sensing applications were provided by USGS staff at the Wyoming workshop. These included remote sensing applications for invasive species and aspen resilience monitoring. **Key takeaways included:** broad interest in continuing to use highly supported GTAC analyses:

- Monitoring Trends in Burn Severity (MTBS, with USGS EROS).
- MODIS Real-Time Forest Disturbance (RTFD).
- Exploring more region-specific direct applications for BSMS.

A key partner and presenter at all four workshops was a representative from the state Natural Heritage or Natural Diversity programs, which maintain and contribute data to the NatureServe Network database. Organized by states, these programs have a mandate to maintain biodiversity assessments, including species lists and occurrences. In some cases, trend analysis can be done with data collected, but not all heritage programs are set up to do this. The organizations are partnered with either state universities, state wildlife agencies, or in some cases, state non-profit conservation organizations. They work in close partnership with federal and state land managers

to collect and share data on species. Presentations ranged from overall review of state systems (Arizona Natural Heritage Program and Wyoming Natural Diversity Database (WYNDD)), to special project presentations (New Mexico State Heritage Program). Questions and discussions at all four workshops focused on the opportunity to become more efficient and standardized with these programs. Often, both regional and forest-level contracts exist with state heritage programs. These third-party contractors are at times better suited to ensure standardized species-data collection and robust inventory and monitoring for rare ecosystems, particularly fens and wetlands. State heritage participants noted that there may also be opportunities to work with other agencies to leverage resources for additional monitoring and assessment activities, but particular attention will need to be given to data management strategies. **Key takeaways included:** high interest in better utilization of existing data, and or adding value with small additions:

- Incorporate state Natural Heritage occurrence data into BSMS trends for focal species, incorporate repeated surveys to assess management effects.
- Leverage existing inventory practices (e.g., fen and wetland spatial inventories, Colorado Natural Heritage Program (CNHP) and WYNDD).
- Leverage participatory citizen science utilized by Natural Heritage programs (e.g., WYNDD).

The Landscape Conservation Cooperatives (LCCs) are a set of regionally specific cooperatives sponsored by the Department of the Interior (DOI) that coordinate multiple federal state, tribal and non-government agencies and organizations. Their mission includes an all-lands approach to share science and management capacity to ensure management toward sustainable resources. The USFS is a key partner for the LCCs, serving both on executive and technical boards. Presentations included an overview of the Desert LCC, and also the potential uses of a web-based data sharing portal, databasin.org. **Key takeaways included:** a need to incorporate LCC potential contributions, acknowledging variability in priorities and focus areas across regional LCCs.

Finally, we asked other federal efforts with broad or landscape-scale monitoring strategies to share components of their process and methodology and any additional recommendations for the USFS efforts. The intent here was two-fold: 1) to share the lessons learned, and 2) to examine partnership opportunities. The BLM AIM, the USFWS I&M, and the NPS I&M programs shared programmatic overviews. A more complete summary of these federal efforts was accomplished during the interview phase and can be found in Appendix B.

Broader-Scale Monitoring Questions: Small Breakout Group Outcomes

In addition to presentations from partners, workshop participants spent time in break-out groups focused on specific resource areas: forest vegetation, wildlife, range vegetation, water, and social, economic, cultural, and recreation resources. The resource-based break-out groups generated separate lists of questions, indicators, and datasets for each workshop. After the workshops were completed, we listed the questions, indicators, and datasets by workshop, and where possible, included related indicators and data for each question. From all four workshops, approximately 100 questions were recorded for each resource area. Questions were grouped by theme within resource areas (some small groups identified themes for question groups during the

workshop, some questions were grouped post-workshop), and post-workshop questions were narrowed according to theme and focus area. A distilled list of questions and associated indicators and datasets for each resource area can be found in Appendix C.

A wide variety of questions were brainstormed in resource area-focused small groups at the workshops. We found that question themes crossed state boundaries — the same major question themes in each resource area were discussed in each state. We attribute most variation across workshops to differences in attendees and particular attendee interests/areas of focus. Additionally, differences in the small-group facilitators, workshop formats, and workshop presentations could contribute to differences across workshops.

The four workshops produced very similar key questions for each resource area, and even across resource areas key themes were apparent. The most common question themes across resource areas were climate change, invasive species, management effectiveness (including the efficacy of restoration treatments), and disturbance processes (including fire and fuels). The only resource area where climate change was not a dominant theme was the social, economic, cultural, and recreation resource area, where the topic was addressed but was not central to the questions developed. Other core question themes by resource area were:

- Forests — forest composition/structure/function, and forest resilience/integrity.
- Wildlife — landscape and habitat connectivity, habitat quality, and species of interest/concern.
- Range — grazing, encroachment, and rangeland condition.
- Water — riparian areas, and watershed, and headwater conditions.
- Social, economic, cultural, and recreation — recreation, economic, social, visitor use, and cultural use.

From all four workshops, we collected approximately 100 questions total for each resource area. The brainstormed questions required a significant amount of synthesis; the workshop produced good questions, but hand-written questions were often incomplete, unclear, or lacked appropriate grammar. By eliminating repetition in the question set, and combining similar questions by theme, we were able to distill this initial set of questions to a list of approximately 30 for each resource area that were representative of questions asked across all workshops (Appendix B). From this list of distilled questions, the core team identified three to five top questions within each resource group. These top questions were chosen to best reflect the main recurring topics in each resource group (Table 3). See Appendix C for a table of potential BSMS questions, indicators, and datasets identified in the workshop process.

Table 3. Reoccurring broader-scale monitoring questions by resource area.

RESOURCE AREA	BROADER-SCALE MONITORING QUESTION
Forests	How are key characteristics of forest structure, function and composition changing over time in relation to desired conditions and HRV at the landscape and ecosystem scale?
	How are climatic variables and disturbance processes (such as wildfire and insects/disease outbreaks) affecting key characteristics of forest structure, function, and composition at the landscape and ecosystem scales?
	Are plan components and management treatments effectively protecting social and ecological values at risk?
	Are management treatments promoting ecosystem resistance and resilience to climate change and disturbance at the stand and landscape scale?
Wildlife	What is the status and trend of focal species?
	What is the status and trend of TES/SCC populations?
	What are the status and trends in the ecological conditions needed to support TES/SPCCs, and how are climate change and other stressors (e.g., uncharacteristic fire, insect and disease outbreaks, recreation, extreme weather events, etc.) affecting them?
	Are plan components and management actions effective at promoting the maintenance and recovery of TES/SCCs populations, and the resilience of key ecological conditions on which they depend?
	What are the status and trends in wildlife habitat and connectivity, particularly for TES/SCC and focal species?
Range	What are the status and trends of grassland community composition, structure, and productivity?
	What are the status and trends in disturbance processes in rangelands? Natural processes? Grazing related disturbance? Infrastructure/development disturbance?
	What are the status of non-native invasive species across the landscape? How are distributions changing over time?
	What are the effects of climate change and drought on grassland community composition and structure, productivity, and soil condition?
Water	What are the status and trends of water quality and hydrologic functions within the watershed and HUCs?

	What are the status and trends in the structure, function, composition and connectivity of lotic systems (i.e., aquatic, riparian, springs, seeps)?
	How is water temperature, snowpack, runoff, flow, groundwater level and recharge, and precipitation changing as a result of climate change?
	What are the status and trends in the structure, function and composition of lentic systems?
Social/ Economic/ Cultural/ Recreation	What are the trends in economic contributions and provisions of NFS lands, for different resources and to different demographics?
	What are the status and trends in recreational uses of USFS lands?
	What are the status and trends in visitorship?
	What are the status and trends in ecosystem service provision and demand?

Additional Questions and Issues: Small Breakout Group Outcomes

In addition to brainstorming monitoring questions across scales, participants brainstormed a wide range of questions around baseline assessment (“what is the current status of resource X”), research (“how does climate change affect resource X?”), and management (“how do we determine management goals and objectives for resource X?”), indicating that participants have information needs beyond traditional monitoring data.

Small groups also discussed potential opportunities and barriers to broader-scale monitoring in their particular resource areas, and many of these were similar across resource areas and are discussed in separate sections in this report. There were a few resource-area-specific challenges that are appropriate to mention here. The social, economic, cultural, and recreation groups often noted the challenge in measuring variables of interest (like the economic or social contributions of NFS lands) and tying them to management activities. While there are a number of USFS databases for visitation and recreation information, it was acknowledged that less information is available for these resource areas than for vegetation resources. Similarly, the water resource groups expressed that not enough information was available for assessment of water resources, and more baseline data is needed.

Wildlife groups had a unique challenge in reconciling broader-scale monitoring with the focal species approach included in the Planning Rule. As forests are in different stages of planning and transition under the new rule, there were varying levels of understanding how the Management Indicator Species (MIS) wildlife approach from the 1982 Planning Rule translates, if at all, to the new focal species approach.

A list of available national-level datasets and datasets relevant to the Southwestern and Rocky Mountain Regions was also developed during the workshop process, both using expert knowledge from our project team and the workshop participants (Appendix D). Workshop participants were engaged in a data sharing discussion during the small group work and were asked to add to a working list of available corporate and partnership datasets that are relevant to

BSM and currently available. Initially, this dataset was created from information gathered during the BSM interview process where BSM themes began to arise and data sources were compiled. During the workshop process, workshop participants were asked to examine the spreadsheet and add known available datasets in their area of expertise. Appendix D is also available as an excel spreadsheet populated by available datasets from various government agencies (e.g., USGS, USFS, FWS, NPS, FIA, BLM, and Natural Heritage programs), corporate, and non-profit entities and partners (e.g., Bird Conservancy of the Rockies (BCR), The Nature Conservancy (TNC)). These datasets are commonly available data and are relevant to all resource areas and monitoring questions. The spreadsheet contains a list of available, remotely sensed products, GIS datasets, assessment project datasets, data from completed analyses, data clearinghouses, geodatabases, and more. Additionally, we include information as to what agency collected or houses the data, a description of the data, the spatial resolution, the spatial extent or coverage of the data, and the location where the data is housed (website or url).

Developing a Broader-Scale Monitoring Strategy

Box 1. Region 3 Mexican Spotted Owl Range-Wide Monitoring.

The Mexican Spotted Owl (MSO) Recovery Plan (USFWS 2012) requires habitat characteristics for the owl that align with vegetation desired conditions set by the USFS Region 3. However, validation monitoring is necessary to assess MSO habitat usage, population status and trends.

Region 3, working with USFWS, contracted with BCR to develop an experimental design and survey project to address the range-wide distribution, occupancy of the MSO, with permanent survey points to address trends through time. These data could be combined with FIA ground plot data, and climate data to try to determine correlations among habitat and climate influences on the MSO, which can only be assessed at broader scales.

Recommendations

Recommendations, based on information gathered through interviews and workshops from sources both internal and external to the USFS, fall into three broad categories: 1) increase efficiency; 2) build capacity; and 3) capitalize on existing opportunities. In general, participants supported the development of a BSMS and strongly recommended that a BSMS link closely to forest plan monitoring of progress toward achieving desired conditions. Specifically, attendees thought the BSMS should align as appropriate with the “Big Eight” monitoring categories found in the Planning Rule, but not be limited to these categories. A regional BSMS was recommended to increase efficiency by applying landscape-scale to providing context for and inform local monitoring. Partners expressed that a BSMS, along with strong communication, would allow better integration of external efforts with existing forest service monitoring efforts.

1) **Increase efficiency**: The Planning Rule directs the USFS to increase efficiencies, while also addressing stressors and threats at the landscape scale. Suggested mechanisms to increase efficiency include:

- **Develop a common set of questions at the regional level.** Realizing efficiencies should start with a set of priority questions common to multiple forests or for a region. Although this could occur at any multi-forest scale, initial efforts to understand commonalities across forests and landscapes a within a USFS region can improve efficiency (see Region 1 BSMS, in development). Opportunities for developing regional

or sub-regional questions may be realized where adjacent or ecologically similar forests are going through revision at the same or similar times.

- **Identify existing monitoring that meets BSMS criteria.** Both USFS participants and partners recognized existing efforts in Regions 2 and 3 that qualify as BSMS, and recommended that regions identify and capture these efforts for reporting and communication purposes. For example, Region 3 is currently engaged in a range-wide Mexican spotted owl (MSO) monitoring effort, working with regional and FIA capacity, and partnering with the USFWS and BCR (see Box 1.)
- **Aggregate existing data from forest-level monitoring.** Leveraging existing data is consistent with Planning Rule guidance that suggest aggregated data may provide data interpretations to the forests that is more informative than their data alone. Existing data collection and storage methods would need to meet consistency criteria, which may require regional capacity to assess the available data.
- **Standardize the monitoring indicators and data collection protocols within and across national forests.** Opportunities across forests for promoting more consistent and robust protocols and guidance for analysis will increase efficiencies and promote meaningful data to answer monitoring questions at multiple scales. Other agency efforts, such as the BLM’s AIM program, set top-down requirements and capacity for oversight, with the intent to facilitate efficient analysis or communication. These agencies may be able to share useful strategies.
- **Utilize existing corporate data and analytical capacity.** USFS staff at regional and forest levels may be able to use corporate data to answer BSM questions. The FIA provides long-term, robust, landscape-scale monitoring in forested lands across ownerships. The FIA also is funded to provide analysis of existing data and through extra funding agreements, can meet other monitoring gaps identified by the forests (e.g., non-forested monitoring, intensification of existing monitoring grids, or time frames (see Box 2)). The RSAC also provides both off-the-shelf ready analyses of disturbances but can also contract to answer specific questions. This strategy creates consistency and efficiency for information delivery and helps to ensure that information will be relevant for end-users.
- **Share lessons learned, including processes, collaboration, and monitoring resources, between and across partners and landscapes.** Other land management agencies and non-governmental organizations (NGOs) have similar direction to

Box 2. Region 1 Vegetation Analysis Tools.

USFS Region 1 has worked closely with the FIA to utilize corporate datasets for multiple scales, and identify needs for intensification of modified Common Stand Exam Protocols. The Summary Database (SDB) is a suite of analysis tools to summarize and analyze FIA data to answer Region 1-specific questions. Forests may also opt to implement mid-cycle re-measurements. Regional costs for sampling intensification in space or time are justified, as consistent data can be made available for project- and forest-level planning.

These tools have been used to facilitate efficient forest plan revision assessment, project level planning, biannual monitoring reporting, and are planned to be used for the Region 1 broad scale monitoring strategy.

incorporate broader-scale, across-boundary assessment and monitoring opportunities. For example, the Greater Yellowstone Ecosystem monitoring strategy and the Northwest Forest Plan monitoring strategies may serve as models for an interagency approach (see Appendix B for more detail on other strategies).

- **Coordinate data sharing and data management.** Another key recommendation across workshops was to develop a format or portal for data sharing across agencies and organizations, ideally a spatially explicit web or GIS-based application. A common theme among USFS participants was that while there is a significant amount of non-USFS data available, it is often difficult to find or acquire, and there is often considerable uncertainty about its accuracy, credibility, and compatibility with other data sources. Coordination and capacity was recommended (see “Build Capacity” below for more details) to make data available, with associated meta-data and appropriate data uses (e.g., appropriate scale, data confidence intervals, etc.).

2) Build Capacity. A BSMS requires capacity at regional or sub-regional levels for implementation. The Planning Rule states the need for a BSMS to exist within existing funding levels; no new funding was allocated for a BSMS. However, we suggest these additional capacity gains may be accomplished from utilizing existing staff, USFS corporate and partner resources, as well as increasing monitoring efficiencies across forests (see previous section). For example, BSMS questions arising from similar forest plan monitoring questions across two or more forests could be more efficiently collected with standardized protocols, utilizing corporate or partner data. More specific capacity recommendations included:

- **Dedicate technical expertise to assist with question and protocol development and integration, data roll-up, and assessment.** We recommend that USFS staff resource and landscape ecology experts, given regional monitoring or management questions, develop the BSM questions, indicators, and identify appropriate datasets. A level of coordination is needed to maximize opportunities across forests, and develop the appropriate rigor using best available science for a BSMS. Capacity may also be needed to analyze data for the broader-scale questions. Integration with USFS Research Stations, the FIA, and other corporate analysts can ensure monitoring plans meet best available science requirements, potentially through peer review of BSMS.
- **Work with partners strategically and efficiently to fill BSMS monitoring gaps.** Both government and non-government partners collect data applicable to a BSMS; data are available for vegetation, wildlife, and watershed resource areas, and in the social and economic realm. This approach may be relevant for questions associated with common cross-boundary resource issues where partners have similar missions (e.g., BLM or NPS), mandates and the desire to leverage existing capacity. Monitoring can include the use of existing databases, such as NatureServe, FIA, state heritage databases, BCR, and use of existing remote sensing products. Partnerships are important elements of the overall strategy and can expand agency capabilities, efficiencies, and maximize the contributions of all entities.
- **Dedicate regional staff for coordination, communication, and adaptive management recommendations.** The need for increased formal and informal communication was a recurring theme throughout this project. Examples of needed

capacity include a regional assessment of existing forest monitoring plans, partner efforts, and current corporate data availability to reduce redundancy and maximize efficient monitoring, as well as the important step of adapting management strategies and actions based on monitoring results. Workshop attendees also recommended the use of multi-organization working groups to ensure appropriate data coordination.

- **Engage line officers and forest staff** in BSMS development to get critical support and buy-in for a BSMS, while also ensuring a BSMS is relevant and a priority for USFS staff.

3) Capitalize on existing opportunities and concurrent efforts. The Planning Rule suggests multiple BSM strategies and sub-strategies can be developed to meet the BSM requirement. This allows a flexibility to be opportunistic across the forests in a region. For example, a BSMS can be developed from the forests (bottom-up), and/or with components from the regional foresters (top-down). Communication among forests and with the regions will provide efficiencies for forests just initiating plan revisions (or monitoring plan transition).

- **Capture BSM needs for each forests opportunistically.** Working across four states and two regions allowed the project to work with national forests and their partners in various stages of plan revision. Participants in workshops acknowledged that timelines of plan revisions had a big impact on their own understanding of the new Planning Rule, and the specific needs or opportunities to inform a BSMS component. It is a challenge to develop a regional BSMS strategy with forests under different revision timelines and Planning Rule direction. However, workshop attendees pragmatically expressed that “this is always the case.” Regional leadership and capacity to initiate internal dialogue would contribute to the internal understanding of BSMS intent and help realize efficiency goals stated in the Planning Rule. There were specific recommendations from the Region 2 and Region 3 workshops:
 - All New Mexico forests, and the Tonto National Forest (Arizona), are or will be revising under the 2012 Planning Rule. There is opportunity to look for similar desired conditions and work to realize where consistent indicators and data may add efficiencies, or tie to a broader-scale questions.
 - Several Region 2 forests are beginning or will soon begin revision under the 2012 Planning Rule. There may be an opportunity to develop a BSMS with these forests particularly involved and also create questions that could be incorporated into existing monitoring plans that were transitioned under the requirements of the Planning Rule.
- **Link monitoring to assessment.** Both interviews and workshop attendees recommended more closely linking all plan components with plan and broader-scale monitoring. As possible, regions and forests should identify key questions and datasets during the forest planning assessment phase. Additionally, the development of desired conditions could contribute to the forest and broader-scale monitoring plan questions and indicators.
- **Utilize national-level reviews of monitoring plan development.** The Washington Office partners on the project team have shared a Washington review of the USFS

monitoring transition plans completed April 2016. This review and any observed efficiencies, opportunities, or lessons learned should be incorporated in the BSMS strategy and future plan revision work.

Box 3 includes examples of how these three actions — increase efficiency, build capacity, and capitalize on existing opportunities — could be incorporated to address the workshop resource question (from Table 3). In addition, more detailed opportunities for existing BSMS, and mid-term and long-term opportunities for a BSMS can be found in Appendix E.

Box 3. Recommendations to address broader-scale monitoring questions in USFS Southwestern and Rocky Mountain Regions.

We recommend three major courses of action, including **increasing efficiency**, **building capacity**, and **capitalizing on existing opportunities**.

QUESTION	APPROACH	EXAMPLE
FOREST: How are key characteristics of forest structure, function and composition changing over time in relation to desired conditions and HRV at the ecosystem and landscape scale?	Utilize corporate datasets and capacity	Regional contract with FIA to evaluate changes in Forest composition and structure over time for specific forest or vegetation types. May also contract for intensification of the FIA grid in priority areas.
RANGE: What are the effects of climate change and drought on grassland community composition and structure, productivity, and soil condition?	Utilize corporate datasets and other nationally available government data Utilize partners strategically	Regional contract with FIA for all-lands condition monitoring. Data from those plots combined with data from NOAA or other sources to assess changes related to climate change. Plot data combined with remote sensing applications to evaluate trends in productivity over time.
WILDLIFE: What is the status and trend of TES/SPCC populations?	Utilize partners strategically	USFS work with specialized non-profits, like BCR, to access data for wide ranging TES/SCCs (e.g., birds, small mammals); to intensify their data collection for management effects on species; to co-locate additional plots on the BCR grid. For species that are more narrowly confined to specific areas, the USFS can contract with state Heritage for monitoring and analysis.
WATER: How is water temperature, snowpack, runoff, flow, groundwater level and recharge, and precipitation changing as a result of climate change?	Coordinate data sharing	The RO utilizes data from USGS, NRCS-Snotel, and NOAA to evaluate trends in water flow and precipitation metrics over time.
SOCIAL/ ECONOMIC/ RECREATION/ CULTURAL: What are the trends in economic contributions and provisions of NFS lands, for different resources and to different demographics?	Utilize corporate datasets	The RO can utilize internal data (outputs, NVUM) and models to evaluate contributions from Forest lands and changing uses over time

Other Considerations

Data Consistency, Data Management, and Data Sharing

Data consistency, database storage, and data access and availability were acknowledged barriers throughout the project. Participants agreed these barriers would need significant capacity to address. While the short- and mid-term solutions, including the strategies for consistent monitoring protocols and data quality assessment and control, would address many issues, intra-agency data management standards recommendation may need higher-level leadership and administrative support to address. The Planning Rule direction suggests a BSMS could depend on data and information sharing, and coordinated data collection, across different jurisdictions. Inter-agency data management agreements are needed to accomplish this recommendation. Additionally, outreach, technical training, and education for USFS staff would be necessary.

Supporting and Sharing Innovation

Results from project interviews and workshops highlighted a significant lack of communication and knowledge about existing innovative strategies among USFS employees, both within and between regions. Staff and partners recommended more mechanisms to effectively support and share innovations developed at forest and regional levels. Relevant innovations may include: approaches for using existing internal and external data; novel and scientifically credible measurement and sampling protocols; innovative analytical approaches and technical tools, such as the use of modeling or other decision-support applications; or the development of plan components and monitoring strategies that effectively promote adaptive planning. USFS staff, in particular, recommended periodic workshops, meetings, or teleconferences in which staff can share innovations or lessons learned. The identification of innovations and the development of diffusion processes may also be accomplished in collaboration with third party organizations, such as universities.

BSMS Audiences and Communication

Workshop participants acknowledged confusion in the Planning Rule with respect to intended audiences for a BSMS outputs (to be provided as appropriate in both the forest-level biennial monitoring report, but also in a regional five-year assessment of monitoring goals). The Planning Rule states the intent of a BSMS is to inform forest plan effectiveness and identify if and when any modifications to plan guidance may be necessary. However, participants also felt there was guidance and opportunity to work closely with other land and wildlife management agencies to better understand key stressors and threats across boundaries.

As regions operationalize BSMS, there was a clearly stated need to identify efficient and effective strategies for both collecting BSMS data (from forests, from corporate datasets) and communicating BSMS results and information back to forests and other audiences. Participants recommended clear articulation of the audiences for BSMS data delivery, and the appropriate time intervals for that communication. An example from plenary breakout sessions across the workshops included suggested audiences for BSMS outcomes (Table 4).

Effective communication can include informal communication; however, multiple workshops noted this informal communication is too dependent on personalities and stability. More formal communication methods are recommended for an agency that places high value on job

movement for advancement. Similar to sharing innovations, the in-person workshops are preferred; report delivery or web delivery are less effective for information dissemination.

Table 4. Suggested outcomes and associated audiences for BSMS

BSMS OUTCOMES	AUDIENCE	COMMUNICATION TYPE
Inform effectiveness of forest plan direction and increase efficiency for forest plan monitoring	National Forests (NF)	Informal: network of shared contacts Formal: workshops, web delivery
Inform regional decision-making	NF and Regional Forester (RF)	Formal: reports, web delivery
Answer questions that cannot be answered at a single forest scale (e.g., trends for focal species; ecological integrity at landscape scales; impacts of climate change)	NF, RF, WO and partners	Informal: network of shared contacts Formal: workshops, reports, web delivery
Communicate regional trends and regional management effectiveness	NF, RF, WO and partners	Informal: network of shared contacts Formal: workshops, reports, web delivery

BSMS Partner Engagement

Finally, the project team, along with facilitators, evaluated the process to develop this framework for a BSMS in the Southwestern and Rocky Mountain Regions. We found that partner engagement had key benefits, but also some potential conflicts, in the contribution toward a BSMS framework.

Benefits to Up-Front Partner Engagement

The sharing of information among USFS, research, other agency and NGO staff was highly valuable to all attendees. Both USFS employees and partners asked many questions of the USFS regional, USFS FIA, the LCC, and the state agency and non-governmental organization presentations. Anecdotally, contacts and follow-up meetings occurred. It was readily acknowledged with reduced budgets and fewer employees, there is less opportunity to fully understand the work within and external to the agencies and that the information sharing component could be a separate workshop. Landscape-level initiatives and efforts may partner with the USFS, but communication of those efforts is incomplete to all of the administrative units (forests).

An additional benefit was the strategic attendance. Because the workshops were arranged by a third party (SWERI), participants were targeted for their current job duties and expertise; this was different than a public participation process, which is required of the USFS to meet their public engagement policies. It allowed for a high level of technical discourse with key partners at all workshops, and the project team felt the questions, indicators, and the list of data sources developed was very thorough and rigorous. The questions and indicators had high similarity across all workshops, even though the states we worked in had high variability in socio-political issues. We suggest this is a result of the technical, natural resource expertise in the room, and predict the public process will gather more of those political differences.

Draw-Backs to Up-Front Partner Engagement

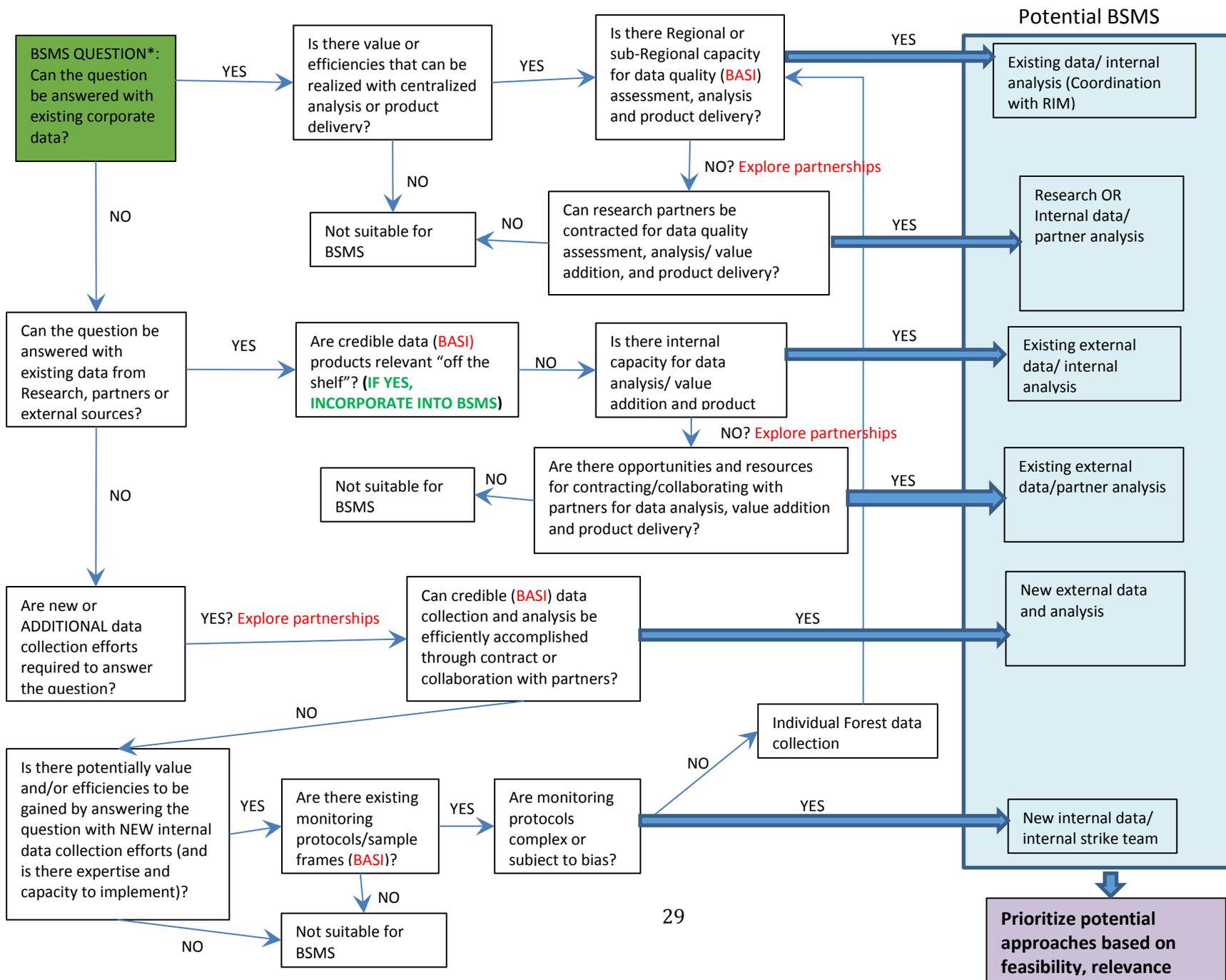
In the first workshops, fully describing a consistent picture of partners' potential roles, or any potential participation in a USFS BSMS, was a challenge. The relevance of the BSMS to these partners was not completely clarified, and continues to be dependent on interpretation by the USFS. While the interviews were conducted largely by phone, and required an hour or more of partner time, the workshops required overnight travel for participants, with no added stipend from our project. We are grateful for those partners who came to the workshop on their own agency funds, but recognize we could have been more efficient with their time.

Broad participation early in the process may inhibit initial shared lessons and information gathering necessary for the regional leadership responsible for the BSMS. The Colorado workshop had the highest proportion of federal attendees; more than half were USFS NFS staff, with an additional quarter representing USFS research analysts (FIA, RSAC, RMRS) and other federal agencies (BLM, NPS, EPA). The remaining quarter were primarily state organizations: state forestry, wildlife and parks, and natural heritage. Only two NGOs were in attendance, one had active monitoring contracts with the USFS and the other was a presenter. Although this workshop had the lowest number of NGO partners, the USFS project team members that had experience with other workshops felt it got to the appropriate technical lessons learned for the USFS staff responsible for a BSMS. This experiences suggests additional pre-work by the USFS, prior to engagement of their partners and public, would provide needed USFS learning. Technical workshops with USFS resource professionals (at regional and forest levels) and corporate analysts will clarify the intent of a BSMS, and any existing BSMS strategies, and allow for more strategic engagement with partners.

Potential Decision Process

The recommendations above include both how to realize efficiencies, build capacity, and capture existing opportunities, and further suggest strategic engagement with partners. Regions 1 and 8 informed our process by including timelines and process flowcharts for decision support. **Figure 2** builds upon work from Region 8 to demonstrate potential decision points for the development of a BSMS. Use of this process begins after the BSMS questions have been collected, either from forest-level plans, regional leadership or management questions, and/or partners. At each flowchart step, a potential question can be assessed for BSMS applicability (see “not suitable for BSMS” boxes). Part of the flowchart also checks the capacity available to answer the questions (e.g., existing data, corporate data, partner data). Questions that end in the blue, Potential BSMS box may be appropriate for a BSMS.

Figure 2. Decision Process for a BSMS. * The process starts with the finalized BSMS questions.



Next Steps for the USFS Southwestern and Rocky Mountain Regions

To achieve a regional BSMS, the Southwestern Region planners highlighted necessary “next steps,” reviewed and edited by Rocky Mountain Region planners. Steps were not meant to be sequential; in fact, several should occur concurrently.

1. To implement a regional forester’s strategy, the region should take the lead with added capacity and technical expertise.
 - a. Review of forest plan questions/transition plan questions.
 - b. Evaluation and validation of the BSMS questions by the regional and forest staff specialists.
 - i. Program integration with other prioritization and assessment processes.
 - ii. Assess: What areas and priorities were missed?
 - c. Identification of priority broad-scale monitoring questions.
 - d. Work closely with forests initiating revision under the 2012 Planning Rule to integrate broader-scale monitoring into forest plans.
2. Enlist partners.
 - a. Evaluate the top questions with available partner datasets.
 - b. Assess: What questions are best addressed through multi-party monitoring?
3. Make broader-scale, corporate data available for use.
 - a. Identify available data and data needs (additional analysis, or collection).
 - b. Identify protocol standardization opportunities across forests.
 - c. Increase use and utility of the corporate database.
 - i. Integrate available data into the corporate database.
 - ii. Identify training needs.
4. Determine scales and responsible managers with regional and forest leadership.
 - a. Determine questions that should be addressed with regional-level data and capacity.
 - i. What regional protocols are already available (e.g., goshawk monitoring)?
 - b. Determine questions that should be addressed with forest-level data and capacity, then aggregated to address regional or cross-regional questions.
 - i. What forest-level protocols are standardized and can be aggregated to address broader-scale questions (e.g., watershed condition framework)?
 - c. Coordinate across regions.
5. Prioritization and funding to be included as part of the strategy.
 - a. Assess the potential for forests to contribute to a BSMS for those questions already addressed at forest-level, that use standardized protocols.
 - b. Assess the potential for regions to contribute for additional landscape capacity (e.g., remote sensing/technical).

Observations: Emergent Questions

The joint Southwestern and Rocky Mountain Region’s project to develop a framework for a broader-scale monitoring strategy explored the intent of the Planning Rule for partnership engagement. This project sought to engage partners up-front to collect information on how to develop the framework as well as get input on key aspects of the framework itself.

Several questions and different views emerged among the project team and key partners during the process of developing and running four workshops. The resulting discussions in team and workshop settings highlight how the Planning Rule, and the associated handbook, can be variably interpreted. The recommendations above are consistent among the staff and partners surveyed; however, below, we highlight some unanswered questions that arose during this project.

1. Some felt that broader-scale monitoring questions must come directly from forest monitoring plans. The intent in the Planning Rule is for the BSMS to be able to directly inform forest management effectiveness and decision making to adjust the plan. At all workshops, some attendees interpreted this as meaning it should only address questions from forest plans. However, some felt that broader-scale monitoring questions should come from regionally developed questions. Most attendees viewed this as an opportunity to include regionally consistent questions in forest plan monitoring plans, along with existing forest plan monitoring questions, to get at some of the expected stressors and threats occurring at the landscape scale (e.g., climate change and associated disturbance agents).
2. Some felt that broader-scale monitoring questions should link to the Inventory, Monitoring and Assessment management questions. We were fortunate to have staff from IMA on the project team. Presentations at workshops acknowledged that there is variability across regions and forests in their knowledge of IMA efforts, including national management questions. However, a national set of questions is difficult to support in a culture that emphasizes a decentralized authority, and it is not clear to many how these inform the BSMS or forest plan monitoring. In addition, more work needs to be done to understand the link between IMA, regional management questions, and the BSMS.
3. There is a tension between the regions and forests in terms of who holds funding and controls the design of monitoring. Staff shared concerns about the “no added resources” for a BSMS, with the acknowledged need for regional-level coordination. Attendees suggested the regional office ultimately holds fiscal responsibility but also were concerned that any centralization of monitoring at the regional level would come at a cost to forest-level monitoring — either through lack of funds, or a lack of control. There was a desire for a BSMS to add information to forest plan monitoring, while not taking away from equally important, forest-level monitoring.

Conclusions

- Monitoring is a critical component of the Planning Rule framework. The intent is to monitor important elements at a scale greater than one forest and inform management direction through adaptive management. This can include multiple forests and surrounding lands within a region or across multiple regions (Examples: forest treatment effects, goshawks, MSO, watershed monitoring, etc.).
- BSMS should link to regionally important management questions and IMA management questions. Regions and forests should identify key questions and datasets during the forest planning assessment and plan component phases.
- BSMS can be built upon current monitoring efforts. Leverage existing data and existing monitoring that meets BSMS criteria. Standardize monitoring indicators and data collection protocols within and across national forests and surrounding landscapes.
- Increase coordination and understanding across land management jurisdictions, supporting an “all-lands” approach to land management. Engage partners active in monitoring to identify efficiencies across land management jurisdictions.
- Utilize existing technical expertise and capacity. Added capacity may be needed to fill gaps and may be found internally or through the use of partners.
- Engaging partners (other state and federal agencies, research branches, NGOs, etc.) can aid in leveraging and expanding existing data sources, filling data gaps, and add technical expertise, capacity, and support.
- Use of corporate databases, partner datasets, existing remotely sensed products and FIA data can provide useful data and information at the landscape level to answer monitoring questions.
- There is a need for support from the Washington Office and regional leadership. Engage line officers and forest staff in BSMS. Regional staff should be dedicated to coordination, communication, and adaptive management recommendations.

Appendices

A. Workshop Process

We include sample agenda and facilitation guidelines to show the evolution of the process used throughout our project. Any components of these documents are available for use by other regions. Materials were developed and shared with permission by Southwest Decisions Resources (SWDR), Tahnee Robertson, owner. For more information about SWDR, visit <http://www.swdresources.com/>.

B. Existing Broader-Scale Monitoring Efforts

The Southwest Ecological Restoration Institutes (SWERI) reviewed and interviewed key contacts from existing or past similar efforts that would meet the broader-scale monitoring intent, or could contribute to a developing BSMS. We summarize those efforts here; however, this is not intended as a complete or extensive review.

C. Broader-Scale Monitoring Questions by Resource Area

Broader-scale monitoring questions are listed here by resource area (small-group) work.

D. Publically Available Broad-Scale Data and Data Sources

This dataset is an Excel spreadsheet populated by available datasets from various government agencies (e.g., USGS, USFS, FWS, NPS, FIA, BLM, Heritage programs etc.), corporate, and non-profit entities and partners (e.g., BCR, TNC, etc.). These datasets are commonly available data housed by an agency or entity, partner agency or program and are relevant to all resource areas. This spreadsheet was built based on expert knowledge of available remotely sensed products, GIS datasets, assessment project datasets, data from completed analyses, data clearinghouses, geodatabases, and more. From the BSM interview process, BSM themes began to arise and data sources were compiled. From this, expert knowledge was used to build out this spreadsheet to communicate the already available national level datasets, and datasets relevant to the Southwestern and Rocky Mountain Regions. This spreadsheet contains information as to what agency collected or houses the data, a description of the data, the spatial resolution, the spatial extent or coverage of the data, and the location the data is housed (website or url). During the workshop process, workshop participants were asked to examine the spreadsheet and add known available datasets in their area of expertise.

E. BSMS Opportunities: Short, Mid, and Long-Term

This appendix incorporates the existing, mid-term, and long-term opportunities that became apparent from the workshops for the Southwestern and Rocky Mountain Regions and is not intended to be comprehensive.

Appendix A: Documents describing the workshop process and development.

The workshops were facilitated by Southwest Decision Resources (SWDR). At each workshop we had 2-4 professional facilitators from SWDR, supplemented by project coordinators from the Ecological Restoration Institute at Northern Arizona University and the Colorado Forest Restoration Institute at Colorado State University.

More information about SWDR can be found at www.swdresources.com.

Agendas and facilitator instructions shared with permission by Tahnee Robertson, Director at SWDR.

1. Agenda for Laramie, WY workshop, last in series of four workshops.
2. Evolution of process:
 - a. Facilitator Instructions for Phoenix, AZ workshop, first in series of four workshops.
 - b. Facilitator Instructions for Laramie, WY workshop, last in series.

AGENDA: Broader-Scale Monitoring Strategy Workshop – Laramie WY

May 11th (8:30 am-5pm) and May 12th (8:00am-12pm)

West Yellowstone Ballroom, Wyoming Union

1000 E. University Ave.

This workshop is one of four workshops that will explore an all-lands approach to identify shared opportunities for efficient and effective inventory and monitoring techniques.

Additional Workshops

Phoenix, AZ: April 5-6
 Albuquerque, NM: April 20-21
 Denver, CO: April 28-29

More Information: <http://www.sweri.eri.nau.edu/BroadscaleMonitoring.html>

Workshop Goals

- 1) Foster learning about:
 - Broader-scale monitoring for Forest Plans: intent and goals.
 - Perceptions of broader-scale monitoring (BSMS R2/R3 project interview results).
 - Partner initiatives, efforts and data.
- 2) Identify potential questions, indicators and metrics with partner land management agencies and stakeholders that could inform a broader-scale monitoring framework.
- 3) Gather input for criteria to refine a broader-scale monitoring framework that would prioritize draft questions, indicators and metrics.
- 4) Identify partnership gaps, needs and opportunities.
- 5) Outline collaborative approach, structure, steps and timeline for refining broad-scale monitoring opportunities.

Agenda

Wednesday, May 11: 8:30 AM – 5PM

TIME	TOPIC
8:30am	Welcome, Introductions and Workshop Overview - Amy Waltz, Andi Rogers
9:00	Overview of Broader-scale Monitoring <ul style="list-style-type: none"> ● Project intent: Broader-scale overview - <i>Amy Waltz, Ecological Restoration Institute, Northern Arizona University</i> (5 min) ● Overview of WY forest task force report and state efforts – <i>Jessica Crowder, Office of the Governor</i> (15 min) ● Wyoming Collaborative efforts – <i>Jessica Clement, Ruckelshaus Center</i> (15 min) ● The 2012 planning rule, Forest plan monitoring and transition in R2 - <i>Trey Schillie, USFS Region 2</i> (15 min) ● Interview results: perceptions on broadscale monitoring, what it is, issues/relevance for Forest planning - <i>Zack Wurtz bach, Colorado State University</i> (30 min)
10:30	Break
10:45	Broad scale monitoring efforts from partners and FS Research <ul style="list-style-type: none"> ● Bureau of Land Management Assessment, Inventory and Monitoring – <i>Kevin Miller, BLM</i> (20

	min) <ul style="list-style-type: none"> Forest Inventory and Assessment, Wyoming products – <i>Sara Goeking or Justin Derose, FIA</i> (30 min)
11:45	Plenary discussion - Reflections on morning presentations
12:00	Lunch
1:15	Resource Breakouts - Crucial resource management questions, indicators, and data <u>Resource areas:</u> <ul style="list-style-type: none"> Vegetation - range or grasslands/noxious weeds/botany Vegetation - forests and/or fuels Watershed – soils/aquatics/riparian/wetlands Wildlife/Fish Social, economic, cultural & recreation Sharing Back
3:45	Break
4:00	Plenary - Data Management, Analysis and Applications <ul style="list-style-type: none"> Wyoming Natural Diversity Database - <i>Gary Beauvais, WYNDD</i> (15 min) Wyoming Landscape Conservation Initiative - <i>Tim Assal, United States Geological Survey</i> (15 min)
4:40	Day 1 Wrap Up, overview of Day 2, evening social
5:00PM	Adjourn - Happy Hour

Thursday, May 12: 8:00AM – 12PM

8:00AM	Welcome and Day 2 overview - Amy/Andi
8:15	Plenary - Data Management, Analysis and Applications <ul style="list-style-type: none"> Invasive species inventory and mapping - <i>Amanda West</i> (15 min) Bird Conservancy of the Rockies - <i>Rob Sparks, BCR</i> (15 min)
9:00	Resource Breakout Groups - Data management, analysis and collaboration opportunities
10:15	Sharing Back
10:30	Break
10:45	Partnerships and Strategies for Broader-scale Monitoring Development Brainstorm and discuss recommendations for development of the Broader Scale Monitoring Strategy
11:45	Wrap Up
12:00	Adjourn

FACILITATOR INSTRUCTIONS (PHOENIX)

BREAKOUT GROUPS - BROADER SCALE MONITORING WORKSHOP

Day 1 Afternoon Breakout: Resource questions, monitoring indicators and criteria

1:00 - 3:30pm: Small Groups

Introductions (name, affiliation) and clarify task (5 min)

1. **Current Efforts: Share current efforts within resource areas** (25 min)

- a) Resource presenter - brief presentation on current monitoring effort (5 min)
- b) All participants - Round robin for each participant to share current monitoring and scale (20 min)

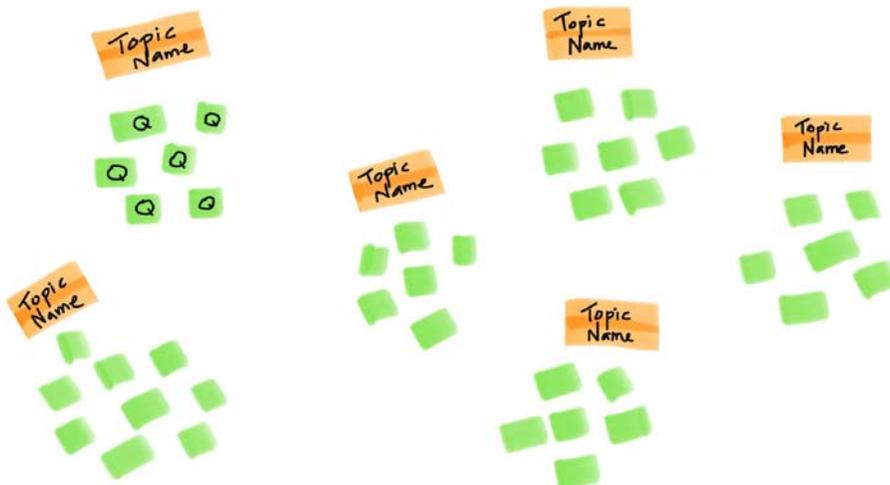
2. **Crucial Resource Questions** (25 min)

a) **Individual work writing on colored sticky notes** (5 min)

- Ask each person to take 5 minutes to write their thoughts on 3-5 sticky notes. Please remind them: 1 idea per sticky note in large, clear lettering (show example)

Question: What are your most crucial resource questions that need longer-term, broader scale monitoring?

b) **Sticky note clustering by topic & discussion** (20 min)



- Ask one person to read their first sticky note and facilitator places it on the wall.
- Then ask who else has a similar question/monitoring need. Each person should read their own sticky before it gets put on the wall (this step crucial for good dialogue)
- Please do not place stickies to cover up the writing of others since we need to photograph them at the end.
- If someone jumps too soon to a new topic, place it in a new area of the wall, but then facilitator should go back to the first until it's finished.
- Quickly add a theme/topic name on a different color sticky and place above each cluster (this

may be a temporary name that helps people track which cluster is which). Name clusters as you go with a word or phrase. If the group is moving rapidly you can add cluster theme names at the end.

- Make sure that all the stickies get on the wall before the group finishes.
- As stickies are being read, please note any clarifying language in ballpoint pen on the sticky, if needed.

Break (10 min)

- Carefully review clusters and for each cluster, craft a concise resource question/monitoring need that captures content of sticky notes. You may need to move/adjust sticky note placement.
 - Write reframed question on a new large sticky and place next to cluster (do not remove individual stickies nor theme header)
- c) **Dot exercise** - to identify top resource question/monitoring needs for future discussion (15 min)
- Give dots to each participant (number of cluster themes divided by 3)
 - Ask them to put one dot per their top theme (no double dotting; dot color doesn't matter)
 - Facilitator count dots and write number next to each
 - Note: this is not prioritization, but a way to go into depth on the items of greater interest to this set of participants given limited time.

3. Selection criteria (20 min)

- a) Review and discuss initial list of potential indicator selection criteria (this is a handout)
- b) Add, refine and/or remove criteria (brainstorm on flipcharts)

4. Indicators (30 min)

- a) Title 5 flip charts with the top 5 resource questions/monitoring needs (most dots), 1 per flip chart
- b) Write subheading "Indicators" - You will be generating a list of indicators under the title
- c) ***Considering our refined list of criteria, what indicators do you recommend for broad scale monitoring for each crucial resource question/monitoring need?***
 - Brainstorm list of indicators under each crucial resource/monitoring need on individual flip chart pages (share example if helpful)
 - Organize flipcharts so that you can move and write on multiple (many indicators may be repeated on more than one flip chart)

5. Apply Criteria (Time permitting): Apply criteria to indicators to do initial evaluation of indicators

3:00-3:30 -- Plenary: Sharing back and discussion

Facilitator highlights main themes from clustering, criteria selection, and indicators that were developed for each crucial resource question. Make this brief - you may be asked to only review the top 3 resource questions (those that received the most votes) and those indicators.

[Day 2 Morning Breakout: Data](#)

9:30 - 11:00pm: Small Groups

1. **Dataset spreadsheet review** - participant review of the regional and national spreadsheets in the folders. Write any additional data sources on index card.
2. **Step back** and review of resource wall work done so far
3. **Data and monitoring partnering opportunities:**
By theme developed from 1st day work, for each theme create a flip chart with three columns:

Existing Data

Needed Data

How to get it/sources/ partnering opportunities

Collect information from small group in informal process.

Day 2 Afternoon Breakout: Partnerships**1:00 - 2:00pm: Small Groups****Partnerships/Collaboration** (*change from resource groups to mixed groups - count off*)

Flip chart used to collect brainstorming on following two questions:

1. What are recommendations for collaboration in the design & integration of the Broader-Scale Monitoring Strategy (e.g., leveraging existing coordinating efforts)?
2. What is it going to take institutionally to be successful with a broader-scale monitoring strategy?

FACILITATOR INSTRUCTIONS (WYOMING)

BREAKOUT GROUPS - BROADER SCALE MONITORING WORKSHOP

DAY 1 BREAKOUTS

1:15 – 3:45 -- Resource questions, monitoring indicators and data (*Resource Groups*)

During lunch -- Facilitators make sure small group wall space is set up with the concentric circle work area

Before breakout begins:

- Put 3 each of green, blue and yellow stickies, and a sharpie at each person's place
- Make sure you have 2 flip chart markers and the Forest Service questions written on green stickies

1:15P **Getting Started** (15 min)

a) **Brief round of introductions**

- ✓ Name and affiliation
- ✓ Why did you come to this workshop or what do you do that could relate to BSMS)

b) **Facilitator review of task and diagram** – in particular explain that there are three levels of scale for questions, monitoring indicators and data, and this activity will help them triage which goes where. Broader scale monitoring is relevant at scales 2 and 3.

1:30 **Crucial Resource Questions and Indicators** (60 min)

a) **Forest Service current resource questions** – FS rep read and place in wall diagram

b) **Individual work writing on groups of sticky notes: GREEN (questions), YELLOW (indicators), and BLUE (data)**

- Ask each person to take 5-7 minutes to write their thoughts on 3-5 sticky notes
- Each resource question goes on a green sticky, write a separate yellow sticky with one or more bulleted indicators that help answer the resource question, and indicate data existing or needed on blue sticky.
- Please remind them: write in large, clear lettering (show example) and keep groups of stickies together

GREEN: *What are your most crucial resource questions that need, broader scale monitoring?*

(1 question per sticky note)

YELLOW: *What indicators will help answer the broad-scale resource question?*

(1 or more indicators per sticky note)

BLUE: *What data exists or is needed to assess these indicators?*

c) **Sticky note clustering by scale and theme**

- Ask one person to read their first sticky note group (question, indicator and data) and identify which scale (1 through 3 as shown in diagram), and hand it to the facilitator to place in the correct circle. If people disagree with the scale choice, ask them to explain and then strive for (quick) agreement on placement.
- Place the sticky note group on the wall together
- Then ask who else has similar questions/indicators/data. Each person should *read their own* stickies before they are put on the wall (this step crucial for good dialogue)

- Please do not place stickies to cover up the writing of others because we need to photograph them at the end.
- If someone jumps too soon to a new theme, place it in a new area of the wall, but then facilitator should go back to the first until it's finished.
- As you go, write a theme name (word or phrase) above each cluster of stickies (or use a different color sticky for the name). If the group is moving rapidly you can add cluster theme names at the end.
- Make sure that all the stickies get on the wall before the group finishes.
- As stickies are read, facilitator please note any clarifying language in ballpoint pen on the sticky, if needed.



- d) Dots (optional)** – If you have a lot of clusters in scales 2 and/or 3, you may do dot voting to narrow the number of themes/questions to work on in the rest of the small group session.
- Give roughly 3 to 4 dots per person (total number of items you are voting on divided by 3).
 - Ask them to put one dot per their top theme (no double dotting; dot color doesn't matter)
 - Facilitator count dots and write number next to each
 - Important: this is not prioritization, but a way to go into depth on the items of greater interest to this set of participants given limited time.

3:30-3:45 – Sharing Back on Questions and Indicators (15 min) - Facilitator share back brief highlights (2-3 minutes each)

3:45-4:00 -- Break (15 min)

DAY 2 BREAKOUTS

9:00 – 10:30 – Data management and collaboration opportunities (*Resource Groups*)

1. **Step back** and review of resource wall work done so far. Invite people to walk up to the wall and really take time to review (5 min)
2. **Dataset spreadsheet reminder** – Remind participants about the data spreadsheets in their packets. If they have additions to this remind them to write on their colored sheet of paper and hand in now, or at the end of the day before leaving. (5 min)
3. **Data Discussion:** Ask the group to consider the information shared so far and reflect on the following questions (as relevant). Capture main points on flipchart
 1. *What are the biggest data challenges for this resource area? (accessibility, sharing, etc)*
 2. *What are the most critical data gaps and need?*
 3. *What FS monitoring at broader-scale could be better informed by partner data/partner monitoring?*
 4. *What are the most important opportunities for cooperation?*

10:15 – 10:30 Sharing Back (15 min) – - Facilitator share back brief highlights (2-3 minutes each)

10:45 – 11:45 – Partnerships and strategies (*TBD – Plenary or small groups - count off*)

Discussion question

Recommendations on how to move forward on broad scale monitoring (i.e. internal, partnering, concrete strategies, etc.)

If small groups:

1. Facilitator record main points of discussion on flipchart
2. Try to move the group towards concrete recommendations.
3. Time allowing, dig deeper on specific recommendations (who should be involved, what resources are needed, what are key next steps?)

USED for all Workshops
~ Small Group Facilitation TIPS ~

Tips for Small Group Facilitators

- LISTEN, try not to answer questions or get into a discussion about an issue
- Be a neutral facilitator - take off your specialist hat and remain neutral to content
- Ask follow up digging deeper questions as needed to get clearer, more useful comments
- Participants should speak more than the facilitator
- Encourage balanced contributions by all participants
- Model and encourage good, respectful communication
- Manage potentially disruptive behavior
- Protect participants from attack (refer to groundrules, etc.)
- Help group stay focused...keep track of time, while trying to keep things moving
- Work with your clusterer as a team (unless you are doing both roles)
- As appropriate, refer questions to relevant agency personnel at the end of meeting
- Ask for help from lead facilitator or other “floaters,” if needed
- Make sure all sticky notes get read by the participants, and placed

Tips for Small Group Sticky Note Clustering

- Cluster as you go
- Don't overlap words so can be photographed at end
- Add clarifying language, in ballpoint pen, to a sticky note if needed
- Add theme names as each cluster
- Ask participant where a sticky note should go, if unsure
- Use a BIN to record comments not relevant to the discussion
- Leave sticky notes up so photos can be taken

Tips for Flip Charting

- Record all comments (people get upset if the recorder filters and skips their comment)

- Write fast but clearly and legibly - alternate colors, use bullets, 1 inch letters, do not write in all caps (it takes longer and often ends up not as easy to read)
- Write participants' words, don't reframe unless necessary
- If a comment is very biased or controversial, you may put it in quotes
- Interrupt to ask for clarification versus skipping comment or recording inaccurately; you can also ask the participant to please summarize if it's difficult for you to summarize a lengthy comment
- Hang pages on wall as you complete them so the group's work is visible
- Number and label pages
- Take cellphone photos of pages at the end (or make sure someone has)

Appendix B. Broader-scale Monitoring Efforts Within Other Land Management Agencies: Options and Observations

Broader-scale monitoring programs currently under-way within the US Forest Service, the National Park Service (NPS), the Fish and Wildlife Service (USFWS), and the Bureau of Land Management (BLM) are designed to meet national or regional direction, but also support unit level planning and management, and therefore may inform the development of a Forest Service BSMS.

Northwest Forest Plan Monitoring Strategy and Pacific Inland Fish Biological Opinion (PIBO) Monitoring Strategy

The Northwest Forest Plan was mandated in 1993 at the executive level following a Presidential proposal for an inter-agency, long-term land management policy (Northwest Forest Plan Record of Decision 1994). The inter-agency monitoring plan was the direct result of a lawsuit on the Plan and subsequent executive direction. The PIBO monitoring program was developed as a result of the Pacific Inland Fish Biological Opinion. It is designed to evaluate the long-term status and trend of riparian aquatic characteristics and measure the effectiveness of management objectives designed to protect anadromous fish in the Interior Columbia Basin (Kershner et al. 2004).

PIBO and the Northwest Forest Plan monitoring efforts represent “top-down” efforts in that they have dedicated funding and staffing and do not rely on unit level personnel or funds to implement their monitoring strategies. Both programs rely on dedicated regional staff, probabilistic survey designs, regionally standardized protocols, and monitoring “strike teams” to ensure consistency and reliability across units. Monitoring strategies were developed through lengthy collaborative processes that relied on technical and managerial steering committees composed of federal agencies and academic scientists and resource specific teams. Both programs also emphasize transparency and credibility through the documentation of protocols and applicable science, implementation processes, data availability and regular reporting. Each program has dedicated full time staff for coordination, scientific analysis, database management, and communication and support for field units, in order to ensure that monitoring information can support management objectives (Kershner et al. 2004). The programs provide data that can be utilized for evaluating progress towards meeting forest plan objectives. According to a program manager in the Northwest Forest Plan monitoring program, information on ecological conditions derived from broader-scale monitoring can support comprehensive planning objectives for specific resources across forests, potentially creating efficiencies with plan revision. Similarly, a respondent from Region 1 noted that forest plan monitoring components in the region have been designed, with the help of regional staff, to be answered using information from the PIBO program.

Key recommendations and applicability to a BSMS:

- Interagency and academic technical team integral to the development of scientifically-rigorous landscape-scale monitoring protocols and consistent data collection.
- Data sharing and transparency involved additional web platform maintained by the Forest Service (www.reo.gov).

- Institutional support at high levels increased success.

National Park Service Inventory and Monitoring Program

Congress enacted the 1998 Parks Omnibus Act, mandating that the agency to improve its science capacity by developing partnerships with academic institutions and research agencies and evaluating the long-term status and trend of park resources (Parsons 2004, NPS 2012). The agency initiated and subsequently received congressional funding for its Natural Resource Challenge in 2001, an initiative that soon led to the development of the agency's Inventory and Monitoring program (I&M).

The NPS I&M program can also be characterized as a “top down” monitoring strategy. According to National and Network I&M staff, the program is notable for its significant organizational autonomy. The budget for the program is allocated annually by Congress in a single line item—one that is separate from park management—and the national I&M office retains authority for the allocation of I&M funding to each of the 32 I&M networks, each of which covers multiple parks. According to NPS respondents, each network is staffed with full-time staff dedicated to inventory and monitoring including, a program manager, a database manager, and often a few agency scientists, such as ecologists or hydrologists. Some networks also employ full-time positions devoted to science communication. Network personnel are responsible for identifying the long-term monitoring of “vital signs”-- key resources of ecological significance that are shared across all parks in each network. On the ground, vital signs monitoring is conducted by “strike-teams” of seasonal employees that use consistent protocols to measure vital signs in each Park in the Network (Fancy 2009, NPS 2012).

National I&M staff noted that in addition to consistencies and reliability across units, the coordinated monitoring and analysis strategy results in significant efficiencies for data collection and analysis. All I&M respondents noted that steering committees-- Technical Advisory Committees (composed of Network managers and external scientists) and a Boards of Directors (composed of Park Supervisors)—have been critical for ensuring that long-term monitoring is scientifically credible, feasible, and relevant to Park management. Respondents also highlighted the program's emphasis on database management. While the NPS has national databases for species and remote sensing products, each network maintains its own database for network vital signs, spending at least 30% of its budget on database management. Monitoring data is analyzed by network staff and reported annually in lengthy monitoring reports, as well as two-page “resource briefs” that utilize a stoplight symbology to convey the status and trend of key resources to park managers and staff (NPS 2012). In each network, the process, monitoring protocols, and budgets are documented in Inventory and Monitoring plans, updated as needed, and available online (<http://science.nature.nps.gov/im/>).

Key recommendations and applicability to a BSMS:

- Availability of and investment in key technical expertise regionally is important to consistent and scientifically credible monitoring.
- Realized key efficiencies for data collection and analysis.

U.S. Fish and Wildlife Service Inventory and Monitoring Program

The USFWS initiated a comprehensive strategy for improving inventory and monitoring in refuges in 2009 in response to of the DOI's Climate Change initiative (USFWS 2010). The agency finalized 7-Year Inventory and Monitoring Plan released in 2013 (USFWS 2013). According to National and Regional I&M staff, the agency sought to learn from and mirror elements of the NPS' I&M strategy, while also ensuring that it was aligned with the needs, culture, and management centered mission of the USFWS. As a result, while the USFWS has adopted some elements of the NPS program, such as standards for documenting monitoring plans and best available science, it ultimately represents a more flexible “bottom-up” approach— one that emphasizes short term effectiveness monitoring and adaptive management through science delivery, outreach, technical assistance, and improved information management (USFWS 2013). This strategy is reflected in recent policy for refuge planning (USFWS 720 FW 2), which requires refuges to develop Inventory and Monitoring Plans (IMPs), and provides explicit guidance for ensuring that monitoring protocols are scientifically credible, feasible, and directly linked to refuge planning and management.

The USFWS I&M program is funded by an annual allocation of approximately 12 million dollars through the agency's climate change initiative; 2 million dollars are allocated to the National I&M office, 1 million dollars are allocated to national database management and strategic priorities, and the remaining 9 million are used to fund additional staff positions specifically devoted to inventory and monitoring in each of the agency's eight biological resource divisions in each multi-state Region (USFWS 2010). Within the Mountain and Prairie Region, for instance, the I&M strategy is supported by a full-time monitoring coordinator, and a three database management and biometric specialists (USFWS Regional Staff). These regional staff provide Refuge biologists and planners with guidance for monitoring and planning objectives, technical assistance and database management support, and inventory products that are useful for planning and monitoring--such as updated vegetation maps and other geospatial data. Zone biologists –characterized as “the face of the Inventory and Monitoring program”— provide significant in-person support and assistance for refuge-level inventory and monitoring activities, and promote coordination and information sharing across refuges in their respective Zones (USFWS National and Regional staff).

IMPs must also be approved by the zone biologist and the regional monitoring coordinator—a strategy designed to provide a measure of accountability for refuge level monitoring (USFWS Regional Staff). This last consideration is especially relevant as refuge managers have significant discretionary and budgetary authority for implementing monitoring in refuges. In addition, the USFWS is also in the process of developing standardized Refuge Condition Assessments for reporting the status and trend of Refuge resources; these are designed to provide a tangible product of the I&M initiative and to help inform management actions (USFWS 2013). Like the Park Service, the USFWS has also emphasized database management. However, in contrast to the NPS strategy, Regional and National I&M staff emphasize that the USFWS has first focused on “getting information off of everyone's C-Drives” and standardizing documentation of applicable science and procedures. As a result, an early emphasis has been on the development of accessible repositories for existing documents, reports, geospatial products, comprehensive species inventories, credible monitoring protocols, inventory and monitoring plans, and legacy data associated with historical refuge biological information.

Key recommendations and applicability to a BSMS:

- Develop at unit-level, but with regional technical support to maximize consistency and efficiency.
- Data management protocols and increased centralization of data key to future success of plan.

Bureau of Land Management Assessment, Inventory and Monitoring

The BLM's Assessment, Inventory, and Monitoring (AIM) strategy was developed in response to an Office of Management and Budget analysis that highlighted a lack of efficiency, standardization, and consistency in BLM monitoring, and the agency's failure to systematically evaluate rangeland conditions and trends at regional and national levels (Taylor et al. 2012, AIM Staff). In contrast to the NPS and USFWS organizational structures, AIM is a centralized at regional and national levels, with little investment in additional personnel and positions at lower levels of the administrative hierarchy. At the western Denver regional office level, AIM is composed of three teams (terrestrial and aquatic ecosystems, and remote sensing) devoted to implementing the five components of the BLM strategy: a standardized set of "core" monitoring indicators and additional "contingent" indicators that allow for local flexibility; a statistically rigorous sampling design; integration with remote sensing; efficient electronic data capture and database management; and implementation processes that link AIM monitoring to iterative management and decision-making cycles at landscape and unit levels (Taylor et al. 2012). Despite the lack of program capacity at lower levels, a defining feature of the BLM's strategy is the intended combination of "top-down" coordinated monitoring with the "bottom-up" promotion of AIM protocols and implementation processes at the landscape and field level.

At the heart of the AIM strategy is a west-wide, low intensity probabilistic sample of terrestrial and riparian plots that, combined with remote sensing applications, can be used to systematically evaluate the status and trend of ecological conditions across the BLM. The program is also currently piloting AIM monitoring strategies at the landscape and field office levels of the agency. At these levels, AIM staff indicated that with support from national teams, local personnel rely on an intensification of the core plots to measure AIM indicators, with additional contingent indicators utilized as needed based on local conditions. AIM implementation at landscape and unit levels is also designed to promote adaptive management and linkages to planning through integration with Land Health Assessments based on NRCS Ecological Site Descriptions (ESDs). By evaluating the existing condition of sites (with AIM indicators and protocols), and comparing them to potential conditions (identified in ESDs), managers can prioritize and identify management actions and track progress towards goals (AIM Staff, Taylor et al. 2012). According to an AIM respondent, standardized indicators and data management processes may result in significant efficiencies for data collection, storage, and analysis. Monitoring data is entered in hand held electronic devices in the field, and after standards for quality control have been applied at the end of the year, data is uploaded to a centralized spatial database. Data analysis occurs at the national level, with the results subsequently sent back to the field (the specific format for communication is still being developed and will likely be tailored to specific management needs). AIM staff also noted that they are currently considering employing monitoring "strike teams" to ensure consistency across landscape or field units, but this strategy has not yet been implemented.

Key recommendations and applicability to a BSMS:

- Use of pilot project areas to test implementation and start small with one key resource (rangeland health assessment) built within a framework to add resources.
- Pilots designed to test and validate existing fine-scale data which could increase efficiency in future sampling.
- Consistent, efficient, landscape-scale monitoring efforts take time to develop and implement.

Tradeoffs

In the interview phase of this project, we asked interviewees about the relative strengths and weaknesses of existing broader-scale monitoring programs in federal land management agencies. Respondents noted that the organizational structures and implementation processes of the purely “top-down” monitoring programs--the NPS I&M, PIBO and NW Forest Plan-- reflect their legal mandates for consistent, scientifically credible long term monitoring across multiple units. Several respondents noted that autonomous budgets help to ensure that monitoring is consistent over time and space, and dedicated staff and program specific databases have promoted effective analysis and communication and reporting to unit-level, regional, and national decision-makers. These programs also share similar characteristics in terms of their design process: extensive collaboration with internal and external scientists to identify monitoring indicators and measurement protocols, technical and managerial oversight committees, and resource specific working groups.

One weakness identified by many respondents is that these top-down strategies are expensive and take time to design and maintain; it is notable as well that all of the top-down strategies were developed as a result of legal mandates. Another weakness, noted by respondents from the NPS and NW Forest Plan, is that while they provide the consistency and scientific credibility needed to evaluate the status and trends of resources across multiple units, the programs have not been systematically utilized to support short term unit level management decisions or iteratively evaluate the effects of management actions through structured adaptive management processes. The NW Forest Plan and the PIBO monitoring programs were both designed to evaluate trends and conditions of ecological characteristics at the region or landscape scale, rather than at the scale of a project or forest. As a result, there is limited inference into the effects of management actions at large scales, especially when compared to fire or other factors associated with natural variability. For instance, data from PIBO may be used opportunistically to evaluate management effectiveness, but only in watersheds that are included in the PIBO sample. In the NPS, funding for short-term effectiveness monitoring in parks has not been as forthcoming as originally expected (Fancy and Bennetts 2012), an issue one NPS respondent noted could potentially result in a loss of support from park managers. According to one respondent from the NPS program, while the 1998 Omnibus Act specifies that park superintendents will be evaluated on the status and trend of park ecological conditions, monitoring information has not been incorporated into performance evaluations, limiting the incentive for it to be incorporated into management decision-making. There has also been resistance to developing State of the Park Reports—mechanisms for directly linking monitoring to park planning—due to their cost and some apprehension from Park Managers that they could be used to evaluate their performance. All respondents from the NPS noted that the network-based structure of the NPS program has also created challenges for ensuring monitoring consistency for similar resources across networks, complicating broad-level assessments, and national-level reporting.

The BLM's program, while essentially "top-down, is designed to evaluate the long-term status and trends or ecological conditions at multiple scales and support adaptive management at unit levels. The relatively lean design of the program—including its emphasis on remote sensing and contracts for monitoring—reflect budgetary limitations. While it is still too soon to definitively address the outcomes of the program and the pilot projects, respondents from AIM and NGOs noted that there may be barriers to the systematic adoption of the AIM protocol and process at landscape and field levels. Due to the decentralized decision-making culture of the agency, and with budgetary authority for most monitoring located at the unit level, systematic adoption at the field-level is dependent on the perceived benefits of consistency, scalability, and efficiencies created by standardized indicators, protocols, data storage and centralized analysis. According to an NGO planning specialist, the implementation of the AIM process for local adaptive management may be complicated by the complexity of the process, the lack of ecological site descriptions in many areas, the long-time reliance on other monitoring protocols and their legacy data, and the lack of flexibility associated with standardized indicators that may not be appropriate in many non-rangeland contexts.

Despite the development of national protocols for some wide-ranging species, such as birds and monarch butterflies, and the success of some coordinated multi-unit monitoring efforts, the USFWS program is primarily a "bottom-up strategy" designed to ensure that local monitoring supports refuge planning and short-term management decision-making. However, with authority for monitoring implementation at the Refuge level, some respondents indicated that the new USFWS IMP policy may not be sufficient for ensuring that monitoring is scientifically defensible and consistent across like units or resources, or that it will be maintained over time due to personnel turnover and shifting Refuge priorities. For instance, USFWS staff noted that despite its acclaim and benefit, the Native Prairie Adaptive Management program (a coordinated, multi-unit adaptive management strategy) still requires significant "cheerleading" from the zone biologist to ensure ongoing buy-in and support from many unit managers. Furthermore, there is a perception from a few NPS and USFWS respondents that while the addition of regional capacity for outreach and support has been critical for improving credibility and oversight, there is still a lack of expertise and capacity at the Refuge level for effectively implementing on the ground monitoring activities.

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Appendix C: Potential BSMS Questions, indicators and datasets

As part of the workshop process, resource-based breakout groups generated separate lists of questions, indicators, and datasets for each workshop. Early synthesis recognized that resource-based questions were very similar across workshops. From all 4 workshops, we collected approximately 100 questions total for each resource area. By eliminating repetition in the question set and combining similar questions by theme, we distilled this initial set of questions to a list of approximately 30 for each resource area that were representative of questions asked across all workshops, and 3 to 5 top questions that best capture the main recurring topics in each resource group. For a complete list of brainstormed questions, visit www.sweri.nau.edu/broadscalemonitoring.html

Resource area example questions, indicators, and datasets

Top Forest Vegetation Broader-scale Monitoring Questions					
IMA category	Planning rule Req.	Question	Type of monitoring	Indicators	Datasets
1.2	2	How are key characteristics of forest structure, function and composition changing over time in relation to desired conditions and HRV at the ecosystem and landscape scale?	Surveillance	Large live trees, snags, coarse woody debris, species composition and distribution (shifts), age and size class distributions, mortality, regeneration and recruitment, structural diversity, BA/SDI; patch size, configuration, and connectivity; carbon stocks; forest encroachment into non-forest	FIA, FORCAMF, FSveg, LANDFIRE, remote sensing products
	6	How are climatic variables and disturbance processes (such as wildfire and insects/disease outbreaks) affecting key characteristics of forest structure, function, and composition at the ecosystem and landscape scales?	Surveillance	carbon stocks; spatial extent, severity and distribution of insects and disease outbreaks; modeled areas at risk; structural diversity, species composition, regeneration and recruitment in areas affected by insect/disease and wildfire; wildfire size, extent and severity; patch size, configuration; vegetative phenology	NIDRM, ADS, FIA plots and future forest change products, MTBS, FORCAMF, LANDFIRE, FSveg, RSAC, NOAA, remote sensing products, NPN
	7	Are plan components and management treatments effectively protecting social and ecological values at risk, and promoting ecosystem resistance and resilience to climate change and disturbance at the stand and landscape scale?	Effectiveness; Modeling	Fuel loading (BA/SDI/fine fuels/Crown density); regeneration/recruitment in treatment areas; number and acreage of prescribed fire treatments; average cost/acre; actual observed effectiveness of fuel treatments; WUI structure locations and risk maps; patch size, composition, configuration; NPP/rates of growth; modeled risk and conditional burn probabilities; treatment location optimization	FACTS, FSveg, NIDRM, NAIP, FIA, state forestry, Remote sensing products

Other potential forest vegetation broader-scale monitoring questions			
IMA category	Planning rule Req.	Question	Type of monitoring
	2, 6	What is the status and trend of insects and diseases?	Surveillance
	2, 6	What tree species, forest types and locations are most at risk to insects and disease in the next ten years?	Modeling
	2, 6	How are insects and disease affecting forest structure and composition at the landscape and stand levels?	Surveillance
		What are the trends in fire severity, pattern, and extent?	Surveillance
		What is the status and trend of atmospheric deposition?	Surveillance
	2	What is the distribution and abundance of live large trees?	Surveillance
	2	What is the distribution and abundance of snags?	Surveillance
	6	What is the status and trend of noxious weeds	Surveillance
	2	How are species distributions shifting over time, particularly at ecotone/ range margins?	Surveillance
		What is the status and trend of sensitive plant and tree species?	Surveillance
	2	What are the trends in coarse woody debris?	Surveillance
	6	How is forest structure and composition responding to uncharacteristic fire?	Surveillance
	7, 8	Are landscape level treatments effective at changing fire behavior and protecting values at risk?	Research
	2	How do landscape scale changes in vegetation affect hydrologic functions?	Research
	2	What is the rate of forest encroachment in non-forest ecosystems?	Surveillance
	7, 8	Are management treatments promoting forest resistance and resilience to disturbance (reword)	Effectiveness
	2	What are the trends in tree regeneration and recruitment in treatment areas?	Effectiveness
		How are carbon stocks changing over time?	Surveillance
	2	How are phenological events changing over time?	Surveillance
	2	How are alpine cover types changing over time?	Surveillance

Top Wildlife Broader-scale Monitoring Questions

IMA category	Planning rule Req.	Question	Type of monitoring	Indicators	Datasets
1.2	3	What is the status and trend of focal species?	Surveillance	Occupancy, distribution, abundance of American pipit (alpine), hairy woodpecker (all forest types), golden-crowned kinglet (late seral conifer), mountain bluebird (open forests), Brewer's sparrow (sagebrush), and common flicker (cavity excavator), hairy woodpecker, warbling vireo, Red squirrel, Abert's squirrel, Pika, American Marten, black tailed prairie dog, cutthroat trout, macroinvertebrates, amphibian species, rare plants	BCR, USFS TES-IP, State Heritage, State Wildlife Agencies, FWS
1.2	4	What is the status and trend of Threatened and Endangered Species (TES)/Species of Conservation Concern (SCC) populations?	Surveillance	Occupancy, distribution, abundance of Goshawk, Canada Lynx, Cutthroat Trout, Boreal Toads, Leopard Frogs, Black footed-ferret, Mexican Spotted Owl, Brewer's sparrow, Preble's jumping mouse, Bighorn sheep, Grizzly bears, Whitebark pine (cone production and mortality), rare plants, Bighorn sheep	BCR, USFS TES-IP, State Heritage, State Wildlife Agencies, FWS
1.2	4, 6	What are the status and trends in the ecological conditions needed to support TES/SCCs, and how are climate change and other stressors (e.g. uncharacteristic fire, insect and disease outbreaks, recreation, extreme weather events) affecting them?	Surveillance	fine-scale species specific habitat components (e.g snags, stream temp); patch size, composition and configuration needed for effective connectivity (e.g early and late seral for Lynx); trends in wildland development; extent and severity of insect mortality; extent and severity of fires; location, extent, duration and severity of extreme climatic events (drought, flooding); forest encroachment; trends in stream temperature, riparian structure and composition; water quality, quantity, timing of flow, temperature, macroinvertebrates; presence/abundance/distribution/rate of spread of noxious weeds and invasive aquatic species	FIA, MTBS, RSAC, ADS, FHTET, USFS TES-IP, USFS FS-VEG, USFS FACTS, NORWEST, NOAA, NRCS- Snowtel, RSAC, NAWQWA/ STORET
1.2	4, 7	Are plan components and management actions effective at promoting the maintenance and recovery of TES/SCCs populations,	Surveillance; Effectiveness	Stream/aquatic connectivity (miles of functional connectivity); forest /rangeland structural diversity and species composition in treatment areas/allotment areas (fine-scale requirements or validation); patch size, configuration, and	USFS TES-IP, USFS FS-VEG, USFS FACTS, FIA, RSAC, NORWEST, NOAA,

		and the resilience of key ecological conditions on which they depend?		connectivity; species occupancy, distribution and abundance data	NRCS- Snowtel, RSAC, BCR
	2; 4	What are the status and trends in wildlife habitat and connectivity, particularly for TES/SCC species?	Surveillance; modeling	sage brush cover and height; perennial plants cover and height; disturbance resulting in habitat degradation; Critical habitat elements, Number of individuals	sage grouse plan amendment

Other potential wildlife broader-scale monitoring questions			
IMA category	Planning rule Req.	Question	Type of monitoring
	3,4	What are the status and trends of riparian and wetland obligate species?	Surveillance
	3	What is the status and trend of focal species?	Surveillance
	4	What is the status and trend of sensitive species/SPCC's?	Surveillance
	4	What is the status and trend of TES?	Surveillance
	4	What is the status and trend of native trout?	Surveillance
	4	Where are critical areas of connectivity? What are they threatened by?	Inventory
	4	What is the status and trend of key forest habitat conditions over time?	Surveillance
	4	What is the status and trend of key aquatic habitat conditions over time?	Surveillance
	4	What is the status and trend of key non-forest habitat conditions over time?	Surveillance
	4	What is the status and trend of key riparian and wetland habitat conditions?	Surveillance
	3	What is the status and trend of pollinators?	Surveillance
	7	What is the effect of forest management treatments on wildlife species at the landscape scale?	Effectiveness
	7	Are plan components and management actions maintaining or improving key elements of composition, structure, function and connectivity for TES/SPCC's?	Effectiveness; Surveillance
	6	What is the effect of insect/disease mortality on wildlife species?	Surveillance
	6	What is the effect of invasive plant species on wildlife species and habitat?	Surveillance
	6	What is the effect of aquatic invasives on aquatic species?	Surveillance
	6	What is the effect of fire and changing fire regimes on wildlife species status and trends?	Surveillance
	7	What is the effect of grazing on wildlife species?	Surveillance
	6	What is the effect of fire on non-forest species and habitat?	Surveillance
	6	What is the effect of fire on riparian species and habitat?	Surveillance
	4,6	What is the effect of changing disturbance regimes on SPCCs, TES?	Surveillance
	6,7	What is the effect of recreation on wildlife?	Surveillance
	6	What is the effect of energy development on wildlife?	Surveillance
	6	How is climate change affecting species distributions?	Surveillance
	6	What are the threats to key habitat corridors?	Surveillance

Top Social, Economic, Cultural, and Recreation Broader-scale Monitoring Questions					
IMA category	Planning rule Req.	Question	Type of monitoring	Indicators	Datasets
	7	What are the trends in economic contributions and provisions of NFS lands, for different resources and to different demographics?	surveillance	# of new forest product businesses; dollars by resource/plan area; revenue in communities; forest-dependent employment	State Economic Data; IMPLAN with resource specific coefficient; local/county government data, Headwaters Economics; Trade associations; State universities compilation of private industries data (# jobs, sales, etc) e.g. UNM Bureau of Business and Economic research; Timber Info Mgmt (TIM) database
	5	What are the status and trends in recreational uses of USFS lands?	surveillance	number of permits and use location; condition of facilities and roads; number of visits by type	NVUM; permit data
	5	What are the status and trends in visitorship?	surveillance	visitor demographics; user satisfaction; number of visits by type	NVUM; Headwaters Economic; USFS Human Dimensions Tool Kit
	2, 7	What are the status and trends in ecosystem service provision and demand?	surveillance	reservoir levels, stream flow, water temperature and quality, vegetation composition and structure	

Other potential social, economic, cultural, and recreation broader-scale monitoring questions			
IMA category	Planning rule Req.	Question	Type of monitoring
	6	What are the status and trends of natural disturbance and other cumulative impacts to heritage and cultural sites?	Surveillance
	5	What are the status and trends in visitorship to heritage and cultural sites?	Surveillance
	5	What are the status and trends of traditional user access and experience? What are the status and trends in traditional users needs related to forest resources?	Surveillance
		What are the trends in economic contributions and provisions of recreation, timber, grazing, and minerals of the forests?	Surveillance
		What are the status and trends of economic contributions of NFS lands, especially to low income and minority populations?	Surveillance
		What is the economic contribution of timber, recreation, mineral and grazing programs from NFS areas toward community (city, county, state) GDP?	Surveillance
	2	What are the status and trends of ecosystem services provided by the USFS?	Surveillance
		What are the status and trends of demand for ecosystem services provided by the USFS?	Research, Surveillance
	5	How are demographic changes (i.e., income, race/ethnicity/ age/ employment) affecting forest uses?	research
	5	What are the status and trends in recreational use of USFS lands?	Surveillance
	6	What are the status and trends in impacts to USFS lands (including cultural resources/heritage sites) due to recreation?	Research, Surveillance
	5	What are the status and trends in recreational visitor experience?	Surveillance
	5	What are the status and trends in engaging the youth and under-represented groups?	Surveillance
		What are the status and trends of the USFS relationship to the public and stakeholders?	
		What are demographic changes (i.e., income, race/ethnicity/ age/ employment) in forest users?	
	5	What are the status and trends in visitor satisfaction?	Surveillance
	6	What are the status and trends in visitor use impacts to NFS lands?	Research, Surveillance
	5	What are the status and trends in visitorship to NFS lands?	Surveillance
	5	What are the status and trends in visitor access to NFS lands?	Surveillance
		What are the patterns in land use and development near Forest boundaries?	Surveillance
		What are the status and trend of social and economic conditions in local communities?	

Top Range Vegetation Broader-scale Monitoring Questions					
IMA category	Planning rule Req.	Question	Type of monitoring	Indicators	Datasets
	2	What are the status and trends of grassland community composition, structure, and productivity?	Surveillance	Temporal trends in species composition and productivity, bare ground, community structure, spatial distribution, species abundance; functional group composition; shifts in ground cover; Annual spatiotemporal pattern of grazing; Timing and magnitude of greenup, senescence and peale greenness; Native herbivory trends, ecological state transition	NRCS Ecological site descriptions and site maps; Cow caster output, MODIS derived products, National Phenocam Network, USA National Phenology Network; long term range monitoring, remote sensing
	6	What are the status and trends in disturbance processes in rangelands? Natural processes? Grazing related disturbance? Infrastructure/development disturbance?	Surveillance; modeling	departure from reference conditions; land cover change; land/veg type conversion (e.g. encroachment); Annual spatiotemporal pattern of fire, Changes in fire intensity, size, location, and intervals; Fire regime departure, Presence of prairie dogs, Structural and compositional diversity that would result from natural disturbance regimes, Spring flooding; Annual spatiotemporal pattern of grazing; Total acres ground disturbance and density (roads, pipelines, powerlines, infrastructure, etc.); Changes in land use-fragmentation: spatial monitoring of changes in land cover, monitoring changes in land ownership	Infra roads and trails (EDW, FSGeodata); Landsat, MODIS, MTBS; remote sensing; NAIP, historic photography; Landfire; FSveg, Terrestrial Ecological Unit Inventory (TEUI)
	6	What are the status of non-native invasive species across the landscape? How are distributions changing over time?	Surveillance; modeling	distribution, location, number of acres; % cheatgrass cover	NRM; TES/IS; long term vegetation plot data, remote sensing
	2; 6	What are the effects of climate change and drought on grassland community composition and structure, productivity, and soil condition?	Research	ratio of C3/C4 plants; Native herbivory trends, ecological state transition; climate data; Plant species and functional group composition; soil moisture, system hydrology	remote sensing; NAIP, historic photography; North Central Climate Science Center data; Phenological network

Other potential range vegetation broader-scale monitoring questions			
IMA category	Planning rule Req.	Question	Type of monitoring
	2	What are the status and trends of grassland community composition, structure, and productivity?	Surveillance
	6	What are the status and trends of temperature and precipitation in rangelands?	Surveillance
	2; 6	What are the effects of climate change and drought on grassland community composition and structure, productivity, and soil condition?	Research
	6	What are the status and trends in disturbance processes in rangelands? Natural processes? Grazing related disturbance? Infrastructure/development disturbance?	Surveillance
	2	What are the status and trends in woody encroachment into rangelands/grasslands? (distinguish between juniper into sagebrush vs "grassland"?)	Surveillance
	6	What are the status and trends in fire dynamics, including burn intervals, intensity, and size? In relation to HRV?	Surveillance
	6	What are the status and trends in vegetation response to fire?	Research
	7	What are the status and trends in grazing?	Surveillance
	6	What are the status of non-native invasive species across the landscape? How are distributions changing over time?	Surveillance
	6	What are the effects of non-native species on rangeland plant community composition?	Research
		What are the status and trends in land use and land cover change?	Surveillance
	4	What are the effects of land use change on T&E species/species of conservation concern?	research
		What are the status and trends in pollinator populations?	Surveillance
	2	What is the status and trend of rangeland condition? (bare ground, salt crust vegetation composition, phenology)	Surveillance
		What are the status and trends in soil moisture, erosion rates, and soil carbon?	Surveillance
	4	What is the status and condition of sage grouse habitat?	Surveillance
		What is the status and condition of wildlife populations? (Prairie dog, grouse, antelope, birds)	Surveillance
		What are the status and trends in genetic diversity and species diversity in rangelands/grasslands?	Surveillance
	4	What are the status and trends of plant species of conservation concern? Natural communities of conservation concern?	Surveillance

Top Water Broader-scale Monitoring Questions					
IMA category	Planning rule Req.	Question	Type of monitoring	Indicators	Datasets
		What are the status and trends of water quality and hydrologic functions within watersheds and HUCs?	surveillance	water quality; changes/miles of 303D listing; timing and quantity of flow; Aquatic invertebrates as bioindicators (bioassessment); Depth of snowpack through the season	Stream gage data, state list 303-D, State integrated report part of impaired waters list; Continuous water quality measurements on impaired streams; Springs Institute data; NORWEST, remote sensing data, GIS data, HUC 12 data, Aggregate HUC12s to answer Qs ; NHD plus stream and waterbodies network, Integrated with watershed boundaries data, USGS – shape data, temp, discharge, etc., State datasets, NLCD data; NRCS – snow water equivalent, etc. PRISM, NDVI, sensors; SNOTEL; Thermograph data; USGS stream gages, monitoring wells; Standardized Precipitation Index (WRCC & NOAA)
	2	What are the status and trends in the structure, function, composition and connectivity of lotic systems (i.e. aquatic, riparian, springs, seeps)?	surveillance	seral state of riparian communities; trend (up/down) of PNC; Departure from PNC, Vegetation responses to precipitation and temperature; Effects of vegetation responses on runoff; non-native species, plant community distribution; wildlife species; pebble counts/sedimentation; pools/riffles/banks; aquatic species patterns of use over time, Vegetation data, GIS data, water temp and quality, miles of restored functional stream connectivity (culverts, dams); miles of stream with native trout; riparian veg connectivity; Macro-invertebrates; Overall water quality: Routine (daily, weekly, monthly, seasonal) for temperature, pH, DO, turbidity, condition; ground water monitoring quantity and recharge	MIM, Winward Greenline, remote sensing and LiDAR; Field based data, NAIP, Natural Heritage/Nature Serve; Watershed Conditions Framework (WCF) datasets (varied)- some local; Biological indicators- Benthic macro-invertebrates, fish surveys (USFS, state, Tribal); Breeding bird survey data for riparian habitats (BCR, USGS); NAIP, Vulnerability Assessments, Species Distribution models, GIS datasets, Nature serve data; Riparian Map (RMAP); USGS National Hydrologic Database; NORWEST

	6	How is water temperature, snowpack, runoff, flow, groundwater level and recharge, and precipitation changing as a result of climate change?	surveillance	Depth of snowpack through the season; Timing of precipitation (snowfall and rainfall); Volume of rain in individual storms; Climate data (precipitation and temperature); water availability and quantity; stream temperature	NRCS – snow water equivalent, etc. PRISM, NDVI, sensors; SNOTEL; Thermograph data; USGS stream gages, monitoring wells; Standardized Precipitation Index (WRCC & NOAA); NORWEST
	2	What are the status and trends in the structure, function and composition of lentic systems?	surveillance	lake water chemistry, visibility, deposition- dry & wet; extent of wetlands in general and fen wetlands specifically; fen and wetland species composition	NWI fen mapping; National Wetland Inventory (FWS); CNHP/WYNDD wetland/fen products

Other potential water vegetation broader-scale monitoring questions			
IMA category	Planning rule Req.	Question	Type of monitoring
		What are the status and trends of overall hydrologic function?	surveillance
		What is the status, condition, and trends of natural water sources (i.e. springs, seeps, and streams)?	surveillance
		What are the status and trends (acres and condition) of wetlands?	surveillance
		What are the status and trends in ground water dependent ecosystems?	surveillance
		What are the status and trends in insects and disease in vulnerable watersheds?	surveillance
		What are the status and trends in watershed conditions in areas with restoration treatments?	surveillance
		What are the status and trends in riparian function?	surveillance
		What are the status and trends in water withdrawal & demands?	surveillance
		What are the status and trends of in-stream habitat sedimentation? Salinity? Temperature?	surveillance
		What are the trends of water quality at the HUC 12 level? At the HUC 5 level?	surveillance
		What are the status and trends of water quality in lentic systems?	surveillance
		What are the status and trends in air quality?	surveillance
		What are the status and trends of aquatic threatened and endangered species? (e.g. cutthroat)	surveillance
		What are the status and trends in aquatic invertebrates?	surveillance
		What is the effect of presence of non-native fish/invertebrates on native fish species biodiversity?	research
		Are areas of refugia for aquatic species changing over time?	surveillance
		What are the status and trends of connectivity across NFS lands and adjacent ownerships for aquatic species?	surveillance
		What are the status and trends in riparian habitat?	surveillance
		What are the status and trends in rare plant species (aquatic, riparian, wetland)?	surveillance
		How are water resources, water budget, seeps, springs, and wetlands changing over time?	surveillance
		What are the status trends of snowpack, runoff, and precipitation (climate)?	surveillance
		What are the status and trends in water temperature?	surveillance
		What are the status and trends of invasive species both terrestrial and aquatic?	surveillance

National Datasets Available					
Agency	What	Available Data	Spatial Resolution	Coverage	Location/Web Address
USFS Forest Inventory & Analysis (FIA)	Plot info on tree species lists, understory veg, soils, lichen, invasives and more	XY point data and associated vegetation databases	multiple	Interior West (AZ,CO,ID,MT,NM,NV,WY,UT)	http://www.fia.fs.fed.us http://www.fia.fs.fed.us/tools-data/index.php http://apps.fs.fed.us/fiadb-downloads/datamart.html
The Nature Conservancy (TNC)	Southwestern Forest Analysis	Use SW REGAP, LANDFIRE, Spatial Ecological Assessments	30m , multiple	AZ and NM	http://azconservation.org/downloads/category/gis
The Nature Conservancy (TNC)	Ecoregional Assessment-Western North America	Geodatabase from 19 Ecoregional Assessments, Biotic communities of the SW, Grasslands of AZ, AZ Freshwater Assessment	30m , multiple	Western U.S.	http://azconservation.org/downloads/category/gis
Integrated Western Landscape Assessment Project (ILAP)	Oregon/Washington and Arizona/New Mexico Existing Veg, Potential veg, soils, HUCs, Landsat derived data, state forest, arid, and woodland type, ownership, soils	Imputed and Random forest derived Potential changes in landscape conditions under different management scenarios	30m , multiple	R3 and R6 AZ & NM	http://westernlandscapesexplorer.info/AccessILAPDataMapsModelsandAnalyses
LANDFIRE USGS/TNC/USFS	Vegetation, fuels, fire regime, disturbance, reference conditions, topographic maps	raster and vector data layers	10m, 30m	North America	http://www.landfire.gov/
USDA National Agricultural Imagery Program (NAIP)	Aerial photography	Digital Orthoquads (DOQQs)	3.75 X3.75	North America	http://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/
BLM Geocommunicator	Oil & Gas leases, Wild Horse & Burro, Special Public Purpose, Rights of Way, Rangeland & Grazing Allotments, Solar	map products	multiple	North American BLM lands	http://www.geocommunicator.gov/GeoComm/

Agency	What	Available Data	Spatial Resolution	Coverage	Location/Web Address
BLM Geographic Coordinate Database (GCDB)	BLM official survey records	Cadastral National Spatial Data Infrastructure (CADNSDI) file geodatabases	30m, multi	North American BLM lands	http://www.blm.gov/wo/st/en/prog/more/gcdb.html
US Gov Geospatial OneStop	Protected Areas of the US (PODUS), Agricultural, Climate, Ecosystem, Energy	Biodiversity, Landcover, EnviroAtlas	multi	North America	http://catalog.data.gov/dataset
USDA Geospatial Gateway	Ortho Imagery, NAIP, Tiger data, soils, cultural, boundaries, precip, temperature, easements, elevation, hydrologic units and more	maps, raster and vector dataset, imagery	multiple	USA- North America	https://gdg.sc.egov.usda.gov/
USFS Field Sampled Vegetation (FSVeg)	FSVeg Software: Common stand exam, fuels, permanent grid inventories	trees, fuels, cwd, surface cover, understory veg.	multiple	USA- North America	http://www.fs.fed.us/nrm/fsveg/
USDA NRCS Soil Data Mart	Soil data by the National Cooperative Soil Survey	databases and map products	multiple	USA- North America	http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
USGS GAP Analysis Program	Landcover, Protected Areas, species range maps, distribution models, aquatic species maps, more	databases and map products	multiple	USA- North America	http://gapanalysis.usgs.gov/
USGS National Geospatial Program	USGS Hydrogeography Datasets	databases and map products	multiple	USA- North America	http://www.usgs.gov/ngpo/
USGS EarthExplorer	Remote Sensing Products	NAIP, Landcover, Veg, DEM and more	multiple	USA- North America	http://earthexplorer.usgs.gov/
Multi-Resolution Land Characteristics Consortium (MRLC)	Landcover, Landcover Change, % Canopy, % Developed	1992, 2001, 2006, 2011	30m	USA- North America	http://www.mrlc.gov/
NLCD Landcover-Albedo Database	NLCD-MODIS derived	Landcover and associated greenness	480m X 480m	USA- North America	http://www.mrlc.gov/nlcdalbedo.php
USGS Libra Map Project	USGS Digital Raster Maps (DRGs) for all 50 states, TIGER files	multiple features included by state	24k map scale	USA- North America	http://libremap.org/
USGS National Atlas	National topographic maps	topos and elevation	10m, 30m	USA- North America	nationalmap.gov ; www.usgs.gov/pubprod/

Agency	What	Available Data	Spatial Resolution	Coverage	Location/Web Address
PRISM Climate Group (OSU)	Spatial Climate Datasets	Annual, monthly, daily precip, temp	multiple (nearest climate stations)	USA- North America	http://www.prism.oregonstate.edu/
USDA PLANTS DATABASE	standardized information about the vascular plants, mosses, liverworts, hornworts, and lichens of the U.S.	Symbols, scientific and common names, family, maps, plant lists, guides	multiple	USA- North America	http://plants.usda.gov/java/
US Fish & Wildlife Service Geospatial Services	Coastal Barriers, Critical Habitat, USFWS Ecosystem Regions, Landscape Conservation Cooperatives (LCCs), Migratory Birds, NA Biod Conservation Joint Ventures, National Wetlands Inventory and more	USFWS National GIS data and Regional Data; PAD-US, Aquatic GAP, Species Data	multiple	USA- North America	http://www.fws.gov/GIS/
USGS Southwest Regional Gap Analysis Project	Regional assessments of the conservation status of native vert species, landcover to inform land management activities	Landcover, Animal Habitat Models, Land Stewardship Data, Regional Analysis	30m; multiple	AZ,CO, NM,NV,UT	http://swregap.nmsu.edu/
USFS Remote Sensing Applications Center (RSAC)	LIDAR, MTBS, Active Fire Maps, aerial photos	Active fire maps, data reports from LiDAR, geospatial data	multiple	US, Western US	http://www.fs.fed.us/eng/rsac/index.html
USGS Center for LIDAR Information Coordination and Knowledge (CLICK)	The goal of CLICK is to facilitate data access, user coordination and education of lidar remote sensing for scientific needs	Point clouds, bare earth, coastal info	multiple	USA- North America	http://lidar.cr.usgs.gov/
USGS LandsatLook	Landsat Images	Landsat 1-8 images	multiple	USA- North America	http://landsatlook.usgs.gov/
USFS Rapid Assessment of Vegetation Condition after Wildfire (RAVG)	Basal area loss within fire perimeter	7 classes	minimum fire size of 1,000 acres	USA- North America	http://www.fs.fed.us/postfirevegcondition/whatis.shtml
USFS/USGS Monitoring Trends in Burn Severity (MTBS)	Map burn severity and fire perimeters 1984-current. National trends in burn severity	Post-fire images, NBR/dNBR/RdNBR images, thematic burn severity	30m	USA- North America	http://www.mtbs.gov/

Agency	What	Available Data	Spatial Resolution	Coverage	Location/Web Address
UNEP Environmental Data Explorer	Geospatial data for forests, populations, emmissions, climate, freshwater	water, forests, population, CO2, fish etc.	multiple	Earth	http://geodata.grid.unep.ch/
NatureServe	Biodiversity data, species range and distribution, wildlife and plant occurrence data	Ecosystem based Mgmt Tool, Species range maps, decision support tools, and more	multiple	US, Canada, Latin America	http://www.natureserve.org/; http://www.natureserve.org/conservation-tools/data-maps-tools
Databasin	Spatial data of biodiversity and conservation (Biological, physical, socio-economic data)	Avain data, protected areas, climate, energy, density, precip, migration patterns etc	multiple	Worldwide	http://databasin.org/
Bird Conservancy of the Rockies	Avian Knowledge Network, Rocky Mountain Avian Data Center	Species occurrence and trends, species assessments, population assessments, occupancy, density, species counts veg cover	points, transects	US and Canada	http://www.birdconservancy.org/resource-center/databases/
National Phenology Network	Trends in phenology NPN database	trends in plant and animal phenology	multiple	USA- North America	https://www.usanpn.org/data; https://www.usanpn.org/data/dashboard
Google Earth Engine	Large scale spatial data- open source	Landsat, Sentinel, MODIS, Aerial imagery and more	multiple	USA- North America	https://earthengine.google.com/
USFS ForCaMF	Climate Score Card- Decision support for Landscape-level Forest Carbon Management	Landsat-based change maps	multiple	USFS Northern region Pilot (MT)	http://cce.nasa.gov/cgi-bin/cce/cce_profile.pl?project_group_id=2791
USFS/LCCs NORWEST	Stream Temperature data and climate scenarios	temperature data and modeled outputs	1 km	Western US	http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html
USFS Insect Disease Survey (IDS)	Defoliation, damage assessment of various insects and pathogens	HUC level survey by watershed	6th level HUC	USA- North America	http://foresthealth.fs.usda.gov/portal http://www.fs.fed.us/foresthealth/technology/adsm.shtml

Agency	What	Available Data	Spatial Resolution	Coverage	Location/Web Address
USDA Natural Resources Conservation Service (NRCS); SNOTEL	SNOTEL	Snowcourse data, surface water supply index, SCAN data (soil moisture), snow, precipitation, and temperature products; Long-term monitoring data	Individual Snotel sites; Hydrological Units	Western US	http://www.wcc.nrcs.usda.gov/products.html ; http://www.wcc.nrcs.usda.gov/snow/
USDA Natural Resources Conservation Service (NRCS): Natural Resources Inventory (NRI)	NRI: "A stastical survey of land use and natural resource consitions on non-federal lands"	Wetlands, Land-use trends, development, soil erosion, Rangelands	multiple	USA- North America	http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/nri/
US EPA STORET	Water Quality Monitoring	Lakes, streams, rivers, water bodies (Biological, physical, habitat)	multiple	USA- North America	http://www3.epa.gov/storet/about.html
USDA FSGeodata Clearinhouse	Forest biomass, forest type distribution. Geospatial data across states	maps, raster datasets, Access datasets	250m, multiple	USA- North America	http://data.fs.usda.gov/geodata/ http://data.fs.usda.gov/geodata/rastergateway/biomass/index.php http://data.fs.usda.gov/geodata/rastergateway/index/index.php
USFS ForWarn	Satelite based change recognition and tracking	Uses eMODIS and MODIS Satellite resolution data, vegetation change, tracks change in NDVI	multiple	USA- North America	http://forwarn.forestthreats.org/
NASA Earth Observatory	Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI)	Satelite imagery of greenness or photosynthetic activeness NDVI as an indcator if drought (MODIS derived)	multi	Northern Hemisphere	http://earthobservatory.nasa.gov/Features/MeasuringVegetation/measuring_vegetation_2.php
Bird Conservancy of the Rockies	Avian Data Node. Links to Avaian Knowledge Network, Partners in Flight, Rocky Mtn Avian Data Center	Species occurrence data for avian species, species ranges, visulaization tools, protocols, decision support tools	point count data, transects, area search, distance sampling, nest success	North America, Mexico	http://www.birdconservancy.org/resource-center/databases/

Agency	What	Available Data	Spatial Resolution	Coverage	Location/Web Address
Cornell Lab of Ornithology: eBird	User records of avian species by region	Species maps, regional sightings, checklists, species occurrence, abundance	Species maps, regional sightings, checklists, species occurrence, abundance	North America, Mexico	http://ebird.org/content/ebird/
USGS North American Breeding Bird Survey	Long-term, large-scale international avian monitoring program beginning in 1966 to track status and trends of North American bird populations	Long-term survey routes and data on bird population data via point counts.	Population abundance, population trends at various scales for more than 420 species	North America, Mexico, Canada	http://www.pwrc.usgs.gov/bbs/
USFS National Visitor Use Monitoring Program (NVUMP)	Reports volume of recreation visitation to National Forests and grasslands	Activity participation, demographics, duration, measures of satisfaction etc.	NA	North America	http://www.fs.fed.us/recreation/programs/nvum/
USDA and DOI Federal Trail Data Standards	FTDS Attributes by category	Trail name, number, use, length, agency, trail management, condition, cost etc.	NA	North America	https://www.nps.gov/gis/trails/
US Census	American Community Survey	Population, economy, geography, survey data	NA	North America	https://www.census.gov/programs-surveys/acs/
Headwaters Economics	Non-partisan data hub, data visualizations	Data on economic development, energy, public lands, wildfire, county payments	NA	North America	http://headwaterseconomics.org/
USGS North American Bat Monitoring Program (NABat)	Data impacts and stressors on bat populations	Monitoring bat population trends, abundance, estimate extinction risk, manage populations	point	North America	https://www.fort.usgs.gov/science-tasks/2457
USFS RSAC Burned Area Reflectance Classification (BARC)	Satellite derived data layer post-fire vegetation conditions	Satellite derived Infrared and near infrared reflectance values and Burn classes: unburned, low, moderate, high	categorical	North America	http://www.fs.fed.us/eng/rsac/baer/barc.html

Agency	What	Available Data	Spatial Resolution	Coverage	Location/Web Address
NOAA Daily Surface Weather and Climatological Summaries DAYMET	Gridded estimates of daily weather parameters	minimum and maximum temperature, precipitation occurrence and amount, humidity, shortwave radiation, snow water equivalent, and day length	1km	North America	https://daymet.ornl.gov/
USGS Vegetation Drought Response Index (VegDRI)	Maps produced to provide regional information about drought effects on vegetation	Change Maps, Vegetation Outlook, time series	multi	North America	http://vegtri.unl.edu/
NC State University National Vegetation Classification	The National Vegetation Classification is a central organizing framework for documentation, inventory, monitoring, and study of vegetation in the United States from broad scale formations like forests to fine-scale plant communities	Vegetation classification and typing	multi	North America	http://usnvc.org/
TreeFlow	tree ring reconstruction database	Reconstructions from tree rings for streamflow, climate	yearly	North America	http://treeflow.info/
Westmap	Climate analysis and mapping toolbox	Precipitation and temperature by region	mean, monthly	Western North America	http://www.cefa.dri.edu/Westmap/
NOAA Climate Assessment for the Southwest CLIMAS	Research on Southwestern Climate outlook	Publications, maps regional outlooks, temp and precip analyses, droughtview, paleoclimate	multiple	Southwestern USA	https://www.google.com/#q=CLIMAS
University of Georgia EDD	Early detection and distribution mapping of invasive species	presence/distribution of noxious weeds and invasives	multiple	USA North America	http://www.eddmaps.org/
USDA- Nonindigenous Aquatic Species	Database of non-indigenous aquatic species	presence of aquatic invasives by state	multiple	USA	http://nas.er.usgs.gov/queries/StateSearch.aspx
National Atmospheric Deposition Program	Point and spatial data for precipitation chemistry	Maps and point data	Multiple	USA	http://nadp.sws.uiuc.edu/data/
VIEWS/IMPROVE Colorado State University	Air quality data in Parks and Wilderness areas	Point data	Multiple	USA	http://vista.cira.colostate.edu/improve/Data/data.htm

Agency	What	Available Data	Spatial Resolution	Coverage	Location/Web Address
USFS/ FTHET Forest Health Protection	Spatial and summary data for insect and disease related issues	National insect and disease risk maps (NIDRM)- spatial risk maps of hazard by pathogen	multiple	USA	http://foresthealth.fs.usda.gov/portal
		Insect and Disease Survey (IDS): county level and national maps of insect and disease conditions	multiple	USA	
		Alien Forest Pests database (AFPE): state nad county report of non-native Forest insects and disease	multiple	USA	
		Forest Disturbance monitor - recent maps of Forest disturbances;	multiple	USA	
		Soil drainage and productivity index: interactive map of soils by productivity index for evaluating vulnerability to insect and disease	multiple	USA	
		Early Detection Rapid Response (EDRR) - database for rapid detection of pathogens	multiple	USA	
Fish and Wildlife Service - GeoFin	Barriers to fish passage	Interactive mapping tool that shows fish barriers and models dam removal	multiple	USA	http://ecos.fws.gov/geofin/
FWS National Fish Health Survey Database	Fish health data	Spatial and point data on fish health surveys	multiple	USA	http://ecos.fws.gov/wildfishsurvey/database/nwfhs/
USFWS - National Wetland Inventory	National wetland maps and monitoring (surface waters and wetlands inventory update coming later this year) data	Web based GIS interface, GIS shapefiles/maps of wetlands, monitoring data (including status and trends)	multiple	USA	http://www.fws.gov/wetlands/

Agency	What	Available Data	Spatial Resolution	Coverage	Location/Web Address
USDA Forest Service National Data Clearinghouse	Enterprise Data: Data collected by FS programs	Fuel treatments, timber harvests, CFLRP data, Integrated Resource Restoration data, Ranger districts, ecological provinces, PNVF, FS Regional Boundaries, & more.	multiple	USA	http://data.fs.usda.gov/geodata/edw/datasets.php
BLM Rapid Ecological Assessments (REAs)	REAs examine ecological values, conditions, and trends within, which are large connected areas that have similar environmental characteristics.	All lands Ecological conditions and trends	multiple	North America	http://www.blm.gov/wo/st/en/prog/more/Landscape_Approach/reas.html
BLM Assessment, Inventory, and Monitoring (AIM)	the status, condition, trend, amount, location, and spatial pattern of renewable resources on the nation's public lands.	Vegetation patterns, wildlife, soils, plant, watershed framework, more	multiple	North America	http://www.blm.gov/wo/st/en/prog/more/Landscape_Approach/Monitoring_for_Adaptive_Management.html
Museum of Northern Arizona (MNA) Springs Stewardship Institute	Survey, rehabilitate, and steward springs systems across the US	Springs and springs-dependent species online database	multiple	North America	http://springstewardshipinstitute.org/
Bureau of Reclamation WaterSMART	Western-wide Climate Risk Assessments	Consistent baseline assessment of climate change impacts to water supply and demand	Risks to water supply, changes in snowpack, timing and quality of runoff, changes in groundwater charge and recharge	Western US	http://www.usbr.gov/watersmart/wcra/index.html
USFS Watershed Condition Framework	A framework for assessing and tracking changes to watershed condition	Approach for proactively implementing integrated restoration on priority watersheds on national forests and grasslands	List of indicators, performance tracking, classifying watershed condition, watershed-scale restoration	USA	http://www.fs.fed.us/sites/default/files/Watershed_Condition_Framework.pdf
USGS National Streamflow Information Program	streamflow information to meet local state, regional and national needs	Gage network and trends	NA	USA	http://water.usgs.gov/nsip/

Agency	What	Available Data	Spatial Resolution	Coverage	Location/Web Address
USGS National Water Information System	Time series, current conditions, daily streamflow conditions and more	lakes and reservoirs, streamflow, water quality, precipitation, groundwater and more	multiple	USA	http://waterdata.usgs.gov/nwis/rt
USGS Amphibian Research and Monitoring Initiative (ARMI)	National program of amphibian monitoring, research, and conservation.	Trend data, species, disease, fire climate change impact on species, national amphibian atlas, design and implementation of a monitoring program, research project	point	North America	http://armi.usgs.gov/
Partners in Amphibian and Reptile Conservation (PARC)	Mapping projects, disease info, Inventory and Monitoring guide	habitat management guides, monitoring guides, links to resources	NA	North America	http://www.parcplace.org/
USFWS Wildlife & Sport Fish Restoration Program	Data on fish and wildlife recreation	# of anglers, hunters, and wildlife watching participants by type of activity, demographics, expenditures, trips and days spent	survey data	United States	http://wsfrprograms.fws.gov/Subpages/NationalSurvey/National_Survey.htm
Outdoor Industry Association	Outdoor recreation database	stats and numbers on recreation	survey data	United States	https://outdoorindustry.org/research-tools/outdoor-recreation-economy/
EPA Air Data	Monitored air quality data from EPA's Air Quality System (AQS)	Data Mart on air quality indices, statistics, values, pollutants and hazards	Visualization tools, spreadsheet data	United States	https://www3.epa.gov/airdata/
Intermountain West Data Warehouse	Air quality data and analysis tools to support regulatory, research, and academic applications	Modeling and monitoring data on emissions, meteorology, initial conditions, ozone, dry and wet deposition summaries	point	Western US	http://views.cira.colostate.edu/tsdw/

Agency	What	Available Data	Spatial Resolution	Coverage	Location/Web Address
Federal Land Manager Database (FED)	Database of environmental data and an integrated suite of online tools and resources to help Federal Land Managers assess and analyze the air quality and visibility in Federally-protected lands such as National Parks, National Forests, and Wilderness Areas	Status and trends of Air quality related values (AQRV), visibility, ozone, PM and haze composition, water quality tool, visibility photographs	site/points	United States	http://views.cira.colostate.edu/fed/
USGS- Rocky Mountain Regional Snowpack Chemistry	Long term data collection sites and links to interactive maps for each subregion, site-specific data, photographs, monitoring protocols and sites, data reports	Individual snowpack chemistry tables by year, water quality samples, snowpack chemistry, monitoring protocols and sites	sites/points	Western US	http://co.water.usgs.gov/projects/RM_snowpack/
USFS National Lichens and Air Quality Database and Clearinghouse	Access lichen data from the National Forest system and find out more about lichens and lichen monitoring in general. Detect, map, evaluate trends, and assess the ecological impacts of air pollutants	Lichen species by geographic area or sensitivity class, lichen elemental analysis data, thresholds and sensitivity ratings, reports, publications, protocols	Plot	United States	http://gis.nacse.org/lichenair/
National Center for Atmospheric Research (NCAR)	Models to aid in understanding the atmosphere, earth systems, and the sun.	weather research and forecasting, community earth system models, atmosphere community climate model	multiple	United States	http://ncar.ucar.edu/

Region 3 Datasets Available					
Agency	Available data	Products	Spatial Resolution	Coverage	Location/Web Address
Integrated Western Landscape Assessment Project (ILAP)	Oregon/Washington and Arizona/New Mexico Existing Veg, Potential veg, soils, HUCs, Landsat derived data, state forest, arid lands and woodland types, ownership, soils	Imputed and Random forest derived Potential changes in landscape conditions under dfferent management scenarios	30m, multi	R3 and R6 AZ & NM	http://westernlandscapesexplorer.info/AccessLAPDataMapsModelsandAnalyses
SW ReGAP	Mapping and assessment of biodiversity to create seamless GIS maps of landcover, all native terrestrial vertebrate species, land stewardship, and management status, and to analyze this information to identify those biotic elements that are underrepresented on lands managed for their long term conservation or are gaps	Landcover, habitat analyses, protected areas	30m	AZ, CO, NV, NM, UT	http://swregap.nmsu.edu/ ; http://earth.gis.usu.edu/swgap/landcover.html ; http://earth.gis.usu.edu/swgap/
USFS Forest Inventory & Analysis (FIA)	Plot info on tree species lists, understory veg, soils, lichen, inavsvives and more	XY point data and associated vegetation databases	multiple	Interior West (AZ,CO,ID,MT,NM,NV,WY,UT)	http://www.fia.fs.fed.us http://www.fia.fs.fed.us/tools-data/index.php http://apps.fs.fed.us/fiadb-downloads/datamart.html
USFS GTR-309 Friggens et. al 2013 Climate Vulnerability Assessment	Climate Vulnerability Assessments, including approaches, scale, predicting response, critical thresholds etc. A method to prioritize landscapes and species for conservation and restoration	Climate Vulnerability Assessment tool for large landscapes and species	multi	SW examples, but North American focus	Friggens, M.; Bagne, K.; Finch, D.; Falk, D.; Triepke, J.; Lynch, A. 2013. Review and recommendations for climate change vulnerability assessment approaches with examples from the Southwest. Gen. Tech. Rep. RMRS-GTR-309. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 106 p. http://www.treesearch.fs.fed.us/pubs/44184
Vegetation GIS Data System (VGS) at U of A	For vegetation data, VGS implements the entire USDA NRCS Plants Database, but allows the user to create their own more limited template species lists. Users may also use their own common names and functional categories for species as desired.	Currently the summary report for cover frequency mixes ground cover and plant species when calculating percent composition. If this is not desireable, use definition version 2 until a report is created that allows species and ground composition to be calculated separately.	30m, multi	Region 3	https://vgs.arizona.edu/download-category/usfs-region-3
The Nature Conservancy (TNC) SW Forest Assessment	Regional Assessment Data, R3 species database, species distributions, vegetation patterns, grasslands, aquatic habitat, areas of biological significance, fire return interval, HRV	Vegetation Forest specific reports withinfo on the status of biological resouces on Nat'l Forest lands. Use SW REGAP, LANDFIRE, Spatial Ecological Assessments	30m, multi	AZ and NM	http://azconservation.org/projects/southwest_forest_assessment

Agency	Available data	Products	Spatial Resolution	Coverage	Location/Web Address
The Nature Conservancy (TNC)	Ecoregional Assessment-Western North America	Geodatabase from 19 Ecoregional Assessments, Biotic communities of the SW, Grasslands of AZ, AZ Freshwater Assessment	30m, multi	Western U.S. and AZ	http://azconservation.org/downloads/category/gis
USFS R3 GIS datasets	Multiple forests within Region 3 by forest	Vegetation, GAP, TEU, Land ownership, forest boundaryies, regional boundaries, and more	multi	R3 Forests	http://www.fs.usda.gov/detail/r3/landmanagement/gis/?cid=STELPRDB5202474
USFS R3 Regional datasets	TEU,forest health, riparian veg, soils	maps, and GIS data	multi	R3 Forests	http://www.fs.usda.gov/detail/r3/landmanagement/gis/?cid=stelprdb5201889
USFS R3 Regional datasets	Insect and disease GIS data: FHP surveys by year, IDS	surveys by year and survey maps	multi	AZ and NM	http://www.fs.usda.gov/detail/r3/landmanagement/gis/?cid=stelprd3805189
USFS Forest Inventory & Analysis (FIA)	Plot info on tree species lists, understory veg, soils, lichen, inavsvives and more	XY point data and associated vegetation databases	multi	Interior West (AZ, CO, ID, MT, NM, NV, WY, UT)	www.fia.fs.fed.us http://www.fia.fs.fed.us/tools-data/index.php http://apps.fs.fed.us/fiadb-downloads/datamart.html
National Forest-level Data					
Mid-Scale Existing Vegetation	Vegetation type,% canopy cover, species type, shrub cover	Veg type, canopy cover, species, shrub	30m	Coconino NF, R3 forests	http://www.fs.usda.gov/detail/r3/landmanagement/gis/?cid=stelprdb5209305
Wildlife survey points	survey and feature points	survey and feature points	30m	Coconino NF, R3 forests	http://www.fs.usda.gov/detail/r3/landmanagement/gis/?cid=stelprdb5209305
Terrestrial Ecological Units	land based ecological units	soils, potential natural vegetation, geology, geomorphology, climate	30m	Coconino NF, R3 forests	http://www.fs.usda.gov/detail/r3/landmanagement/gis/?cid=stelprdb5209305
AZ National Forest Socio-Economic Assessments	Demographic patterns and trends, economic characteristics, land use, users etc.	Statewide assessment	NA	R3	http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_019899.pdf
USDA	Survey Results of the American Public's Values, Objectives, Belief's and Attitudes Regarding Forests and Grasslands	Values with respect to public land. Social assessment	NA	North America	http://www.fs.fed.us/rm/pubs/rmrs_gtr095.pdf
Arizona Forest Resource Forest Assessment (2010)	Overview of forest resource issues in AZ, priority areas, collaborative opportunities and more	forest conditions and trends- maps, fire, impared waters, fire regime, landscapes, ecoregions, and more	multi	AZ	https://azsf.az.gov/sites/default/files/documents/files/Arizona%20Forest%20Resource%20Assessment-2010.pdf
New Mexico Statewide Natural Resources Assessment and Strategy	Strategy for identifying, prioritizing and conducting natural resource management and restoration activities	Land ownership, biodiversity, economic potential, forest health, fragmentation, watersheds, wildfire risk and more	multi	AZ	http://www.emnrd.state.nm.us/SFD/documents/New_MexicoNatural_ResourceAssessment.pdf

Region 2 Datasets Available					
Agency	Available data	Products	Spatial Resolution	Coverage	Location/Web Address
USFS Forest Inventory & Analysis (FIA)	Plot info on tree species lists, understory veg, soils, lichen, inavsives and more	XY point data and associated vegetation databases	multiple	Interior West (AZ,CO,ID,MT,NM,NV, WY,UT)	http://www.fia.fs.fed.us http://www.fia.fs.fed.us/tools-data/index.php http://apps.fs.fed.us/fiadb-downloads/datamart.html
USFS R2 Geospatial Data	data on R2 forests	Allotments, fire dispatch areas, forest management plan, roads, recreation sites	multiple	CO, WY, KS, NB, SD	http://www.fs.usda.gov/detail/r2/landmanagement/gis/?cid=stelprdb5165938
Colorado BLM	CO BLM data sources. Areas of Critical Environmental Concern, Wild Horse & Burro Herd Areas, Grazing allotments and more	Natural resources, Base data, Energy, Lands & Minerals	multiple	CO	http://www.blm.gov/co/st/en/BLM_Programs/geographical_sciences/gis/GeospatialData.html
Colorado Geological Survey	Spatial data layers for CO	Landsat, MODIS, Aerial imagery, census data, recreation, roads, wildlife, geology	multiple	CO	http://coloradogeologicalsurvey.org/geologic-mapping/gis-data/
Colorado GeoData Cache	Spatial data and LiDAR for CO	Lidar, aerial imagery	multiple	CO	https://geodata.co.gov/
Colorado BLM	CO BLM data sources. Areas of Critical Environmental Concern, Wild Horse & Burro Herd Areas, Grazing allotments and more	Natural resources, Base data, Energy, Lands & Minerals	multiple	CO	http://www.blm.gov/co/st/en/BLM_Programs/geographical_sciences/gis/GeospatialData.html
Colorado Data Sharing Network/CDPHE	Water monitoring data from STORET, NAQWA, USGS, state, municipal and third party organizations	Spatial web-based interface that shows point locations and links to datasets	multiple	CO	http://www.coloradowaterdata.org/
Colorado Natural Heritage	Spatial data for Wetland, Riparian, and Fen, potential conservation areas; Colorado biodiversity tracking datase (BIOTICS)	Colorado Wetland Inventory mapping product (web-based spatial datasets); rare species occurrences lists and tracking; ecological systems descriptions	multiple	CO	http://www.cnhp.colostate.edu/download/download.asp and http://csurams.maps.arcgis.com/apps/webappviewer/index.html
Colorado Forest Restoration Institute	Spatial data on fuels treatments and home locations in the WUI	GIS shapefiles	multiple	CO	Contact Mike Caggiano (michael.caggiano@fs.fed.us)
Colorado DNR State Land Board	Land inventory and GIS for CO	Surface ownership, mineral estate layers, oil & gas, stewardship trust, district boundaries, & more.	multiple	CO	http://trustlands.state.co.us/MAPSANDDATA/Pages/MapsAndData.aspx
Colorado Dept. of Local Affairs	CO Information Marketplace	Population data, census, highways, water rights, & more	multiple	CO	http://dola.colorado.gov/gis-cms/content/gis-resources
CO Geospatial Centroid CSU	Commonly used datasets of CO	Links to existing datasets in geology, environmental conservation, imagery, hydrography, ownership and more.	multiple	CO	http://gis.colostate.edu/data.aspx
CO Map (CSU)	CO Ownership, management, and protection service.	Maps of protected lands	multiple	CO	https://comap.cnhp.colostate.edu/
ColoradoView	Spatial Data for CO	Landsat, MODIS, Aerial imagery,GIS layers	multiple	CO	http://coloradoview.org/cwis438/websites/ColoradoView/Data.php?WebSiteID=15

USGS - Interactive Energy database	Data and decision support tools for managing energy development	GIS data, Interactive web mapper, decision support tools	multiple	CO, NM	http://my.usgs.gov/eerma/
Colorado Parks and Wildlife	Aquatic Data Management System (ADAMAS) and GIS data (AQ-GIS) Aquatic Biological Data	Aquatic biological monitoring data, and linked spatial data	multiple	CO	http://cpw.state.co.us/learn/Pages/ResearchAquaticData.aspx
Colorado CDPHE Water Quality Control Division	Spatial data on stream quality	Online map of impaired/clean streams	multiple	CO	https://www.colorado.gov/pacific/cdphe/clean-water-gis-maps
National Park Service Rocky Mountain Network	Monitoring data on streams, wetlands/riparians, upland veg, alpine ecosystems, lakes, in NPS jurisdictions	Data, resources reports and briefing papers	multiple	CO	http://science.nature.nps.gov/IM/units/romn/index.cfm
Colorado Department of Health and Environment	Colorado census tract and county socio-demographic GIS data	spatial socio-economic data	multiple	CO	http://www.chd.dphe.state.co.us/default.aspx
State of Kansas GIS data access	Spatial layers, LiDAR, administrative boundaries etc.	Lidar 2015, 2015 NAIP, administrative boundaries, demographics and census, cultural and recreational, elevation, environmental resources, rasters, geology and soils, water resources	multiple	KS	http://www.kansasgis.org/
Univ of WY WyGISC	Univ. of WY Geodatabase; DRGs, aerial photos	GeoHun Explorer, Pathfinder, Imagery	multiple	WY	http://www.uwyo.edu/wygisc/ ; geospatialhub.org ; http://applications.wygisc.org/
WyBIO	WY Biodiversity Citizen Science Initiative	Biological data on plants, animals, fungi etc.	multiple	WY	http://wyobio.org/
WISDOM	WY Interagency Spatial Database & Online Management System	WY Wildlife resources	multiple	WY	http://wisdom.wygisc.org/
WY Density and Disturbance Calculation Tool (DDCT)	Sage Grouse and Online DDCT	Data on Sage Grouse Core Area Policy	multiple	WY	https://ddct.wygisc.org/home.aspx
SuiteWater- WY Natural resource planning Tool	WY water resources, watershed level planning	Web based interface to integrate GIS, spatial data, photo, docs, etc	multiple	WY	http://suitewater.wygisc.org/
Wyoming State Geological Survey	WY resources	Data on energy sources and development, minerals, water, geology, wind and power projects, oil and gas, coal	multiple	WY	http://www.wsgs.wyo.gov/
Wyoming Geospatial Hub	Data layers across multiple themes.	BLM, Federal land stewardship, sage grouse initiative, climatology, land surveys, watershed boundaries and more.	multiple	WY	http://geospatialhub.org/
Wyoming County Commissioners Association	Socio-economic data and assessments	County level reports and narratives on socio-economic trends and conditions	multiple	WY	contact WY County Commissioners association
Wyoming Natural Diversity Database	Rare Plants, Animals, and Vegetation Communities survey data and distributions	mapped occurrences by species	multiple	WY	http://www.uwyo.edu/wyndd/data-dissemination/
Wyoming DEQ Air Quality	Spatial and point data for air quality	Web based real-time interface, and data spreadsheets	multiple		http://www.wyvisnet.com/
WYDEQ surface water monitoring	Water quality monitoring information	Water data	multiple	WY	http://deq.wyoming.gov/wqd/surface-water-monitoring/

NPS Greater Yellowstone Network	Amphibian, Upland, whitebark pine, stream/riparian, alpine, land use, climate data	Resource briefs and publications, data	multiple	WY	http://science.nature.nps.gov/im/units/gryn/monitor/index.cfm
WY Migration Initiative	data on ungulate migration patterns	online mapping resource	multiple	WY	http://migrationinitiative.org/content/migration-viewer
USGS Sagemap	Detailed roads data	GIS shapefiles	multiple	WY	http://sagemap.wr.usgs.gov/ListData.aspx
SW ReGAP	Mapping and assessment of biodiversity to create seamless GIS maps of land cover, all native terrestrial vertebrate species, land stewardship, and management status, and to analyze this information to identify those biotic elements that are underrepresented on lands managed for their long term conservation or are gaps	Landcover, habitat analysis, protected areas	30m	AZ, CO, NV, NM, UT	http://swregap.nmsu.edu/ ; http://earth.gis.usu.edu/swgap/landcover.html ; http://earth.gis.usu.edu/swgap/
USFS GTR-309 Friggens et. al 2013 Climate Vulnerability Assessment	Climate Vulnerability Assessments, including approaches, scale, predicting response, critical thresholds etc. A method to prioritize landscapes and species for conservation and restoration	Climate Vulnerability Assessment tool for large landscapes and species	multiple	SW examples, but North American focus	Friggens, M.; Bagne, K.; Finch, D.; Falk, D.; Triepke, J.; Lynch, A. 2013. Review and recommendations for climate change vulnerability assessment approaches with examples from the Southwest. Gen. Tech. Rep. RMRS-GTR-309. Fort Collins, CO: U.S. http://www.treesearch.fs.fed.us/pubs/44184 Department of Agriculture, Forest Service, Rocky Mountain Research Station. 106 p.

Appendix E: BSMS opportunities across short-, mid- and long-term timeframes

1. Short-term opportunities

Program/product	Location/ extent	Partners	Comments/opportunities
National Atmospheric Deposition Program (NADP)	R2, R3	NADP	Data collection and analysis available from NADP website— Forests know of it, but don't always report data or analysis in Monitoring reports. Regional coordination of information dissemination could be valuable
Forest Health Monitoring (FHM)– aerial surveys	R2, R3 (national program)	FHM	Determine status and trends in indicators of forest conditions on an annual basis. A widely used example of an existing BSMS.
Breeding bird and small mammal monitoring	R2, R3	BCR	Robust and scaleable sample frame that can be leveraged for additional monitoring. In R2, Forests have been instructed to incorporate BCR monitoring information for focal species into their monitoring plans.
RSAC- Change detection	R2	RSAC, TEAMS	Pilot change detection/FSVeg update project for insect severity currently completed for Med-Bow Routt, underway for additional Forests in R2
LiDAR	R3	RSAC, FS	Use LiDAR data to track changes in forest structure and density, wildlife habitat characteristics etc (North Rim, Mogollon Rim data and more)
Southwest Forest Assessment	R3	TNC	Continue, expand, re-measure the status of biological resources on national forest lands. Regional assessment of inventory, species distributions, veg patterns, grasslands, aquatic habitat, fire return interval, HRV and more
Climate Vulnerability Assessments	R3 (can use nationally)	USFS, RMRS, LCCs	Addresses vulnerability of species and habitats.

Program/product	Location/ extent	Partners	Comments/opportunities
			Information on climate change effects and possible management actions with multiple approaches, scales, targets.
Integrated Western Landscape Assessment Project (ILAP)	R3	OSU, USFS	Prioritize management actions across large landscapes using vegetation conditions and future trends, wildfire hazard, key wildlife habitat conditions and trends and more.
FIA forest trends	R2, R3	FIA	Change detection over time over multiple indicators of forest structure and composition
SNOTEL data products	R2, R3	NRCS	Snow and precipitation monitoring products that are easily analyzed by Forest staff via web app
Forest Health Risk maps	R2, R3	FHTET	Risk maps, monitoring for outbreaks of insect/disease available from FHTET, could be refined, leveraged with Forest level data
Fen/Wetland/GDE inventory and monitoring	R2, R3	CNHP, WYNDD, Springs institute	Inventory and monitoring of GDEs—spatial inventory products currently being adopted by some Forests in CO, WY, and R3.
NORWEST stream monitoring	R2, R3	RMRS-Boise	Stream monitoring data already collected by Forests, analyzed by RMRS-Boise. Could be improved with technical training for Forest staff, re: data collection and use of spatially balanced samples
NVUM	R2, R3	Internal	Visitor use info—may need to augmented by Forest level efforts for greater relevance

2. Mid-Term Opportunities

Program/product	Location/ extent	Partners	Comments/opportunities
All-lands condition monitoring	R2, R3	Multi	Long term, non-forest condition monitoring plots—collected in R1. Could be leveraged with models and decision-support from RMRS.
NAIP acquisition	CO	BLM	Potential for leveraging funds for .5m NAIP acquisition
Forest encroachment	R2, R3	CNHP, RSAC	Use of remote sensing imagery to track changes in Forest encroachment in alpine and rangeland environments. Under way in San Juans.
R1 FIA data analysis products	R2, R3	Region 1, FIA	Use of R1 data analysis products for vegetation analysis, integration of CSEs and FIA plot data
Monitoring Trends in Burn Severity	R2, R3	FIA, RSAC	Burn severity maps and data—could be integrated easily into Forest plan and Regional Monitoring, validated/refined at Forest level
GLORIA alpine monitoring	R2	CNHP, NPS	Potential to contract with CNHP, NPS to implement and analyze GLORIA alpine monitoring protocols in R2 Forests—already being done on San Juan, RMNP, Great Sand Dunes.
Southwest Climate Science Center	R3	USGS, SWSC & consortium	Effects of climate change on hydrology and wetlands, design monitoring strategies for hydroclimatic change and terrestrial ecosystems
Precipitation, temperature, climate extremes	R2, R3	R8, NOAA, Western Water Assessment	Climate indicator information and spatial products for Forests and Regions (currently being explored in R8)
Macrobenthic invertebrates monitoring	R2	USFS, potentially USGS, EPA	Macrobenthic monitoring strategy utilized by White River NF, currently being considered

Program/product	Location/ extent	Partners	Comments/opportunities
			on ARP—could be adopted by other Forests, with economies of scale for analysis
Bat Monitoring	R2, R3	USGS	Use of NABat sample frame and database for bat monitoring by Forests—not widely adopted across Forests in R2
Phenology monitoring	R2, R3	National Phenology Network	Gridded map products for tracking changes in phenology over time at the broad scale, opportunities for Forest level validation/refinement (currently being pursued in R9)

3. Long-term Opportunities (with investment)

Program/product	Location/ extent	Strategy	Comments/opportunities
Broad scale noxious weed monitoring and decision-support	R2	USGS, BLM, FWS, State agencies	Potential for USGS to use existing data on noxious weeds, modeling, to create risk maps and decision support. Similar effort underway in R1 in collaboration with partners in the Crown of the Continent.
Riparian inventory/monitoring	R2	BLM, RMRS, RSAC	Broad scale and consistent riparian monitoring is lacking in R2. There is potential for the use of forthcoming RMRS products for riparian classification/ stratification, and remote sensing, ground truthing to evaluate broad scale trends in riparian characteristics over time
Coordinated Forest inventory for habitat	R2	BCR	Regional coordination of CSEs (spatially balanced sample frame, potential for sentinel sites), greater use of FIA, remote sensing consistent classification, for Lynx or other key forest habitat assessment/monitoring across Forests
LiDAR	CO	State of Colorado, CFRI	State of Colorado is currently building comprehensive LIDAR coverage for the whole state, data is free to acquire, costs for forest structure metrics currently being explored at CFRI.
LiDAR	R3	FS, State	R3 should invest in expanding LiDAR footprint and consider before/after data - treatment and restoration activities, monitoring changes in wildlife habitat characteristics etc.

Program/product	Location/ extent	Strategy	Comments/opportunities
FIA Disturbance Trends/Forest Canopy cover products	R2, R3	FIA	New products that track forest canopy cover change from disturbance over time--soon to be available
FIA FORCAMF	R2, R3	FIA	Products for tracking Forest level carbon over time--available soon
Species distribution models	R2, R3	North Central Climate Science Center, SW Climate Science Center	Potential for developing species distribution models, decision and monitoring support for key species (being done in Greater Yellowstone in cooperation with NPS)
Landscape level fire behavior/ fuel treatment decision-support	R2, R3	Landfire, MTBS, other	Use of stand and treatment data, potentially LiDAR in R2, to evaluate treatment effectiveness, provide decision-support for future treatments in the WUI
Species habitat validation and monitoring	R2, R3	BCR, RSAC, USFS, BLM, FWS	Potential to integrate BCR data with other habitat data at plot and landscape scale, validate species habitat relationships, track habitat conditions over time