

Design of a Workshop Process to Support Consideration of Natural Range of Variation and Climate Change for Land Management Planning Under the 2012 Planning Rule

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Abstract—The planning units of the National Forest System are beginning to revise their existing land management plans using the 2012 Forest Service regulations. Ecological integrity is a central concept to the regulations. However, implementing the concept is challenging in light of climate change. Historical ecology, particularly the concept of natural range of variation, informs planning for ecological integrity and climate change. This report discusses a March 2016 workshop held for the Intermountain Region to address ecological integrity, NRV, and climate change, all high priority topics for land management planning. It describes presentations included in the workshop on the evolution of the concept of natural range of variation, the 2012 planning rule, and data considerations. As part of the workshop, we developed a worksheet that managers and planners may use to consider ecological integrity, climate change, and natural range of variation. This report summarizes the use of this worksheet for two ecosystems of interest to the region: spruce-fir and alpine vegetation. We also provide recommendations, including to consider natural range of variation as a tool for planning for ecological integrity.

Keywords: climate change, NRV, ecological integrity, workshop

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INTRODUCTION

National forests, grasslands, prairies, and other administrative units (hereafter “planning units”) of the National Forest System (NFS) are beginning to revise their existing land management plans using the 2012 Forest Service regulations that outline how a planning unit should meet the statutory requirements of the National Forest Management Act (NFMA). These regulations, also referred to as the 2012 planning rule, aim to “guide the collaborative and science-based development, amendment, and revision of land management plans that promote the ecological integrity of national forests and grasslands and other administrative units of the [National Forest System]” (36 CFR 219.1). The 2012 planning rule explicitly acknowledges the need for land management planning to allow the Forest Service to adapt to a changing climate.

The 2012 planning rule requires consideration of system stressors when addressing ecological integrity in the context of ecological sustainability ([36 CFR 219.8](#)). The Forest Service directives for implementing the 2012 planning rule consider climate change to be a system stressor (USDA FS 2015). Planning units had previously begun incorporating considerations of climate change adaptation and mitigation into land management planning and project-specific planning in line with guidance from the Forest Service’s Washington Office. In 2011, the Forest Service national roadmap described the agency response to climate change in three ways: “1) *Assess* current risks, vulnerabilities, policies, and gaps in knowledge; 2) *Engage* employees and stakeholders to seek solutions; and 3) *Manage* for resilience, in ecosystems as well as in human communities, through adaptation, mitigation, and sustainable consumption strategies,” (USDA FS 2011, p. 4). Forest Service Research and administrative unit staff have worked together in the development of planning unit-level and region-wide vulnerability assessments (Halofsky et al. 2011; Hayward et al. 2017; Rice et al. 2012; Swanston et al. 2011).

Ecological integrity is a central concept of the 2012 planning rule. It is an important component of ecological sustainability and of maintaining the diversity of plant and animal communities (see [36 CFR 219.8 and 219.9](#)). The 2012 planning rule defines ecological integrity as “the quality or condition of an ecosystem when its dominant ecological characteristics...occur within the natural range of variation and can withstand and recover from most perturbations imposed by natural environmental dynamics or human influence” (see glossary; [36 CFR 219.8 and 219.9](#)).

Evaluating ecological integrity and ecological sustainability under the long-term stress of climate change presents a significant challenge in land management planning. Practitioners must apply ecological concepts in situations defined by considerable uncertainty given the difficulty of predicting future environmental dynamics and the human influence. The application of historical ecology, specifically the concept of natural range of variation (NRV), enables an understanding of system dynamics. However, implementation of historical ecology and NRV into land management planning is an evolving practice. Several other similar concepts use reference conditions to guide management, including historic range of variability, future range of variability, and social range of variability. In this document, we focus on natural range of variation, since the 2012 planning rule explicitly mentions this term (see Appendix A).

Natural range of variation (NRV) is a helpful tool for assessing ecological integrity, but there are additional considerations in planning beyond NRV, such as the social acceptability of planned actions. Natural range of variation represents a frequency distribution of historical conditions with long tails. Ideally, specialists conducting land management planning would seek to develop

formal and informal science-management partnerships to aid in addressing this challenge. Further, planning units undergoing revision would benefit from having a consistent and science-based approach to assess and plan for climate change effects in the context of the NRV and ecological integrity. In some regions of the National Forest System, key ecological characteristics are being identified regionally, while in other regions, individual planning units are identifying key ecological characteristics.

This report discusses a March 2016 workshop held for the Intermountain Region to address ecological integrity, NRV, and climate change—all high priority topics for land management planning. Scientists and staff involved with land management planning were brought together to share scientific and experiential knowledge around these topics. We provide context for the workshop based on the 2012 planning rule, outline the workshop approach, and share key lessons learned. Individual planning units or other Forest Service regions may use this document and its appendices to design similar workshops or prepare information to support land management planning in the future.

DESIGN OF THE WORKSHOP

The primary objective of this workshop was to identify the information needed by a planning unit to determine when climate change could perturb ecological integrity characteristics as indicated by examining NRV. Such relationships would be relevant, for example, when climate change could perturb structure, function, composition, and connectivity such that the ecosystem was unable to withstand or recover from most perturbations. The challenge of considering NRV, ecological integrity, and management has been recognized and different approaches have been suggested (Romme et al. 2012; Wurtzebach and Schultz 2016). Of importance to these recommended processes was identifying key ecological characteristics and evaluating these characteristics with respect to NRV first, then assessing the effects of climate change.

We chose to use a workshop setting to bring research scientists and NFS resource staff together to explore the concepts of ecological integrity and NRV. We focused the workshop on only a few selected ecosystems to allow the workshop participants the opportunity for close examination of NRV and climate change. While NRV plays a substantial role in the workshop, it is important to remember that the key goal of land management planning is to restore and maintain ecological integrity, and NRV is a tool to support that goal.

Within the Intermountain Region, land management plan revision and a regional climate vulnerability assessment were initiated as independent efforts but have begun to align due to shared goals and activities. The Intermountain Adaptation Partnership (IAP), a science-management partnership, was formed in 2014 to assess the vulnerability of the Intermountain Region to climate change and to develop adaptation strategies for resource management.¹ The IAP effort is seen as providing a scientific basis for understanding and evaluating the potential effects of climate change and a published reference that can be drawn on during the planning process. The Ashley National Forest and Manti-La Sal National Forest, of the Intermountain Region, formally initiated the land management planning process in 2016. They are among the first planning units nationally to do so under the Forest Service directives issued in 2015 for implementing the 2012 planning rule.

To provide for a science-based approach that included expertise on climate change effects and NRV, we drew on both the IAP and plan revision efforts. Consequently, the workshop followed

recent examples to employ science-management partnerships to develop land management plans that effectively address climate change vulnerability (Littell et al. 2012; Peterson et al. 2011; Swanston et al. 2016). We engaged members of the IAP to participate in the workshop, bringing the early results of the IAP vulnerability assessment into a conversation about land management planning. We solicited suggestions from the Ashley National Forest and Manti-La Sal National Forest to ensure relevance of the workshop to their land management planning processes. As a result, the workshop focused on lodgepole pine (*Pinus contorta*) forests as an exercise involving all workshop participants, because there is a relatively good understanding of the disturbance regime for this species. Alpine ecosystems and spruce-fir ecosystems were addressed in separate breakout sessions. However, these ecosystems are relevant to the whole region and the consideration of NRV focused on the region, as a whole. The same approach could be employed for single administrative units.

Workshop participants (scientists, land management planners, and resource specialists) needed to be able to share a common language with respect to land management planning and vulnerability assessments. To provide the context for this mutual understanding, we created a primer document summarizing language pertaining to ecological integrity, NRV, and climate change in the context of the 2012 planning rule (Appendix A).

We also developed the NRV workshop tool worksheet and accompanying guide to lead participants through a structured approach for planning and facilitate resource specialists to identify dominant ecological characteristics and assess the following:

- the NRV of these characteristics;
- how climate change may affect these characteristics and their relationship to NRV;
- the role of other stressors; and
- how management actions consistent with the land management plan may affect these characteristics.

We used the workshop as a test run for the worksheet, with the intention that it could be used thereafter by planning and resource specialists as part of the assessment phase in the land management planning process. The worksheet and accompanying guide, revised based on feedback from the workshop, are presented in Appendix B.

WORKSHOP

In March 2016, we convened the NRV and climate change workshop in Ogden, Utah. Organizers included individuals from the Forest Service Intermountain Region, Forest Service Rocky Mountain Research Station, and Colorado State University. Workshop attendees included NFS regional resource specialists, Forest Service and academic researchers, and planning and resource specialists from administrative units in the region beginning or planning for plan revision.

The workshop spanned 2 days (see Appendix C for the agenda). The first afternoon included general presentations providing overviews of the 2012 planning rule and NRV as part of ecological integrity, a discussion of how NRV can inform management in the context of climate change, and information from the IAP vulnerability assessment. The first part of the second day was spent considering additional information from the IAP vulnerability assessment and a detailed look at how Forest Service Forest Inventory and Analysis (FIA) data can inform defining the relationship

between NRV and recent conditions for lodgepole pine. For the afternoon of the second day, the group then split into subgroups to develop NRV characterizations for two different ecosystem types, spruce-fir and alpine ecosystems.

Conceptual Evolution of NRV

On Day 1 of the workshop, James Long, T.W. Daniel Professor of Forestry, Utah State University, discussed the development of the concept of NRV, summarized here. The NRV concept gained prominence as a result of Morgan et al. (1994) and is rooted in restoration ecology employing concepts of disturbance and historical ecology. The NRV “characterizes fluctuations in ecosystem conditions or processes over time...define(s) the bounds of system behavior that remain relatively consistent over time,” (Morgan et al. 1994). Although definitions may vary, the concept focuses on reference conditions for structural, compositional, and functional characteristics, with a strong emphasis on disturbance processes. The concept emphasizes the fact that ecosystem characteristics vary over time, and NRV captures the pattern of this variation. When considering NRV, it is integral to recognize scale, both temporal and spatial. A particular characteristic may not reflect the NRV on the stand scale, but, at broader spatial scales, the characteristic may represent a common condition in the NRV (see Turner et al. 1993). Timescales generally focus on the pre-European settlement time period. In general, scholars of NRV implicitly acknowledge Native American influence on landscapes, but do not often try to explicitly account for it. An example of successful incorporation of NRV into management decisionmaking is the use of the natural fire regime to inform management in ponderosa pine (*Pinus ponderosa*) forests in the Southwest. In sum, there is considerable utility of the NRV tool in the context of management and planning; however, application of NRV must proceed carefully.

In the context of a changing climate, the use of reference conditions in the form of NRV may guide forest restoration and management. Natural range of variation represents a range of conditions under which a system was able to function in the past and recover from perturbation. Thus, restoration of system structures informed by NRV may enable restoration of system functions. Hanberry et al. (2015) note that using reference conditions can be useful for evaluating approaches to restoring historical trajectories of ecosystems so they are better positioned to adapt to climate change and can help us to recognize ecological integrity. It also is important to recognize that NRV and reference conditions may not be applicable in all situations.

The presentation included several suggestions for considering the NRV in the context of planning:

1. *Ultimately, when determining key ecological characteristics, it is operationally necessary to focus on a short list (i.e. less than six characteristics).*
2. *Explicitly defining terms such as resistance and resilience is integral to considering alternative approaches to climate change adaptation.* Climate change adaptation often focuses on resistance and resilience. Essentially, land managers seek to build systems that can bounce back from disturbance. It is important to explicitly define what is meant by resilience in a particular ecosystem. DeRose and Long (2014) provide more information on the relationship between resistance and resilience and how management directions can be developed to address these concepts.
3. *Natural range of variation is often misinterpreted as a target, but is more useful as a tool to assess the status of systems.* The NRV informs the development of desired conditions and

other plan components. The NRV can help planners understand how a system with ecological integrity operates and when conditions may be more or less resilient. When establishing reference conditions, it may be difficult to determine the appropriate time period. In general, timeframes for considering NRV are defined by the frequency of disturbance and the rate of system recovery associated with the major disturbance regimes for the ecosystem in question.

4. *Maintaining a system to manifest characteristics that were common during the reference period may not always be possible or appropriate.* The Forest Service directives that accompany the 2012 planning rule provide insight on how to proceed when these situations arise (USDA FS 2015, p. 59–60; see also Appendix A). For instance, maintaining conditions for species protected by the Endangered Species Act may take precedence over NRV at some scales, or in some situations, it may be difficult or impossible to maintain conditions commonly experienced during the reference period within the NRV for a system.
5. *The assessment phase of unit planning is an opportunity to characterize NRV.* In the assessment phase, administrative units may identify the types of aquatic and terrestrial ecosystems in the NFS lands covered by the land management plan (plan area), identify key characteristics for these systems, explore the NRV, and assess changes in these systems through time.
6. *Several questions may help managers use NRV.* The following questions drawn from Romme et al. 2012 may help managers think about how NRV guides management. Are elements of NRV socially acceptable? Are there conditions outside NRV that threaten ecological integrity? Does NRV provide clues about intervention? Is restoration of historical conditions both socially acceptable and ecologically feasible? As these questions suggest, the overall purpose of using NRV should be to inform planning for ecological integrity.

Ecological Integrity and NRV in the 2012 Planning Rule

Chris Iverson, Deputy Regional Forester, U.S. Forest Service Intermountain Region, provided an overview of NRV and ecological integrity requirements in the 2012 planning rule. This presentation noted the key role of ecological integrity in meeting ecological sustainability requirements (36 CFR 219.8). Ideally, a robust and comprehensive expression of desired conditions to provide for ecological integrity at multiple scales throughout the planning area will provide a “systems” approach to sustain component parts of the ecosystems—individual species to achieve diversity requirements. In addition, managing for ecological integrity offers a “coarse filter” approach to meeting requirements to manage for the diversity of plant and animal communities (36 CFR 219.9). Where the coarse-filter desired conditions for the ecological integrity “systems” approach are insufficient to sustain Federally listed species under the Endangered Species Act, proposed and candidate species, and species of conservation concern, complementary “fine filter” species-specific desired conditions will be required to meet diversity requirements.

As noted in the Forest Service directives, NRV helps managers identify key characteristics pertaining to structure, function, composition, and connectivity at multiple scales, for which plan components may be important. In his presentation, Chris Iverson emphasized that the NRV concept is a tool rather than a management target. Using NRV may not be appropriate in situations

where systems are severely degraded, where restoration is not feasible given the jurisdictional or fiscal capability of the Forest Service, and where it may interfere with public health or safety. He also noted that the Forest Service has been considering NRV as a guide for land management planning for some time; the 2000 interim planning rule incorporated NRV as a guiding concept, for example.

The presentation also provided examples of implementation of NRV for managing habitat for the greater sage-grouse (*Centrocercus urophasianus*) and for stream monitoring. For the sage-grouse, desired conditions for characteristics at the landscape scale, such as percentage of sagebrush cover, and stand-scale characteristics, such as sagebrush canopy cover and perennial grass height, can provide conditions to sustain key components of sage-grouse habitat. For streams, indicators such as width-depth ratio, bank stability, and stream departure can be addressed by using departure from reference conditions as an expression of NRV in order to sustain salmon and steelhead habitat.

Identifying the NRV for Specific Ecosystems: Data Considerations and Worksheet Implementation

Before working on individual ecosystems, participants heard presentations about the Forest Service FIA program, a robust data collection effort that monitors the health, productivity, and status of forest resources in the United States (USDA FS 2016). The FIA data can help managers understand the distribution of vegetation and age classes across administrative units. These data provide an overview of age class distribution of lodgepole pine across the region. Insect outbreaks and fires drive this distribution, and the legacy of fire suppression following settlement is evident in the distribution. The FIA data also provide perspective on how ecosystems may change following disturbance. Staff from FIA discussed data on NRV for lodgepole pine to inform the group exercise on lodgepole pine.

Worksheet Implementation

On Day 2, the participants separated into two groups to address specific ecosystems: spruce-fir and alpine vegetation. Our intention here is not to provide a comprehensive understanding of the ecosystem but to provide the essence of the outcomes of the workgroup discussions. These outcomes could be important for understanding NRV, ecological integrity, and influences of climate change. Land management planning teams analyzing the same ecosystem may implement the worksheet independently rather than rely on the above assumptions. Furthermore, the information included in this report reflects an understanding of the local history and scientific findings of the specific ecosystems discussed at this workshop. We encourage land management planning teams to use the worksheet along with best available scientific information to validate the information collected.

Spruce-fir

James Long, Utah State University, and Justin DeRose, Research Ecologist, U.S. Forest Service Rocky Mountain Research Station, led the group discussion on spruce-fir ecosystems in the Intermountain Region. Spruce-fir refers to ecosystems that include both Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*). The group began by discussing general characteristics of spruce-fir ecosystems. Appendix D includes a completed worksheet for the spruce-fir ecosystem.

- **Geographic setting.** Spruce-fir ecosystems are found at high elevations in moist and cool sites.
- **Disturbance.** Fuel is abundant in spruce-fir ecosystem, although climate limits fire. Fire is infrequent, but generally large and severe when it does occur. Insect outbreaks represent the most important disturbance to spruce-fir ecosystems. Spruce beetles are endemic to the ecosystem, but reach epidemic populations when there are high densities of large-diameter trees and appropriate climatic conditions for the beetles.
- **Climate change vulnerability.** The potential for increased drought and temperatures as a result of climate change increases the vulnerability of spruce to disturbances, such as insect epidemics. It is unclear whether recent spruce beetle epidemics are unprecedented or fall within the natural range of variation. However, it is important to seriously consider potential impacts of climate change on spruce beetles.
- **Structure.** Spruce stands display gap-phase dynamics driven by wind, insect- and disease-driven mortality, and other disturbance interactions.
- **Processes.** Regeneration occurs in openings; clear cutting often results in very low spruce regeneration density. The high value that humans associate with spruce forests suggests that planting may be necessary when regeneration does not occur. Models may determine where and what may be planted. An important consideration in seed or seedling selection is identifying the seed source that reflects the likely future climate of the site where planting is desired.

In the exercise implementing the workshop tool, the spruce-fir group identified spruce beetle (*Dendroctonus rufipennis*) regimes as a key ecological characteristic (Appendix D). The group assessed this characteristic at both stand and landscape scales:

- **General.** Endemic spruce beetle populations create and maintain the gap-phase dynamic thus ensuring structural and compositional diversity. Spruce beetles are the dominant disturbance for this ecosystem. Endemic (as opposed to epidemic beetle populations) allow for connectivity of stands of living trees.
- **Current status.** Recent epidemics have resulted in widespread mortality throughout the region. The group indicated that FIA and aerial detection surveys provide information on the current status of the spruce beetle populations. A well-developed body of literature provides insight on the natural range of the variation of spruce beetle regimes. This literature suggests the presence of less severe epidemics in the past. Dendrochronological and paleoecological (pollen) data provides information on return intervals.
- **Natural range of variation.** Metrics to assess NRV include the extent and severity of beetle-caused mortality. The NRV of spruce beetle regimes suggests that the most severe epidemic events are very infrequent; thus, it is difficult to assess whether recent epidemics are in line with historical conditions. As a result of outbreaks, stand-level structure and composition may also be out of NRV.
- **Climate change.** As demonstrated in peer-reviewed literature, spruce beetle populations are vulnerable to climate change. Changes in temperature and moisture have been demonstrated to influence beetle population success. Climate change will affect the frequency and intensity of the spruce beetle disturbance regimes.

- **Management actions.** Forest managers have no practical ability to control a spruce beetle epidemic at the landscape scale. However, ensuring age class diversity prior to an outbreak may confer resilience, since younger, smaller diameter trees would not be susceptible to the outbreak and will influence the rate of forest development following the disturbance. At a stand scale, managers may implement silvicultural treatments and semiochemical strategies to respond to spruce beetle epidemics.
- **Land management plan development and priorities.** Spruce-fir is an important ecosystem in the region, and the Forest Service manages a substantial majority of the system. Accordingly, spruce beetle disturbances represent an important feature for assessment and planning units may develop narratives to inform plan components that consider the influence of spruce beetle disturbances. This assessment may inform desired future conditions that reflect the need to maintain a diversity of size classes for spruce or an understanding that older spruce-fir forests are less likely to occupy the plan area. Guidelines, such as “Increase size class diversity” with measurable outcomes and specific timeframes, may also be incorporated into plan development. Monitoring may also track spruce beetle outbreaks.

Alpine Vegetation

Dave Tart, Regional Ecologist, U.S. Forest Service Intermountain Region, led the group addressing alpine plant communities. This category includes non-forested vegetation found above the continuous forest line. The group identified two dominant ecological characteristics: soil cover and protection, and plant species composition.

Soil Cover and Protection

For soil cover and protection, the group discussed the following:

- **General.** Alpine areas vary widely in the proportions of ground covered by gravel, rock, or vegetation. Soil is critical to the survival of alpine plant species and vegetative cover is critical to holding and protecting the soil.
- **Current status.** On the Ashley National Forest, monitoring indicates that total ground cover is high, with less than 10 percent bare soil, but areas where persistent snow beds melt are slowly colonized by plants due to the very short growing seasons. Thawing of snow banks uncovers bare ground; this natural occurrence needs to be explained to stakeholders. Existing monitoring efforts and historic photos offer information on the current status of soil cover.
- **NRV.** Ground cover ranges from 70 percent near late-melting snow banks to 100 percent in alpine turf and meadow communities. Monitoring data indicate that the system does not currently appear to be uncharacteristic; it exhibits structures and functions expected based on NRV.
- **Climate change.** Climate change may reduce plant cover due to warmer, and possibly drier, conditions. Changes in snow cover may also expose more bare soil. It is uncertain whether climate change will reduce ground cover to values uncharacteristic of the NRV of the region’s alpine vegetation. Over time, newly exposed bare soil may be colonized by species, such as conifers, moving from lower elevations. Paleoecological data may document past climate change effects.

- **Other stressors.** Other stressors include herbivory and increased recreation use of alpine areas leading to increased soil compaction, displacement, and erosion. These stressors may reduce ground cover and increase the amount of bare soil to uncharacteristic values based on the reference value. Information on these stressors include monitoring goat herbivory and using trail counters to assess recreational use.
- **Management actions.** Management may affect this soil cover through actions such as the rerouting and maintenance of trails.

Plant Species Composition

The group also considered plant species composition:

- **General.** Plant species composition is considered important for protection of soil resources, biodiversity, and habitat for pollinators and animals.
- **Current status.** On both the Ashley National Forest and the Manti-La Sal National Forest, species compositions are as expected, based on available monitoring data.
- **NRV.** Knowledge of NRV for species composition suggests that a variety of species should be present; however, there is no detailed knowledge regarding the distribution or relative abundance of species. The loss of individual species or loss of a community type may suggest the system is uncharacteristic, as based on NRV. Such changes have likely occurred during past warming periods. Monitoring data provides limited insight on NRV. The group determined that the system is similar to that expected, based on NRV.
- **Climate change.** Climate change may result in loss of plant cover or change in species composition on some sites; although on moist sites, plant cover may stay the same. In warmer or drier areas, climate change may shift plant species composition out of NRV. Paleoecological data that incorporate past warm periods may provide information on how climate change will affect species richness, the mix of plant communities, and the spatial extent of the alpine zone. However, it appears that human activities are accelerating the rate of climate change, and species may not have sufficient time to adapt or migrate from their current locations.
- **Other stressors.** Herbivory and increased recreation use will also stress plant species composition, affect reproduction of plant species, and result in a loss of species. These stressors were not present during past climate change events and will very likely shift species composition in ways uncharacteristic of the system, as based on NRV. Information on these stressors include monitoring goat herbivory and using trail counters to assess recreational use.
- **Management actions.** Similar to soil cover, management may affect plant species composition through actions such as the rerouting and maintenance of trails.

WORKSHOP FEEDBACK

Feedback from the workshop participants suggested that the workshop's structure was helpful to critically address climate change and ecological integrity through NRV to inform land management planning. Workshop participants found the presentation on the 2012 planning rule valuable, and we recommend that future workshops include such an overview. Furthermore, future

workshops may benefit from expert presentations on ecological integrity and NRV and FIA data to provide a common context among participants to facilitate subsequent discussions.

We identified several challenges with implementing the workshop. While we identified the ecosystems to focus on prior to the workshop, we spent considerable time identifying key characteristics of those ecosystems during the workshop. In the future, it may expedite the process to have resource specialists and other members of the planning team identify potential key characteristics in advance of meeting to go through the worksheet. Both groups narrowed in on a few dominant characteristics, which were largely focused on species composition and disturbance dynamics.

Identifying the appropriate scale for assessing and parameterizing NRV also presented challenges. The spruce-fir group decided to assess spruce beetle regimes at both the stand and a broader spatial scale concurrently, in order to address this challenge, an approach that other planning units may want to consider using. During the workshop, we described this broader spatial scale as a “landscape scale.” We recognize that using this term may be complicated as “landscape” can describe scales of different magnitudes depending on the context.

Participants also had suggestions regarding the NRV workshop tool worksheet. For future iterations, participants suggested that individuals fill out the tables independently prior to coming together as a group. This would avoid the possibility of “group think.” One participant suggested that, given the expected uncertainty associated with climate change impacts, it is important to qualitatively assess the level of certainty associated with the assumptions made about ecological integrity when completing the table. An additional column would allow users to assess certainty of assumptions on a coarse (for example, low, medium, high) scale. Workshop participants emphasized that use of this tool is best suited as a part of the assessment of current conditions and available information rather than as analysis to support particular objectives.

Participants also thought that implementation of the tool could occur outside of the context of formal workshops. One participant suggested that land management planning teams might use the tool to develop ecosystem narratives to spark a conversation on what ecological integrity means for a particular system. Participants suggested that planning units using the tool consider whether the tool could support better communication with the public

Workshop attendees also identified thought-provoking questions that arose around several different issues related to NRV, ecological integrity, and climate change. Researchers and regional specialists who support planning efforts may benefit from preparing to address the following questions:

- How do you reconcile NRV and management of lands to meet desired conditions based on social, cultural, or economic objectives?
- Would you assess ecological integrity and NRV for a wildlife population or should wildlife populations be handled separately?
- Do ecosystem function, structure, and composition account for other more fine-scale factors (e.g., a particular ecosystem service)?
- How do you approach situations where an ecosystem state may be stable or resilient, but not desirable? For example, cheatgrass (*Bromus tectorum*) invasions are stable in the long-term and can withstand perturbation, but the presence of cheatgrass does not fall within NRV.
- What does resilience mean for a stand or landscape, particularly when we expect changes due to climate change?

- What are examples of reference conditions across NRV for an ecosystem? Which metrics can be used to describe reference conditions?
- What is the relationship between ecosystem and habitat type?
- For individual planning units, ecosystems are generally geographic not taxonomic. How do you put these concepts in geographic context?
- How do you reconcile when climate change adaptation strategies, such as resistance and resilience, may conflict with NRV as a tool?
- Planning units have to develop a land management plan for their planning area, but also have to reflect on larger scales as well. How do you reconcile these scales? For instance, understanding the NRV for many ecosystems often will require considerations at a scale larger than the plan area.

CONCLUSIONS AND RECOMMENDATIONS

The 2012 planning rule requires planning units undergoing land management plan revision to consider climate change. Plans should seek to maintain or restore ecological integrity, a concept that integrates NRV and the ability of ecosystems to withstand and recover from perturbations. In this report, we discuss efforts to improve the Forest Service's capacity to address climate change in the context of land management planning and science-management partnerships. We developed the NRV workshop tool that offers an opportunity to structure an assessment of ecological integrity, NRV, and climate change. We implemented this tool in a workshop associated with the Intermountain Adaptation Partnership vulnerability assessment effort. This workshop was an opportunity for initiating discussions and testing tools described herein so future groups may build upon the work and adapt it to their needs.

Based on the workshop, we have identified several key insights and recommendations that we highlight below:

- **Ecological integrity is the key focus.** As a first consideration, managers may consider whether characteristics reflect reference conditions. However, it is also necessary to consider whether the current system may persist. Natural range of variation helps identify whether there are relevant management responses that may help maintain or restore ecological integrity. It is also necessary to consider whether the system may withstand and recover from disturbances, which reflects the second half of the definition of ecological integrity.
- **NRV is complicated.** Using historical ecology to guide management is challenging in light of considerable uncertainty in terms of both reconstructing the past and anticipating the likely future conditions with regards to the impacts of climate change. The concept is an evolving pursuit in academic scholarship.
- **Using NRV as a tool to determine ecological integrity.** NRV is a tool or a guide for evaluating ecological integrity, not a management goal. The NRV for an ecological characteristic represents a frequency distribution of conditions that occurred in the past. Accordingly, using the concept dichotomously has limited utility; that is, describing characteristics as “inside” or “outside” of NRV is often not productive in determining ecological integrity. Rather, it is important to use NRV to inform decisionmaking in light of climate change to pursue ecological sustainability.

- **Determining dominant ecological characteristics.** Identifying dominant ecological characteristics to guide management for ecological integrity is a necessary first step in order to develop plan components for ecological integrity. Yet, identifying appropriate characteristics for which to explore NRV and build plan components presents a challenge to planning teams. We encourage planning teams to use the worksheet and approach outlined here to iteratively assess the appropriateness of selected characteristics as being dominant characteristics. Important considerations when identifying characteristics include data availability, the feasibility of affecting the characteristic through management actions, opportunities to monitor the characteristics, and scale considerations.
- **Scale.** Across the National Forest System, different approaches to determine scale exist, including identifying key characteristics at the regional level or at the level of the individual plan area. Furthermore, selecting the appropriate scales—both temporal and spatial—at which to explore NRV presents an additional challenge. Using longer temporal or larger spatial scales likely broadens the distribution of reference conditions.

We recommend several changes to the design and execution of the workshop that may help practitioners and scientists convening future workshops or engaging with planning and NRV:

- **Pre-reading.** We assigned the primer (Appendix A) as pre-reading for the workshop. However, attendees had different levels of familiarity with the 2012 planning rule and with the concepts of ecological integrity and NRV. Accordingly, we suggest that attendees of future workshops or planning teams read the primer or other readings on NRV and land management planning prior to convening a workshop.
- **Context or setting.** Implementation of a workshop considering NRV needs to consider the context of the focal region or planning units. Our workshop addressed the Intermountain Region. Accordingly, we focused on ecosystem types of value to the Intermountain Region, particularly to the two planning units that were beginning their plan revisions at the time of the workshop. When addressing NRV for other planning units or region, researchers and managers may want to consider important human uses and ecosystems that make up the context of those units or region.
- **Workshop timing.** We conducted our workshop prior to the formal initiation of land management planning processes in the region. There are benefits and drawbacks associated with identifying dominant ecological characteristics and addressing NRV for these characteristics depending on when this is done in the land management planning process. For example, planning units may undertake the process outlined in this research note early in the assessment phase in order to identify key information sources that inform consideration of ecological integrity, NRV, and climate change. Alternatively, undergoing this process after completing the assessment phase may be more productive in terms of identifying specific characteristics and developing plan components informed by a consideration of the NRV of these characteristics. It may be most beneficial to consider NRV using an iterative process at multiple stages of the land management planning process.

GLOSSARY

Adaptation—Adjustment in natural or human systems to a new or changing environment. Adaptation includes, but is not limited to, maintaining primary productivity and basic ecological

functions such as energy flow; nutrient cycling and retention; soil development and retention; predation and herbivory; and natural disturbances. Adaptation occurs primarily by organisms altering their interactions with the physical environment and other organisms. (FSH 1909.12, Zero Code)

Ecological integrity—The quality or condition of an ecosystem when its dominant ecological characteristics (for example, composition, structure, function, connectivity, and species composition and diversity) occur within the natural range of variation [NRV] and can withstand and recover from most perturbations imposed by natural environmental dynamics or human influence. (36 CFR §219.19)

Ecological sustainability—The capability of ecosystems to maintain ecological integrity. (36 CFR §219.19)

Economic sustainability—The capability of society to produce and consume or otherwise benefit from goods and services including contributions to jobs and market and nonmarket benefits. (36 CFR §219.19)

Ecosystem services—Benefits people obtain from ecosystems, including:

1. *Provisioning services*, such as clean air and fresh water, energy, fuel, forage, fiber, and minerals;
2. *Regulating services*, such as long term storage of carbon, climate regulation; water filtration, purification, and storage; soil stabilization; flood control; and disease regulation;
3. *Supporting services*, such as pollination and nutrient cycling; and
4. *Cultural services*, such as education, aesthetic, spiritual and cultural heritage values, recreational experiences and tourism opportunities. (36 CFR §219.19)

Landscape—A defined area irrespective of ownership or other artificial boundaries, such as a spatial mosaic of terrestrial and aquatic ecosystems, landforms, and plant communities, repeated in similar form throughout such a defined area.

1. *Broader landscape*—For land management planning pursuant to 36 CFR part 219 and this Handbook, the plan area and the lands surrounding the plan area. The spatial scale of the broader landscape varies depending upon the social, economic, and ecological issues under consideration. (36 CFR §219.19; FSH 1909.12, Zero Code)

Natural range of variation—The variation of ecological characteristics and processes over scales of time and space that are appropriate for a given management application. In contrast to the generality of historical ecology, the NRV concept focuses on a distilled subset of past ecological knowledge developed for use by resource managers; it represents an explicit effort to incorporate a past perspective into management and conservation decisions (adapted from Wiens et al. 2012). The pre-European influenced reference period considered should be sufficiently long, often several centuries, to include the full range of variation produced by dominant natural disturbance regimes such as fire and flooding and should also include short-term variation and cycles in climate. The NRV is a tool for assessing the ecological integrity and does not necessarily constitute a management target or desired condition. The NRV can help identify key structural, functional, compositional, and connectivity characteristics, for which plan components may be important for either maintenance or restoration of such ecological conditions. (FSH 1909.12, Zero Code)

Plan components—The parts of a land management plan that guide future project and decision-making. Specific plan components may apply to the entire plan area, to specific management

areas or geographic areas, or to other areas as identified in the plan. Every plan must include the following plan components—Desired conditions; Objectives; Standards; Guidelines; Suitability of Lands. A plan may also include Goals as an optional component. (FSH 1909.12, Zero Code)

Social sustainability—The capability of society to support the network of relationships, traditions, culture, and activities that connect people to the land and to one another, and support vibrant communities. (36 CFR §219.19)

Stressor—Factors that may directly or indirectly degrade or impair ecosystem composition, structure or ecological process in a manner that may impair its ecological integrity, such as an invasive species, loss of connectivity, or the disruption of a natural disturbance regime. (36 CFR §219.19)

Sustainability—The capability to meet the needs of the present generation without compromising the ability of future generations to meet their needs. (36 CFR §219.19)

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APPENDIX A: PRIMER²

OVERVIEW OF KEY 2012 PLANNING RULE LANGUAGE ON ECOLOGICAL INTEGRITY, NATURAL RANGE OF VARIATION, AND CLIMATE CHANGE

Introduction

On April 9, 2012, the Forest Service released a final rule (“2012 planning rule”) detailing how National Forest System (NFS) planning units should meet planning requirements outlined in the National Forest Management Act. The Forest Service also produced final directives in January 2015, specifically Forest Service Manual (FSM) 1920 and Forest Service Handbook (FSH) 1909.12, providing more detailed policy, instructions, and definitions. This document describes how the rule and directives address ecological integrity, natural range of variation (NRV), and climate change. This primer is provided as background for a workshop or less formal work by practitioners to develop criteria and considerations to use in informing assessment and plan development when climate change has implications for how we apply NRV to examine ecological integrity.

Ecological Integrity

The purpose of the 2012 planning rule is “to guide the collaborative and science-based development, amendment, and revision of land management plans that promote the ecological integrity of national forests and grasslands and other administrative units of the NFS,” (36 CFR 219.1(c)). Accordingly, plans should enable that national forests and grasslands “consist of ecosystems and watersheds with ecological integrity and diverse plant and animal communities” (36 CFR 219.1(d)). Ecological integrity is an important component of ecological sustainability and of maintaining the diversity of plant and animal communities (see 36 CFR 219.8 and 219.9). In 219.19, the 2012 planning rule defines ecological integrity as follows:

The quality or condition of an ecosystem when its dominant ecological characteristics (for example, composition, structure, function, connectivity, and species composition and diversity) occur within the natural range of variation [NRV] and can withstand and recover from most perturbations imposed by natural environmental dynamics or human influence.

ECOSYSTEM

The 2012 planning rule defines an ecosystem as follows (36 CFR 219.19):

A spatially explicit, relatively homogenous unit of the Earth that includes all interacting organisms and elements of the abiotic environment within its boundaries. An ecosystem is commonly described in terms of its:

1. *Composition.* The biological elements within the different levels of biological organization, from genes and species to communities and ecosystems.
2. *Structure.* The organization and physical arrangement of biological elements such as, snags and down woody debris, vertical and horizontal distribution of vegetation, stream habitat complexity, landscape pattern, and connectivity.
3. *Function.* Ecological processes that sustain composition and structure, such as energy flow, nutrient cycling and retention, soil development and retention, predation and herbivory, and natural disturbances such as wind, fire, and floods.
4. *Connectivity.* Ecological conditions that exist at several spatial and temporal scales that provide landscape linkages that permit the exchange of flow, sediments, and nutrients; the daily and seasonal movements of animals within home ranges; the dispersal and genetic interchange between populations; and the long distance range shifts of species, such as in response to climate change.

Natural Range of Variation

The 2012 planning rule does not define natural range of variation (NRV). However, the Handbook provides a comprehensive definition of NRV:

The variation of ecological characteristics and processes over scales of time and space that are appropriate for a given management application. In contrast to the generality of historical ecology, the NRV concept focuses on a distilled subset of past ecological knowledge developed for use by resource managers; it represents an explicit effort to incorporate a past perspective into management and conservation decisions (adapted from Wiens, J.A. et al., 2012). The pre-European influenced reference period considered should be sufficiently long, often several centuries, to include the full range of variation produced by dominant natural disturbance regimes such as fire and flooding and should also include short-term variation and cycles in climate. The NRV is a tool for assessing the ecological integrity and does not necessarily constitute a management target or desired condition. The NRV can help identify key structural, functional, compositional, and connectivity characteristics, for which plan components may be important for either maintenance or restoration of such ecological conditions. (FSH 1909.12, Zero Code, page 14)

There are situations when it may be inappropriate for plans to include components to restore or maintain NRV, and this may be a consideration during assessment. FSH 1909.12 states:

For specific areas within an ecosystem, the Responsible Official may determine that it is not appropriate, practical, possible, or desirable to contribute to restoring conditions to the natural range of variation. Natural range of variation includes a wide range of characteristics, some more common than other characteristics. To achieve social, economic, cultural, or ecological objectives it may be desirable to manage for uncommon conditions in specific areas in the plan area. For an ecosystem to withstand or recover from disturbance events caused under unique circumstances, it may be necessary to manage for characteristics that were rare or never occurred in the past. The following are examples of situations where it is NOT appropriate, practical, possible, or desirable to design plan components to restore past conditions for specific areas within an ecosystem:

- a. The system is so degraded that restoration is not possible.
- b. The ability to restore the desired ecological conditions or key ecosystem characteristics is beyond the authority of the Forest Service, the fiscal capability of the unit, or the inherent capability of the plan area.
- c. The system is no longer capable of sustaining key ecosystem characteristics identified as common in the past based upon likely future environmental conditions.
- d. Conditions that rarely or never occurred in the past, but that can be managed for in the future, will better contribute to long-term ecosystem sustainability and adaptation to the effects of a changing climate.
- e. Conditions that rarely or never occurred in the past, but that can be managed for in the future, will better address public health and safety concerns.
- f. Conditions common in the past are directly opposed to integrated desired conditions (desired conditions that represents a balance of social, economic, cultural and ecological needs).

(FSH 1909.12, Chapter 20, section 23.11a. Pages 59-60)

Considerations of Climate Change in the 2012 Planning Rule

The planning framework outlined in the 2012 planning rule is intended to enable the “Forest Service to adapt to changing conditions, including climate change, and improve management based on new information and monitoring,” (36 CFR 219.5). The rule classifies climate change as a system stressor that must be considered when addressing ecological integrity in the context of ecological sustainability (36 CFR 219.8). Furthermore, monitoring activities should track the impacts of climate change and other stressors (36 CFR 219.12).

FSM 1920 includes the following as an objective of planning:

4. Improve the resilience of National Forests and Grasslands to climate change and other stressors.

(FSM 1920, Chapter 1921, Section 1921.02, page 9)

FSH 1909.12 defines climate change adaptation as follows:

Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. This adaptation includes initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects. Adaptation strategies include the following:

1. Building resistance to climate-related stressors.
2. Increasing ecosystem resilience by minimizing the severity of climate change impacts, reducing the vulnerability, and/or increasing the adaptive capacity of ecosystem elements.
3. Facilitating ecological transitions in response to changing environmental conditions.

(FSH 1909.12, Zero Code. Page 5)

Planning Process

The rule outlines a three-part planning framework, involving assessment, plan development, and monitoring (36 CFR 219.5).

In the assessment phase, national forest and grassland planning teams must assess which ecosystem types occur in the plan area, identify and evaluate existing information for those ecosystems, and assess the need for change (36 CFR 219.6). Of the fifteen required assessment topics, the following five relate to ecological integrity:

- (1) Terrestrial ecosystems, aquatic ecosystems, and watersheds;
- (2) Air, soil, and water resources and quality;
- (3) System drivers, including dominant ecological processes, disturbance regimes, and stressors, such as natural succession, wildland fire, invasive species, and climate change; and the ability of terrestrial and aquatic ecosystems on the plan area to adapt to change;
- (4) Baseline assessment of carbon stocks;
- (5) Threatened, endangered, proposed and candidate species, and potential species of conservation concern present in the plan area; ...”

(36 CFR 219.6(b))

In plan development, addressed in the rule at 36 CFR 219.7, the set of plan components must meet the requirements set forth for sustainability, plant and animal diversity, multiple use, and timber. The requirements for sustainability at 36 CFR 219.8(a)(1) and plant and animal diversity at 36 CFR 219.9(a)(1) include the requirement that the plan includes plan components to maintain or restore the ecological integrity of the ecosystems in the plan area.

The plan must also include a plan monitoring and evaluation program (36 CFR 219.7(f)(1)(iii)). The monitoring section of the rule at 36 CFR 219.12 requires that the plan monitoring program enables the responsible official, usually the forest supervisor, “to determine if a change in plan components or other plan content that guide management of resources on the plan area may be needed,” (36 CFR 219.12(a)(1)). The rule requires monitoring questions and indicators be developed to test relevant assumptions, track relevant changes, and measure management effectiveness and progress toward achieving the plan’s desired conditions and objectives (36 CFR 219.12(a)(2)). They must address at least eight required topics, the following of which relate to ecological integrity:

- (i) The status of select watershed conditions
- (ii) The status of select ecological conditions including key characteristics of terrestrial and aquatic ecosystems
- (iii) The status of focal species to assess the ecological conditions required under §219.9 [which emphasizes ecosystem diversity and integrity to maintain or restore plant and animal diversity]...
- (iv) Measureable changes on the plan area related to climate change and other stressors that may be affecting the plan area.

Prompting Questions for the Workshop Around Employing NRV to Evaluate Ecological Integrity in Light of Climate Change

1. What key ecological characteristics are most useful for informing our understanding of the integrity of the ecosystem? Which are useful during each phase of planning?
2. Will climate change degrade ecological integrity, and if so, what are appropriate actions in the next 10–20 years? How might we assess this, plan for it, and monitor for it?
3. How do we know managing to maintain system characteristics in the past based on NRV is no longer appropriate for social, cultural, economic, or ecological reasons?
4. For systems that currently exhibit high ecological integrity reflective of reference conditions, how can we manage those systems to keep key ecological characteristics consistent with NRV to support resilience in the face of climate change? In other words, where is there a current need for change?
5. How might climate change affect how we conceptualize the NRV for a system?
6. What insights regarding the dynamics of the system become apparent when we examine its historical dynamics across longer time horizons? What does this tell us about potential responses to scenarios of climate change?

Endnotes

¹ The climate change vulnerability assessments for the Intermountain Region were recently published.

Halofsky, J.E.; Peterson, D.L.; Ho, J.J.; [et al.], eds. 2018. Climate change vulnerability and adaptation in the Intermountain Region [Part 1]. Gen. Tech. Rep. RMRS-GTR-375. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 1-197.

Halofsky, J.E.; Peterson, D.L.; Ho, J.J.; [et al.], eds. 2018. Climate change vulnerability and adaptation in the Intermountain Region [Part 2]. Gen. Tech. Rep. RMRS-GTR-375. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 199-513.

² The primer presented in this report incorporates edits made following the workshop based on suggestions provided by reviewers. Accordingly, it slightly differs from the primer provided to workshop attendees.

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APPENDIX B. WORKSHEET AND ACCOMPANYING INSTRUCTIONS (SEE EXAMPLE IN APPENDIX D)

Part 1

General				Current Status	
Dominant ecological characteristic	Category	Relevant spatial scale	Importance	Description of current status	Information on current status
<i>Provide a brief description of dominant ecological characteristic.</i>	<i>Select one of the following: composition, structure, function, connectivity.</i>	<i>Select one of the following: landscape (broad-scale), forest, or stand. Provide additional description if necessary.</i>	<i>Why is this ecological characteristic important?</i>	<i>Provide description of the current status of the characteristic. Quantify if possible.</i>	<i>Available information on the current status.</i>

Part 2

NRV				Climate Change		
NRV of characteristic	Metrics for NRV	NRV information	Reflects NRV?	Climate change vulnerability	Affect NRV?	Climate change information
What is the NRV of the characteristic?	How do we tell if the system reflects conditions in line with NRV for the characteristic?	Available information on NRV.	Does the system currently reflect NRV for this characteristic? What information is needed to determine the causal factor?	Is this characteristic vulnerable to climate change? In what ways will climate change impact this characteristic?	Will climate change shift the characteristic away from reference conditions? How can we tell?	Available information on impacts of climate change to characteristic.

Part 3

Other Stressors				Management Actions			Plan Development and Priorities			
Other stressors	Impacts of other stressors	Affect NRV?	Information on other stressors	Likelihood of management to affect characteristics	Assessment	Plan components	Monitoring			
List stressors other than climate change.	Describe impacts of other stressors on the characteristic.	Will the stressor shift the characteristic away NRV? How can we tell?	Available information on stressors.	How feasible is it to impact this characteristic through management actions? What specifically could be done and are these practical to implement?	Is this a high priority for assessment and why? Consider data availability; importance of the characteristic to ecological, social, and economic sustainability; and impacts of climate change.	How can we build plan components for this characteristic and why? How can we address NRV and ecological integrity in these plan components?	Is this a high priority for monitoring and why? How feasible is it to monitor this characteristic?			

ECOLOGICAL INTEGRITY, NRV, PLAN DEVELOPMENT, CLIMATE CHANGE

Introduction

The purpose of this document and accompanying worksheet is to allow Forest Service planners and scientists to systematically address ecosystem integrity in the face of climate change by evaluating individual dominant ecological characteristics. Ecological characteristics derive from the following categories: composition, structure, function, and connectivity. The worksheet considers NRV of these characteristics as well as vulnerability to climate change and other stressors. Information inputted on characteristics, NRV, and stressors informs consideration of specific management actions, assessment priorities, plan component development, and monitoring objectives. Section 1 of this appendix includes instructions for the accompanying worksheet. Section 2 asks general questions that can be addressed after completing the worksheet.

Section 1: Worksheet Instructions

Before beginning the worksheet, you will want to consider relevant ecosystems found within your planning unit. You will use a worksheet for each ecosystem. You will begin by listing stressors to the ecosystem (e.g., climate change, invasive species, grazing, timber harvesting, insects) on the sheet titled Stressors. Feel free to brainstorm on this sheet. You will likely select a subset of these stressors to include on the next table.

After listing stressors, you will move on to the sheet titled Ecological characteristics. You will consider ecological characteristics of the ecosystem. The table asks questions organized into several categories:

- General. This section includes general information about the dominant ecological characteristic.
 - o Dominant ecological characteristic. Provide a brief description of dominant ecological characteristic. In this field, you will provide a short description of the ecological characteristic that will be addressed in this row (e.g., “Sapling recruitment”; “Age-class distribution”; “Fire return interval”).
 - o Category. Select one of the following: composition, structure, function, connectivity. This field requires you to categorize the characteristic. Options to choose from include composition, structure, function (or process), and connectivity. Definitions of these categories can be found in the accompanying primer or in the 2012 planning rule directives.
 - o Relevant spatial scale. Select one of the following: landscape, forest, or stand. Provide additional description if necessary. This field addresses the appropriate spatial scale for considering the ecological characteristic. Spatial scale can be considered on a spectrum from stand-level to forest-level to landscape-level. Landscape-level refers to a broad spatial scale larger than an individual planning unit. Feel free to provide additional details on the spatial scale including whether the characteristic can be evaluated at multiple scales.

- o Importance. Why is this ecological characteristic important? In this section, you will describe the characteristic and explain its importance to the ecosystem and its ecosystem integrity.
- Current Status. This section addresses the current status of the characteristic.
 - o Description of current status. Provide description of the current status of the characteristic. Quantify if possible. In this field, you will describe the current status of the characteristic. If possible, you will quantify the characteristic using the appropriate metric. Please address how the current status may vary across locations within your planning unit.
 - o Data on current status. Available data on current status. You will list data sources that are available on the current status of the characteristic as well as any general data sources pertinent to the characteristic. Data sources may include geospatial datasets, FIA data, General Technical Reports, peer-reviewed literature, and others.
- NRV. This section addresses the natural range of variation (NRV) of the characteristic, an important aspect of ecological integrity in the 2012 planning rule. The primer provides a definition of NRV.
 - o NRV of characteristic. What is the NRV of the characteristic? In this field, you will describe the NRV of the characteristic, quantifying metrics when possible. Qualitative descriptions are helpful in addition to quantification. If possible, please address the spatial and temporal scales considered when defining NRV. Numbers can be expressed as ranges.
 - o Metrics for NRV. How do we tell if the system reflects conditions in line with NRV for the characteristic? When filling in this field, you will want to consider whether there are specific monitoring items, experiments, data, or observations that can inform whether the system is within NRV. For some characteristics such as fire return interval given the long time scale, it may be difficult to tell whether a system is within or outside of NRV.
 - o NRV data. Available data on NRV. You will discuss data sources available to classify NRV for the characteristic. Paleoecological and dendrochronological data are often helpful for classifying NRV. If relevant, address data gaps in this field.
 - o Reflects NRV? Does the system currently reflect NRV for this characteristic? What data is needed to determine the causal factor? Based on the metrics established in the previous field, the current status of the characteristic, and your knowledge of the ecosystem, you will want to describe whether the ecosystem exhibits conditions that reflect common conditions during a historical reference period for this particular characteristic. Please include description of relevant uncertainties.
- Climate Change. This section addresses the characteristic's vulnerability to climate change and how climate change may impact NRV and ecological integrity.
 - o Climate change vulnerability. Is this characteristic vulnerable to climate change? In what ways will climate change impact this characteristic? In this field, you will discuss the vulnerability of the ecosystem and the specific characteristic to climate change. Consider changes in mean temperature and precipitation as well as the occurrence of extreme events such as droughts. Please discuss relevant uncertainties.

- o Affect NRV? Will climate change shift the characteristic away from reference conditions? How can we tell? Discuss the relationship between climate change vulnerability, NRV, and ecological integrity. The impacts of climate change may impact a characteristic such that it moves out of NRV. If the characteristic is not currently within NRV, consider whether climate change would shift the characteristic towards or away from NRV.
- Data. Available data on impacts of climate change to characteristic. Discuss data sources that may inform consideration of climate change vulnerability of the ecosystem and the specific characteristic. Potential data sources include downscaled climate change projections and vulnerability assessments.
- Other Stressors. Factors other than climate change may be stressors for the ecosystem. Possible other stressors include invasive species, grazing, timber harvesting, and insects. You will have already listed relevant stressors to the ecosystem; return to your list for this section.
 - o Other stressors. List stressors other than climate change. Incorporate your list of stressors made on the previous sheet. Feel free to provide additional description beyond a list. If stressors interact, are cascading or cumulative, note that in the table.
 - o Impacts of other stressors. Describe impacts of other stressors on the characteristic. In this field, you will provide information on how these other stressors may affect the characteristic.
 - o Affect NRV? Will the stressor shift the characteristic away from the NRV? How can we tell? You will want to think about whether the listed stressors will affect whether the characteristic continues to reflect NRV.
 - o Data on other stressors. Available data on stressors. Discuss data sources as well as data gaps.
- Management Actions. This section requires you to think about specific management actions that may have an impact on the characteristic.
 - o Likelihood of impact. How feasible is it to impact this characteristic through management actions? What specifically could be done and are these practical to implement? Consider whether there are feasible management actions or tactics that can affect the characteristic. For certain characteristics, there may not be any management actions that can affect the characteristic given economic, technical, or policy barriers. Discuss feasible management actions that could be employed to affect the characteristic. It is especially helpful to consider whether these management actions would maintain or restore ecological integrity. For management actions that might not be practical, discuss why this is the case.
- Plan Development and Priorities. This section addresses how the planning team may incorporate information developed in this worksheet about dominant ecological characteristics, NRV, and climate change into plans. It addresses the assessment, plan development, and monitoring phases.
 - o Assessment. Is this a high priority for assessment and why? Consider data availability, importance of the characteristic to ecological, social, or economic sustainability, and impacts of climate change. In this field, you will consider whether this characteristic

should be a priority for assessment in the first phase of planning. You should consider the importance of the characteristic to ecological, social, or economic sustainability. You should consider whether the Forest Service has any influence or management control over the characteristic. Public interest in the characteristic may elevate its importance for assessment.

- o Plan components. How can we build plan components for this characteristic? How can we address NRV and ecological integrity in these plan components? Consider how the characteristic and its NRV can be incorporated into the plan. Consider the need for desired conditions that have specific enough descriptions to determine progress or achievement; objectives for measurable, time-specific changes in the conditions; design criteria as standards or guidelines to ensure subsequent projects or activities result in or at least do not prevent attainment of objectives or desired conditions; or the need to prohibit certain activities from specified areas to ensure progress toward or achievement of desired conditions or objectives.
- o Monitoring. Is this a high priority for monitoring and why? How feasible is it to monitor this characteristic? In this field, address whether monitoring for the characteristic would provide information that the responsible official can use to determine if a change to the plan, a change in management under the plan, a change in future monitoring, or a new assessment is needed.

Section 2: Key questions for framing end-of-day presentation

Insert Ecosystem Here

Answer the below questions based on the worksheet exercise.

Which are the most valuable ecological characteristics for telling us if the system exhibits ecological integrity? What do they tell us about the status?

What scientific information describes key characteristics of NRV, ecological integrity, and climate change for this ecosystem?

Are there management options that can maintain or restore ecological integrity? Will climate change affect ecological integrity?

Are there particular ecological characteristics relevant to NRV and ecological integrity included on the worksheet worth prioritizing for assessment, plan development, and monitoring? (Consider which assessment items would give us the best opportunities to track current conditions and trends, what plan components can be included, and how can monitoring test assumptions about ecological integrity, NRV, track trends, or track the impact of stressors and management actions.)

APPENDIX C: AGENDA

Forest Service Intermountain Region (R4) Workshop on Climate Change and Natural Range of Variation

Date: March 21–22, 2016 (1.5 workdays)

March 21 Location: USFS Intermountain Office, 324 25th St, Ogden, UT 84401

March 22 Location: Courtyard Marriott Ogden, 247 24th St, Ogden, UT 84401

Project Objective (from BeSmart proposal):

The objective is to identify the information needed by the land management planning process, in particular the assessment, to determine when climate change could perturb ecological integrity characteristics (structure, function, composition, connectivity) outside of the NRV.

Organizers:

- Linda Joyce, Research Ecologist, USFS Rocky Mountain Research Station
- Courtney Schultz, Assistant Professor of Forest and Natural Resource Policy, Colorado State University
- Gina Lampman, Regional Planner, USFS Intermountain Region

AGENDA

Day 1 (Courtney Schultz – Moderator)

Location: Regional Office, Room 5118

- 1:00–1:15: Welcome and statement of purpose (Courtney Schultz, Linda Joyce)
- 1:15–1:30: Introductions: workshop participants
- 1:30–2:15: Overview of 2012 Planning Rule and NRV as part of ecological integrity (Chris Iverson, USFS Intermountain Region)
- 2:15–2:30: Break/Informal discussion
- 2:30–3:30: Overview of Natural Range of Variation (NRV) and how the concept can be useful for management and in the context of climate change (Jim Long, Utah State University)
- 3:30–3:45: Break/Informal discussion
- 3:45–4:30: Overview of the Intermountain Adaptation Partnership, including results from the Vegetation Chapter on projected changes to ecosystems and resultant key vulnerabilities under climate change (Pat Behrens, USFS Intermountain Region)

Day 2

Location: Courtyard Marriott Ballroom

- 8:00–8:10: Welcome and housekeeping
- 8:10–9:00: Overview of the Disturbance Chapter from the IAP, reporting results on how climate change will affect major disturbances in the Intermountain Region (*Danielle Malesky, USFS Intermountain Region*)
- 9:00–10:45: Full group exercise on defining NRV for lodgepole pine. (*Jim Long, and John Shaw, USFS Rocky Mountain Research Station, to lead.*)
- 10:45–11:00: Break
- 11:00–11:15 – Introduction to the group exercises – **Following the introduction, full group separates into two sub-groups to address two different ecosystems. Ballroom will be divided into two rooms.**
- (*Facilitators: Spruce-fir—Thomas Timberlake/Courtney Schultz; Alpine—Linda Joyce*)
- 11:15–11:45: Presentation from ecosystem experts on how to characterize NRV for the ecosystem at various temporal and spatial scales for two chosen ecosystem types (*Spruce-fir—Justin DeRose, USFS Rocky Mountain Research Station; Alpine—David Tart, USFS Intermountain Region*)
- 11:45–1:00: Lunch
- 1:00–2:00: Group discussion on how to use this information to define and assess dominant ecosystem characteristics. Objectives include to: 1) outline the current status of the characteristics; 2) capture the NRV of the characteristics and track whether climate change is pushing characteristics outside of NRV; and, 3) address the impact of other stressors. During this period, groups should cover the following worksheet sections:
 - o General;
 - o Current status;
 - o NRV;
 - o Climate change; and,
 - o Other stressors.
- 2:00–3:00: Group discussion of management actions to address NRV of characteristics and incorporation into plan development phases: assessment, plan components, and monitoring. During this period, groups should cover the following worksheet sections:
 - o Management actions; and,
 - o Forest plan development and priorities.
- 3:00–3:15 Break
- 3:15–4:30: Presentations to entire group from both ecosystem sub-groups on progress for the day
- 4:30–5:00: Wrap-up and next steps (capturing lessons learned; identifying follow-up steps and future needs)

APPENDIX D: EXAMPLE OF COMPLETED WORKSHEET

Part 1

General				Current Status	
Dominant ecological characteristic	Category	Relevant spatial scale	Importance	Description of current status	Information on current status
Provide a brief description of dominant ecological characteristic.	Select one of the following: composition, structure, function, connectivity.	Select one of the following: landscape (broad-scale), forest, or stand. Provide additional description if necessary.	Why is this ecological characteristic important?	Provide description of the current status of the characteristic. Quantify if possible.	Available information on the current status.
Spruce beetle regimes	Process	Landscape	Endemic spruce beetle populations create and maintain the gap-phase dynamic (structural and compositional diversity). Spruce beetles are the dominant disturbance for this ecosystem. Endemic (as opposed to epidemic) beetle populations are important to connectivity.	Recent epidemics have resulted in widespread mortality throughout the region.	FIA data; Aerial Detection Survey (ADS)

Part 2

NRV						Climate Change		
NRV of characteristic	Metrics for NRV	NRV information	Reflects NRV?	Climate change vulnerability	Affect NRV?	Climate change information		
What is the NRV of the characteristic?	How do we tell if the system reflects conditions in line with NRV for the characteristic?	Available information on NRV.	Does the system currently reflect NRV for this characteristic? What information is needed to determine the causal factor?	Is this characteristic vulnerable to climate change? In what ways will climate change impact this characteristic?	Will climate change shift the characteristic away from reference conditions? How can we tell?	Available information on impacts of climate change to characteristic.		
Good literature on less severe epidemics and return intervals. Endemic populations result in mortality to small patches (order of a few acres or less).	Extent and severity of beetle-caused mortality.	Dendrochronological data and paleo data (pollen) may be used to determine return intervals of events. Written records may be used for more recent events.	Incredibly infrequent most severe epidemic events. Recent most severe epidemics may be unprecedented.	Yes. Changes in temperature and moisture have been shown to influence beetle population success.	Yes. See answer to the left. Shift from endemic to outbreak likely as a result of temperature increases and moisture deficit. Length of epidemics may be extended depending on hosts.	Peer-reviewed literature.		

Part 3

Other Stressors				Management Actions			Plan Development and Priorities			
Other stressors	Impacts of other stressors	Affect NRV?	Information on other stressors	Likelihood of management to affect characteristics	Assessment	Plan components	Monitoring			
List stressors other than climate change.	Describe impacts of other stressors on the characteristic.	Will the stressor shift the characteristic away NRV? How can we tell?	Available information on stressors.	How feasible is it to impact this characteristic through management actions? What specifically could be done and are these practical to implement?	Is this a high priority for assessment and why? Consider data availability; importance of the characteristic to ecological, social, and economic sustainability; and impacts of climate change.	How can we build plan components for this characteristic and why? How can we address NRV and ecological integrity in these plan components?	Is this a high priority for monitoring and why? How feasible is it to monitor this characteristic?			
(Wind; avalanches - may be inherent aspects of systems)				No ability to practically control an epidemic at the landscape scale. Age class diversity prior to an outbreak may confer resilience, since some trees will not be susceptible to the outbreak. Staggered planting to create structural diversity.	There are data available. Spruce beetles affect ecological, economic, and social sustainability. Spruce-fir is an important system region-wide and the Forest Service manages 85% of the system. Develop narrative to build plan components on.	Desired future condition: maintain a diversity of size class for spruce. Create guidelines for size class distribution (e.g., "Increase size class diversity"). It is important to maintain infrastructure.				Yes.

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