Rio Grande National Forest – Modeling Assessment of Ecosystem Integrity, Systems, Drivers & Stressors

Photo: US Forest Service

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Megan Creutzburg, Miles Hemstrom and Myrica McCune
Institute for Natural Resources, Oregon State University

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Introduction

This is a partial report from the Rio Grande National Forest (RGNF) Assessment, completed by INR in 2015. The full report included elements of RGNF planning documents not included here, as they were not finalized at the completion of the vegetation modeling.

An assessment of natural range of variation (NRV), current conditions, and future trends for terrestrial and riparian ecosystems was informed by state-and-transition simulation models (STSMs) run by analysts at the Institute for Natural Resources, Oregon State University. STSMs can be thought of as box and arrow diagrams, where boxes represent state classes describing vegetation composition and structure (Figure 1). Arrows represent the drivers and stressors that cause state class change, such as growth, mortality, disturbance, and management. These drivers and stressors are called transitions, and can be represented as deterministic transitions, causing change at a specified age, or probabilistic transitions, specifying an annual probability of a transition occurring. STSMs are particularly useful for assessing trends due to multiple drivers and stressors acting simultaneously on the landscape. Each STSM corresponds to a single ecosystem. The STSMs used for this assessment vary in their complexity and their drivers and stressors based on the dynamics of each ecosystem. The major forested STSMs also incorporated information from literature, regional data, and experts on the Forest, as detailed in Appendix B.
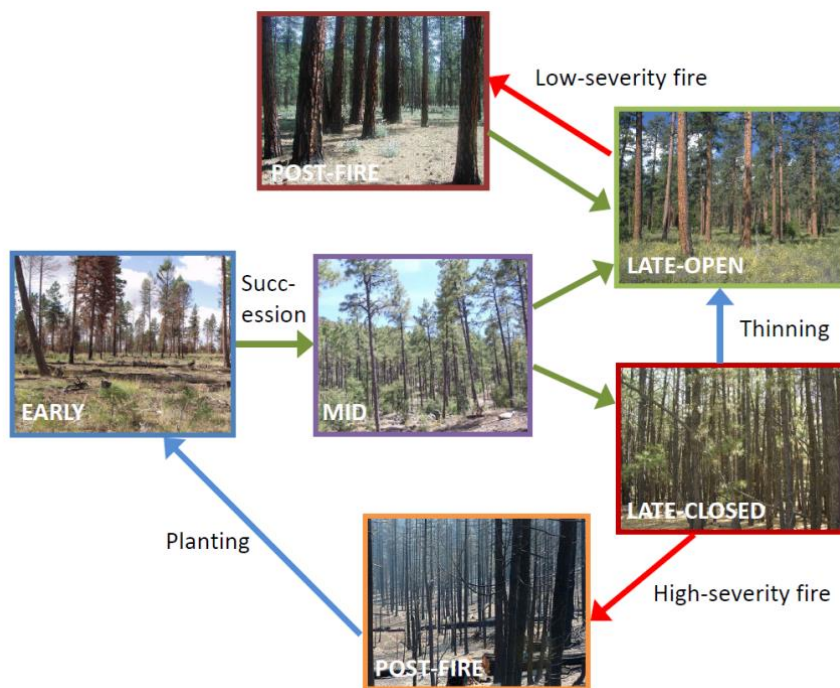
Figure 1 Generic STSM diagram showing six alternate state classes varying in their composition and structure within a forested ecosystem. Arrows represent drivers and stressors that cause change among state classes, with green arrows representing succession, red arrows representing wildfire, and blue arrows representing management treatments.

For the RGNF assessment, two basic sets of STSMs were constructed for each ecosystem – one for historic conditions to approximate the natural range of variation (NRV), and one for contemporary

conditions to project conditions under alternative future scenarios. These two sets of models differed in their drivers and stressors (see *Characterizing Drivers and Stressors*, below). These STSMs were used to run three scenarios

1) The NRV scenario (also called historic range of variation or HRV) shows expected natural or historic conditions based on running NRV STSMs to equilibrium (500 years). Graphs show average historic conditions under model equilibrium, with a range of plus or minus one standard deviation from the average across 100 years and 10 Monte Carlo simulations.

2) The No Management scenario used contemporary condition STSMs to project future condition with no management activities, except continued wildfire suppression. This scenario provides a baseline for future conditions without management interventions to compare against various management alternatives.

3) The No Action scenario used contemporary condition STSMs to project future condition under current rates of management activities (timber harvest, prescribed fire, etc.) on the RGNF, assuming no change from the existing forest plan direction and budget levels. Current management treatments were based on records in the USFS FACTS database from the past 11 years. The No Action scenario also assumes continued wildfire suppression.

STSMs were run in the ST-Sim platform, version 2.3.8, freely available on the web (http//www.apexrms.com/stsm). The basic functionality of the STSMs is driven primarily by transition probabilities representing the dominant processes in each ecosystem. However, various advanced functions of the ST-Sim model were also used for this assessment. We simulated variability from year to year in fire weather, representing normal, high and extreme fire conditions. We also modeled insect outbreaks as cyclical or episodic events in some ecosystems, with no insect activity for a certain number of years followed by several consecutive years of high insect activity. Each Monte Carlo simulation varied in the sequence of wildfire conditions and timing of insect outbreaks to account for stochastic variability. Therefore, our models included the chance that large and intense disturbances could occur, but these events had a low frequency. The actual, recent occurrence of large, intense disturbances on the RGNF may be just chance events that, while possibly having also occurred in the past, are statistically rare. On the other hand, those recent disturbances may reflect a changing "normal" due to altered climatic or other drivers. Future monitoring will help us understand whether large, intense disturbances are statistical anomalies or reflections of changing basic drivers.

For this assessment, we ran the ST-Sim model spatially, with maps of ecosystems (vegetation types), current vegetation composition and structure, and management areas represented as spatial data layers. We also modeled some transitions (wildfire, insect outbreaks, and management activities) spatially, allowing disturbances to spread across cells using an assumed distribution of patch sizes. Other transitions (growth and mortality, livestock grazing, etc.) were modeled non-spatially, where each cell was simulated independently of neighboring cells. See Appendices A and B for more details.

Vegetation Projections

For each scenario, we ran 10 Monte Carlo simulations to include variability in stochastic events such as wildfire conditions and insect outbreaks. NRV projections are shown for model equilibrium (400-500 year projections; although note that both the average and SD are similar for a single time step at 500 years). Future STSM projections are shown for time steps 20, 50, 100, 300 and 500 years into the future

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under the No Management scenario. Projections are also shown comparing the No Management and No Action scenarios 50 years into the future. Note that STSM projections are most useful for comparing scenarios and have limited value as "forecasts" of long-term future conditions, particularly since they do not account for the potential impacts of climate change. This is particularly true for 300-500 year future projections, which are an indication of conditions under contemporary model equilibrium and not predictions of the future.

Characterizing Vegetation Condition

For this assessment, we characterize vegetation condition into Habitat Structural Stages (HSS) developed by USFS Region 2 (Table 1). We refer to canopy cover 0-10% as 'grass/shrub', 10-40% as 'open', 40-70% as 'mid' and 70-100% as 'closed' in the descriptions below. A HSS category for aspen-dominated stands with variable size and canopy cover was also added for this analysis. HSS has two categories for non-forested ecosystems, including natural meadow and natural shrubland. Natural meadow (1M) includes all state classes within the Rocky Mountain Alpine Turf and Southern Rocky Mountain Montane-Subalpine Grassland STSMs. Natural shrubland (2S) includes all state classes within the Rocky Mountain Gambel Oak - Mixed Montane Shrubland, Sagebrush Shrubland, and Inter-Mountain Basins Greasewood Flat STSMs. We combined HSS classes 1T and 2T for this report because we cannot distinguish grass/forb from shrub/seedling in disturbed areas with forested potential. Note that STSM projections are not shown individually for non-forested ecosystems because each non-forested system is classified as a single HSS (either natural meadow or natural shrubland), with no change over time. Instead, descriptions of major changes (e.g., changes in the proportion of grasses/shrubs or invasion by exotic species) in these systems are briefly described. The full ST-Sim model output with complete state class-level detail can be used for more in-depth examination of trends within ecosystems, if desired.

Habitat Structural Stage (HSS)	Size Class	Tree Canopy Cover
1M- Natural Meadow	-	-
2S- Natural Shrubland	-	-
1T/2T- Grass/Shrub, Previously Trees	all	0-10%
3A- Sapling-Pole 10-40% cover	sapling-pole (0-9" DBH)	10-40%
3B- Sapling-Pole 40-70% cover	sapling-pole (0-9" DBH)	40-70%
3C- Sapling-Pole >70% cover	sapling-pole (0-9" DBH)	>70%
4A- Mature 10-40% cover	mature (9+" DBH)	10-40%
4B- Mature 40-70% cover	mature (9+" DBH)	40-70%
4C- Mature >70% cover	mature (9+" DBH)	>70%
Aspen	all	all

Table 1. Definitions of habitat structural stages (HSS) used to characterize ecosystem condition.

Characterizing Drivers and Stressors

Drivers and stressors are represented in the STSMs as transitions, shown as arrows between state classes. Transitions varied widely between STSMs based on the dynamics of the ecosystem and the model source. Drivers and stressors modeled in the RGNF include growth and succession, wildfire, endemic levels of insects and disease activity, epidemic (outbreak) levels of insect activity, livestock grazing, drought, flooding, exotic invasion, tree encroachment, management activities, and a few others.

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Some transitions were divided into multiple types; for instance, forested models include multiple levels of wildfire severity (e.g., nonlethal, mixed-severity, and stand-replacing). Several different types of management transitions were also included in the No Action scenario, and are detailed for each ecosystem below and in Appendix B. Note that growth and endemic levels of mortality are not reported by the ST-Sim model where they are modeled as deterministic transitions, as they are in the non-forest and riparian models, but are reported where they are probabilistic, as they are in most of the forested models. This means that the growth and endemic mortality drivers are not shown for the non-forest and riparian projections, even though they are included in the models.

In some cases, the drivers and stressors in the NRV (historic) models differ from those in contemporary condition models used for future projections. In the forested models, the drivers and stressors are mostly the same, except the probability of wildfire is different between historic and contemporary conditions (Appendix B). Management treatments are also included as drivers and stressors in contemporary condition models, but are only activated in the No Action scenario. In some of the non-forested models, other drivers and stressors differ between historic and contemporary condition models. For example, several non-forest models include livestock grazing and exotic grass invasion under contemporary conditions, whereas those stressors are absent from historic condition models. This report details drivers and stressors by ecosystem for NRV equilibrium conditions (400-500 year projections) and for future conditions under the No Action scenario (0-100 year projections). Future levels of drivers and stressors are similar between the No Management and No Action scenarios; therefore the No Management scenario is not shown in the graphs of drivers and stressors. The models presented here do not include any potential impacts of climate change.

Assessment Area

The RGNF STSM modeling assessment encompassed about 1.7 million acres of forests, woodlands and grasslands on the RGNF and surrounding landscape (Figure 2). A buffer of 6.2 mi (10 km) was added around the RGNF boundary to encompass the broader landscape context, containing forests, woodlands and shrublands. This report focuses mostly on conditions and trends within the RGNF boundary only, but projections for the broader context area, including the RGNF and the 6.2 mi buffer, are shown at the end of the report. The landscape was also divided into 10 management areas, which were used to place management treatments in appropriate locations (Appendix A). These were grouped into three levels of management intensity, and we examined trends separately for each. However, projections rarely differed between areas differing in management intensity, so we do not report results by management area here.
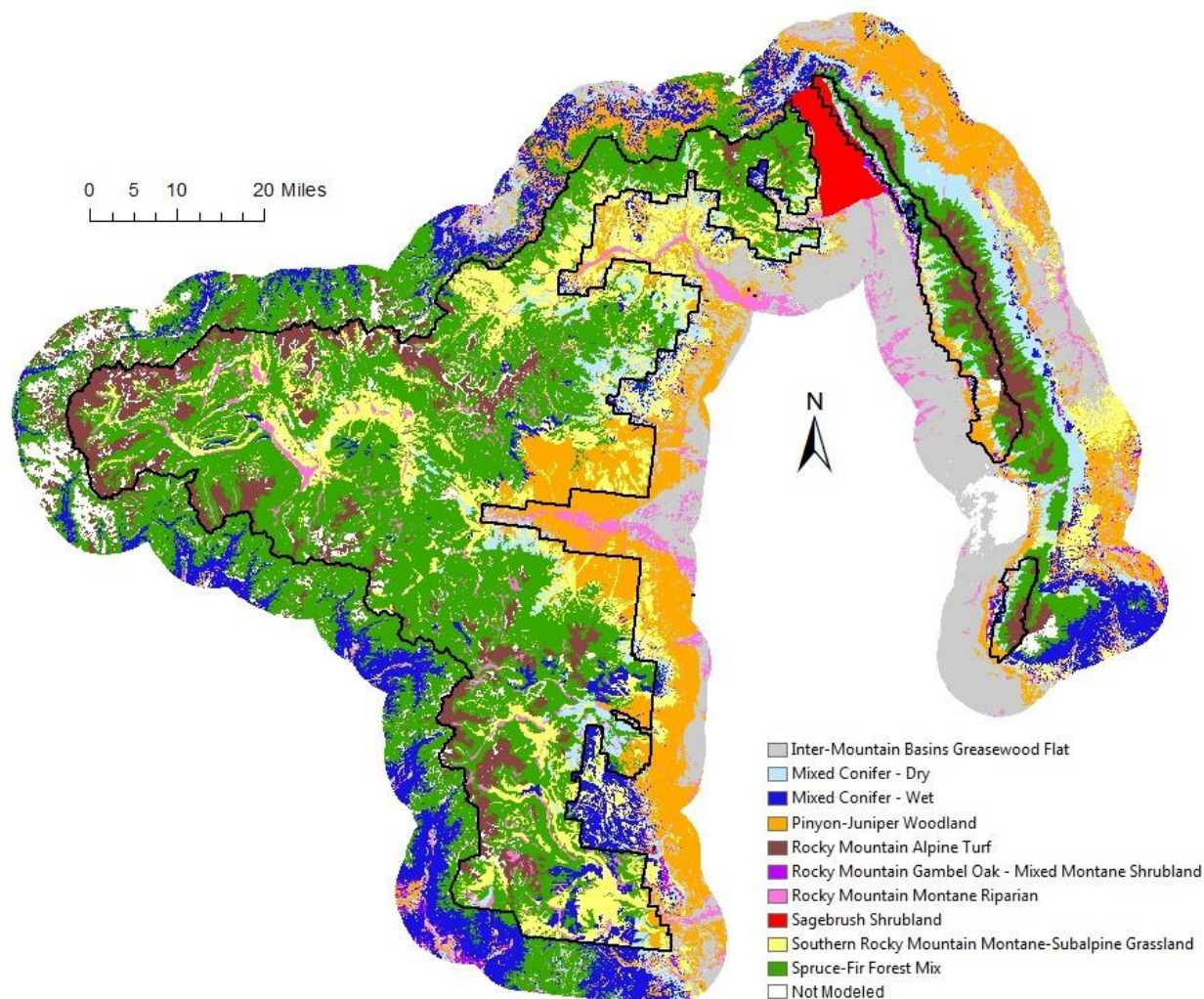
Figure 2. Map of ecosystems on the RGNF. The RGNF boundary is shown in black, and the landscape context area included a 6.2 mile buffer around the forest.

Spatial data layers were compiled in raster format with 120m resolution. See Appendix A for details of spatial data processing.

Current Vegetation Condition

The current composition and structure of vegetation on the RGNF was determined based on vegetation maps supplied by the RGNF assigned to state classes in the STSMs. These state classes were then grouped into HSS for reporting (Table 2, Figure 3). Currently, the most common HSS on the Forest is natural meadow (1M), due to large areas occupied by Rocky Mountain Alpine Turf and Southern Rocky Mountain Montane-Subalpine Grassland ecosystems. Of the forested area, most of the landscape is comprised of mature, open stands (4A), with grass/shrub, open sapling-pole, mid cover mature, and aspen each comprising about 10% of the landscape. In the broader RGNF landscape including the context area, natural shrublands (2S) comprise a substantial portion of the landscape, and the proportion of the landscape occupied by sapling-pole trees is greater.

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Habitat Structural Stage (HSS)	RGNF Acres		RGNF and Landscape Context Area	
	Acres	Percent	Acres	Percent
1M- Natural Meadow	495,936	29%	765,656	19%
2S- Natural Shrubland	6,366	0%	509,226	12%
1T/2T- Grass/Shrub, Previously Trees	190,270	11%	349,223	8%
3A- Sapling-Pole 10-40% cover	171,678	10%	566,786	14%
3B- Sapling-Pole 40-70% cover	101,526	6%	620,641	15%
3C- Sapling-Pole >70% cover	5,256	0%	161,572	4%
4A- Mature 10-40% cover	376,921	22%	458,371	11%
4B- Mature 40-70% cover	173,329	10%	345,847	8%
4C- Mature >70% cover	44,635	3%	68,793	2%
Aspen	165,675	10%	265,884	6%

Table 2. Current number of acres in each HSS, based on maps of current vegetation and incorporating recent, large disturbances.

Note that the current landscape composition at a broad landscape scale should be interpreted cautiously, particularly across the boundary between the RGNF and surrounding context area. There is a sharp distinction in HSS across the RGNF boundary in many places (Figure 3), which is at least partially due to three major differences between maps used within the RGNF perimeter and maps used outside the forest in the context area (6.2 mi buffer). Firstly, the data source of the maps differed. Current vegetation data from within the Forest boundary was supplied by the RGNF while data from outside the boundary came from gradient nearest neighbor imputation. Secondly, maps within the RGNF were represented as polygons whereas maps outside the forest were raster maps. Thirdly, the maps within the RGNF boundary incorporated an updated canopy cover map to include the impacts of recent large fires and the multi-year spruce beetle outbreak. This updated canopy cover layer was obtained from the USFS Remote Sensing Applications Center (RSAC) and was used to update the percent canopy cover (but not tree size) in areas affected by recent disturbance. These differences resulted in a distinct shift in current vegetation condition across the RGNF boundary in many places (Figure 3), which may reflect ecological condition but also reflects differences in underlying data. See Appendix A for details on spatial data sources and processing.
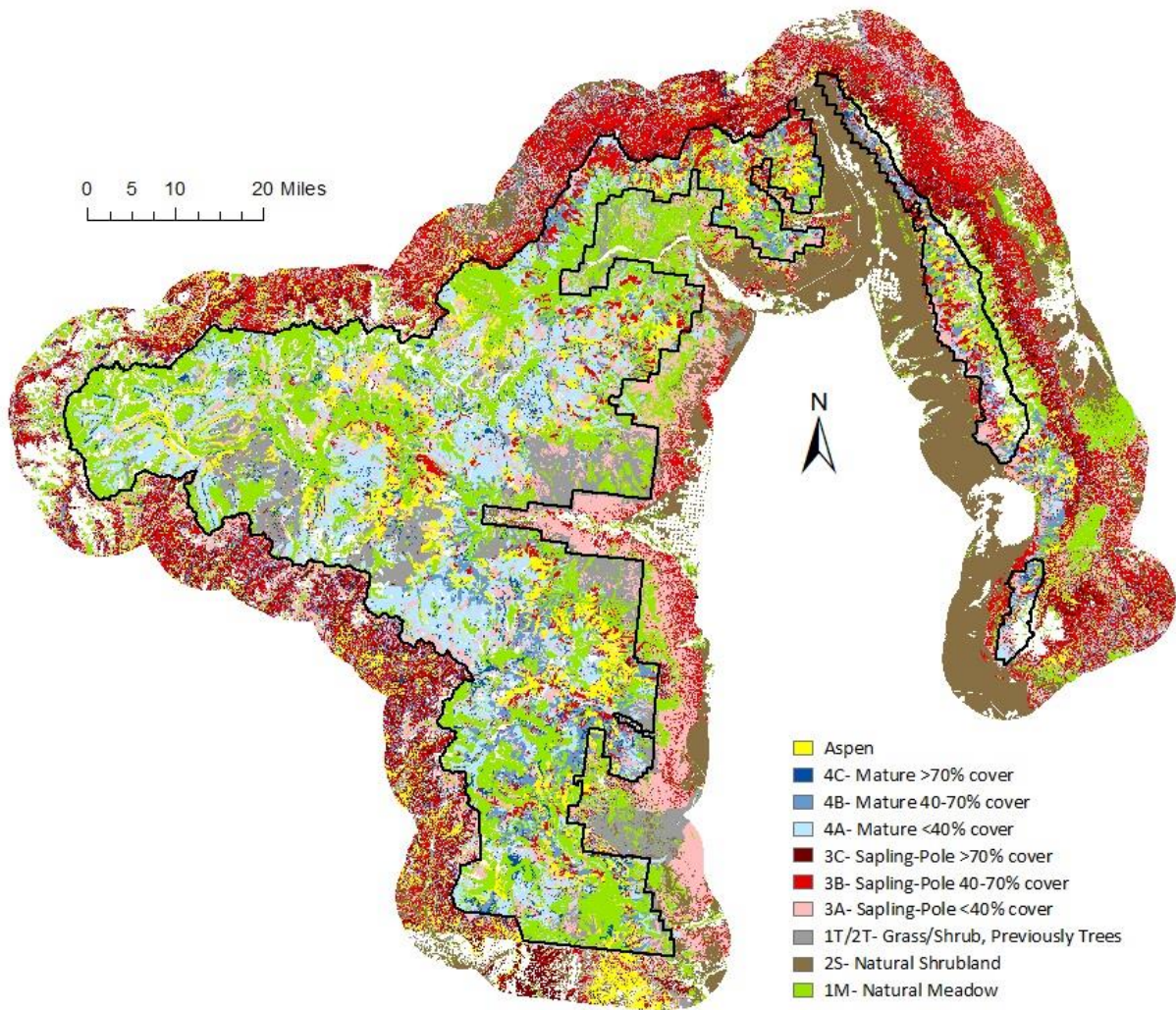
Figure 3. Map of current HSS conditions across the RGNF and surrounding context area landscape.

Historic and Future Projected Future Conditions

We used LTAs as our approximation of ecosystems on the RGNF. Based on discussions with Forest experts and descriptions in the Forest's guide to LTAs, we grouped the 13 LTAs on the Forest into eight ecosystems with similar vegetation dynamics, each represented as a STSM. We also modeled an additional two ecosystems that occur primarily outside the Forest, for a total of 10 ecosystems modeled (Table 3). The landscape proportion in each ecosystem is shown in Figure 4 and their spatial distribution is shown in Figure 2.

Ecosystem	LTA Number(s)	Model Code	RGNF Acres	RGNF + Context Area Acres
Spruce-Fir Forest Mix	1, 13	R3_SFM	929,645	1,442,390
Mixed Conifer-Wet	2	R3_MCW	42,718	423,037

Mixed Conifer-Dry	3, 5	R3_MCD	94,925	265,311
Rocky Mountain Alpine Turf	4	LF_2811440	191,800	260,063
Pinyon-Juniper Woodland	6, 12	R3_PJO	100,070	582,015
Rocky Mountain Gambel Oak - Mixed Montane Shrubland	7	R3_GAM	1,224	25,951
Southern Rocky Mountain Montane-Subalpine Grassland	8, 9	R3_MSG	304,136	505,593
Rocky Mountain Montane Riparian	10	LF_2811590	61,932	124,363
Sagebrush Shrubland	-	R3_SAG	5,014	43,525
Inter-Mountain Basins Greasewood Flat	-	R3_ISS	128	439,750
			1,731,592	4,112,000

Table 3. Ecosystems modeled for the RGNF assessment. Acres in each ecosystem are reported for the RGNF only and the landscape context area (including a 6.2 mi buffer), and omits areas that have snow, rock or other non-vegetated cover. RGNF acres also omit private inholdings within the forest. LTA number corresponds to the list of LTAs in the introduction, and model codes correspond to the model documentation in Appendix A.
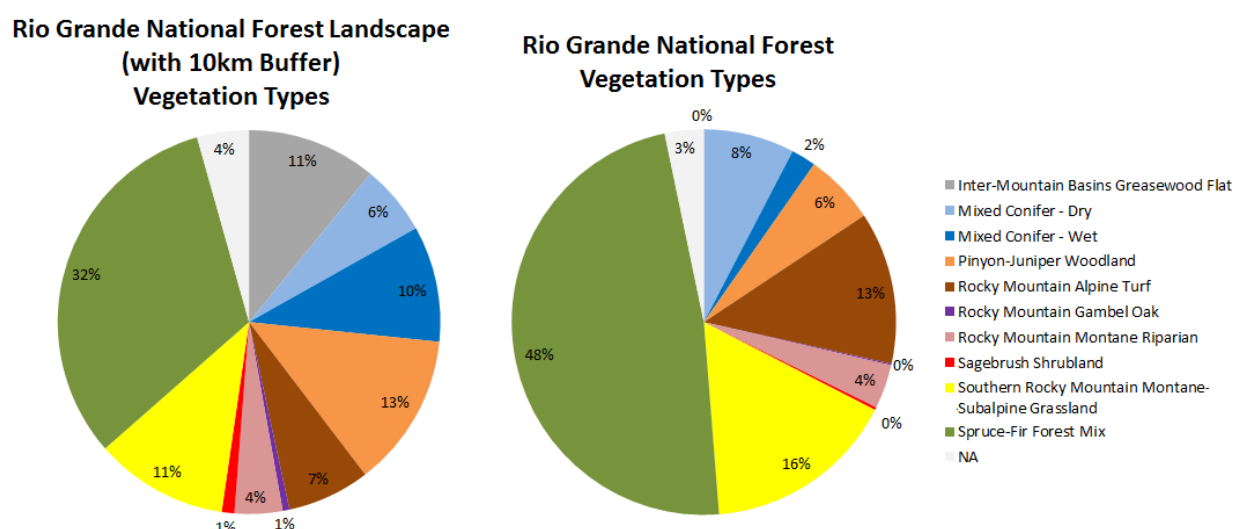

Figure 4. Proportion of the landscape occupied by each ecosystem across the entire modeled landscape (including 6.2 mi buffer) (left) and on the RGNF only (right). NA refers to areas that have snow, rock or other non-vegetated cover.

Rio Grande National Forest – All Ecosystems

This section presents vegetation projections across the whole RGNF, followed by projections for each of the major ecosystems individually. Projections including the landscape context area (6.2 mi buffer) can be found at the end of the report under *Rio Grande National Forest Landscape Context Area*.

Natural Range of Variation

Under NRV, roughly 30% of the RGNF was comprised of natural meadows and (few) shrublands, which did not vary over time in their HSS classification (Figure 5). The remainder of the RGNF was dominated by forests, including about 16% in aspen stands. Forested canopy cover under NRV was projected as 31% conifers with mid cover, 14% closed conifer conditions, and 8% open conifer stands. Historical

projections indicate that most of the RGNF was comprised of mature conifer trees (42%) with 11% in smaller sapling-pole sizes. Only 1% of the RGNF is expected to be in grass/shrub with forested potential (HSS 1T/2T) under historic conditions, indicating rare stand-replacing disturbance.
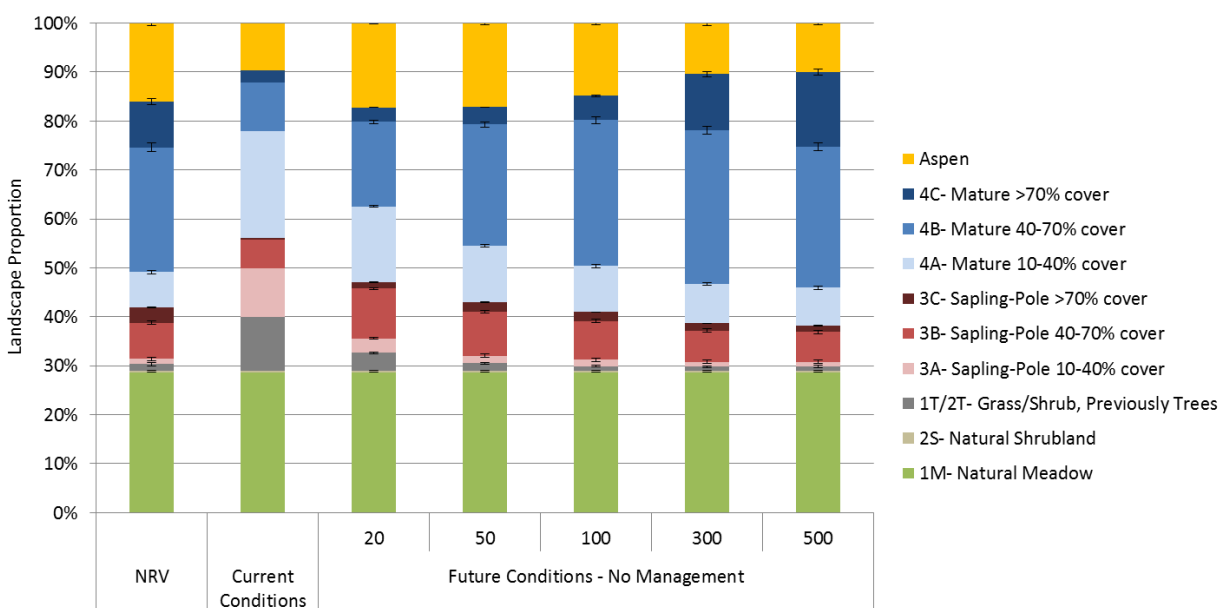

Figure 5. Comparison of HSS classes under NRV equilibrium, current conditions (time zero) and future projections under No Management at 20, 50, 100, 300 and 500 year time steps across all ecosystems within the RGNF. Error bars show ± 1SD across 10 replicate simulations.

Status and Trends

Current conditions on the RGNF contain abundant grass/shrub with forested potential (HSS 1T/2T), roughly 10-fold greater than projected under NRV conditions (Figure 5). Current conditions also contain more sapling-pole trees and a much greater proportion (31%) of open stands compared to NRV conditions. The abundance of grass/shrub and open conditions are largely a result of a severe spruce beetle outbreak and large wildfires over the past several years. The proportion of aspen at present is also smaller than projected under NRV, due to less wildfire maintaining this early-seral species under contemporary conditions. Very large and intense disturbances were rare in our simulations and did not substantially influence NRV condition. This is not to say that these kinds of disturbances do not occur naturally, but that they are not captured in the range of conditions represented by the STSMs. In short, the RGNF overall is currently moderately to substantially departed from typical NRV conditions, though the degree of departure varies by ecosystem (see sections below).

Projected future conditions indicate overall recovery toward NRV as the result of natural processes (Figure 5). After 500 years, future model equilibrium suggests there may be slightly less aspen than expected under NRV due to lower contemporary wildfire levels. The projected future proportion of mature trees is also greater than under NRV, particularly in forests with closed canopy conditions. In sum, our modeling indicates that the RGNF will likely move from currently departed conditions toward NRV as it recovers from recent disturbance. However, it may remain somewhat departed from NRV due to lower overall levels of wildfire resulting from fire suppression.

Across the entire RGNF, projections under the No Management and No Action scenarios after 50 years were nearly indistinguishable (Figure 6). This is not surprising, as the extent of management treatments is extremely small, with <0.2% of the landscape treated with management activities each year.
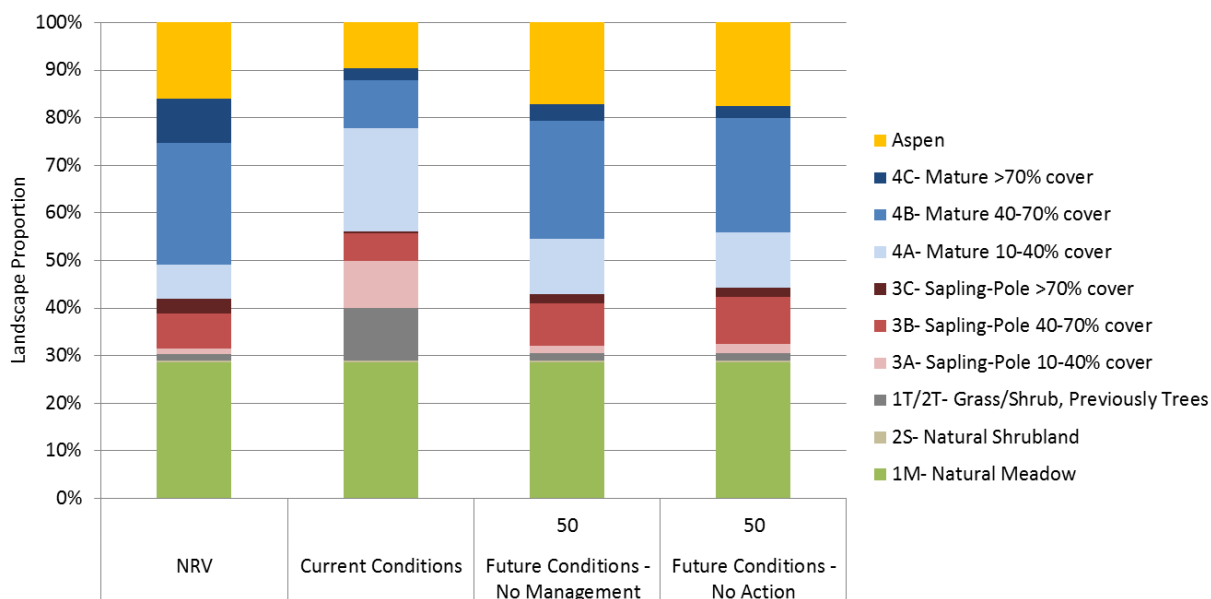

Figure 6. Comparison of HSS classes under NRV equilibrium, current conditions (time zero), and No Management and No Action scenarios (50 years in the future) across all ecosystems in the RGNF.

System Drivers and Stressors

Drivers and stressors varied widely among ecosystems across the RGNF, and are detailed below for each ecosystem separately. The dominant drivers across the landscape included growth & mortality (not shown), livestock grazing in non-forest models, and (in some cases) wildfire (Figure 7). Wildfire affected three times more area under NRV conditions than contemporary conditions due to contemporary fire suppression. Other drivers included insects and disease, weather-related events (e.g., droughts and floods), other natural disturbances (e.g., beaver activity in riparian areas), and management. Overall, management treatments such as thinning, prescribed fire, and timber harvest were applied to <0.2% of the RGNF each year under the No Action scenario, indicating that management (other than wildfire suppression) is a relatively minor driver and stressor at a landscape scale.
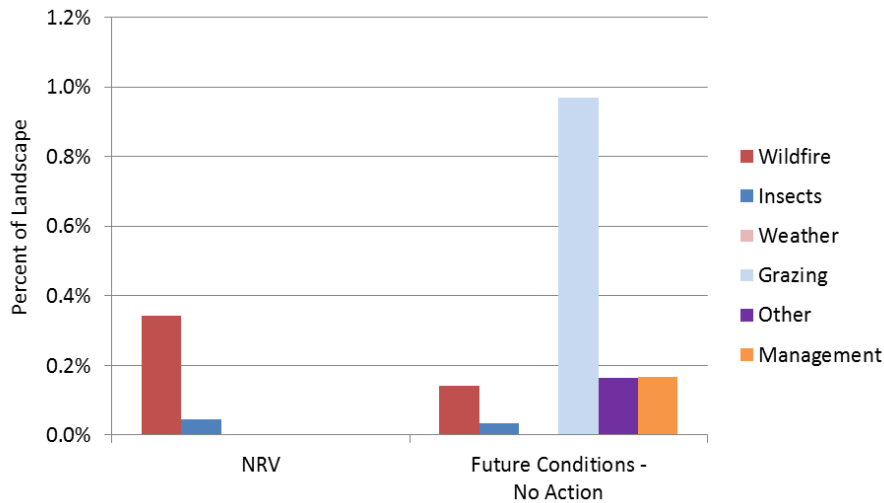
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Figure 7. Average percent of the RGNF landscape affected by drivers and stressors, compared between NRV equilibrium and average 100 year future projections under the No Action scenario.

Spruce-Fir Forest Ecosystem

The Spruce-Fir Forest ecosystem encompasses two LTAs on the RGNF, including Engelmann Spruce on Mountain Slopes, and Engelmann Spruce on Landslides. This ecosystem is comprised primarily of Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) associations. Significant areas within this type are dominated by quaking aspen (*Populus tremuloides*), sometimes with a conifer component, depending upon successional status. These subalpine conifer forests represent the highest elevation forests in the area, ranging in elevation from about 9,000 to 11,500 ft. They occur along a variety of gradients, including gentle to very steep mountain slopes. Sites are cold year-round, and precipitation is predominantly snow, which may persist until late summer.

Natural Range of Variation

NRV simulations indicate that about 70% of the Spruce-Fir Forest ecosystem was historically dominated by conifer species, with the remaining 30% in aspen (Figure 8). Note that some aspen may be present in many of the other HSS classes; the aspen HSS class indicates stands dominated by aspen. Under NRV, 60% of the ecosystem was occupied by mid and closed conifer cover, with only 8% of the landscape in open conifer cover. A very small proportion (1%) of the landscape under NRV contains grass/shrub conditions resulting from stand-replacing disturbance.
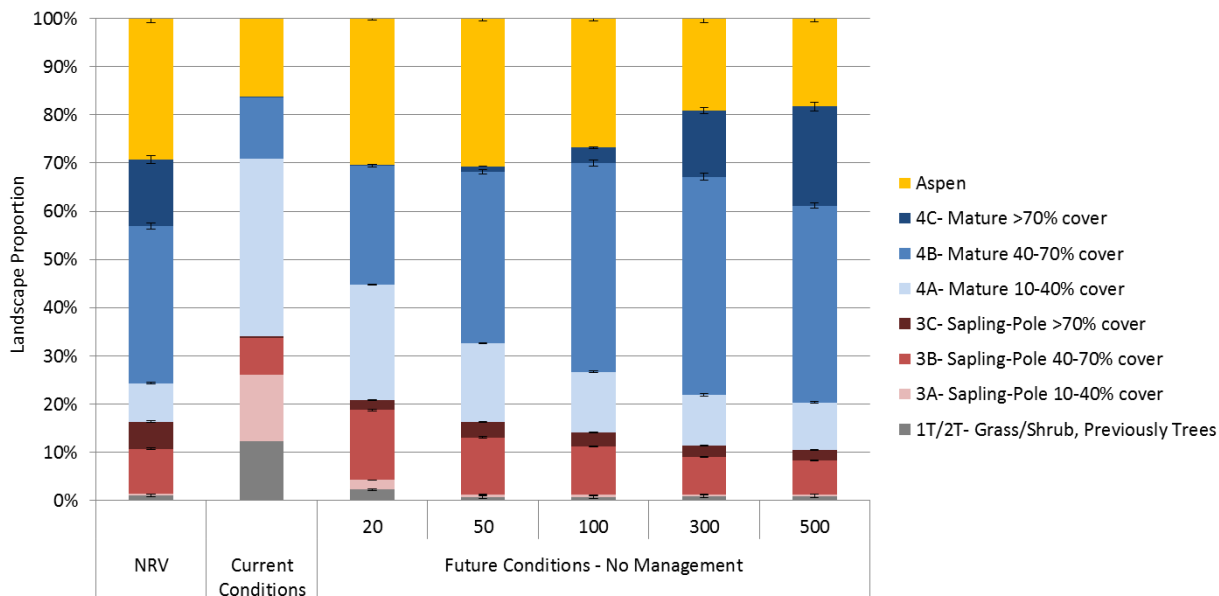
Figure 8. Comparison of HSS classes under NRV equilibrium, current conditions (time zero) and future projections under No Management at 20, 50, 100, 300 and 500 year time steps in the Spruce-Fir Forest ecosystem. Error bars show ± 1SD across 10 replicate simulations.

Status and Trends

The Spruce-Fir Forest ecosystem is currently substantially departed from NRV due to the effects of recent wildfires and a large, multi-year spruce beetle outbreak, which caused substantial spruce mortality, opened canopy conditions, and created patches of grass/shrub across wide areas. Under current conditions, only 20% of the landscape contains mid canopy cover (and <1% closed canopy), with 51% of the area in open canopy cover (6-fold greater than NRV) (Figure 8). This ecosystem also contains substantial patches of early seral grass/shrub conditions due to recent large wildfires, with more than 10-fold greater grass/shrub than projected under NRV. The proportion of aspen in the Spruce-Fir Forest ecosystem is also currently lower than projections under NRV (18%). In sum, the current condition in the Spruce-Fir Forest is substantially departed from NRV due to recent, large disturbances. Although very large events such as the recent spruce beetle outbreak have probably occurred historically, they are extremely rare and are not represented in our modeling.

Future projections for the Spruce-Fir Forest ecosystem generally show a trajectory of recovery toward NRV conditions over time (Figure 8). The current overabundance of grass/shrub conditions largely disappears in the first 20 years of projections, and open conifer forests are mostly replaced by mid- and closed cover forests over the first century of projections. Aspen stands increased in short-term and mid-term projections as areas currently dominated by grass/shrub recovered from large wildfire events through establishment of seral aspen. Longer-term projections, however, show a decline of aspen stands to levels roughly 10% lower than under NRV, mostly due to lower levels of wildfire under contemporary conditions. Future equilibrium (500 year) projections indicate conditions slightly departed from NRV, with less aspen and more mature, closed conifer cover than expected under NRV.

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Comparison of 50 year projections in the No Management and No Action scenarios indicate little landscape-scale impact of management in the Spruce-Fir Forest (Figure 9). This is due to the low proportion of the landscape treated with management activities (see *System Drivers and Stressors*).
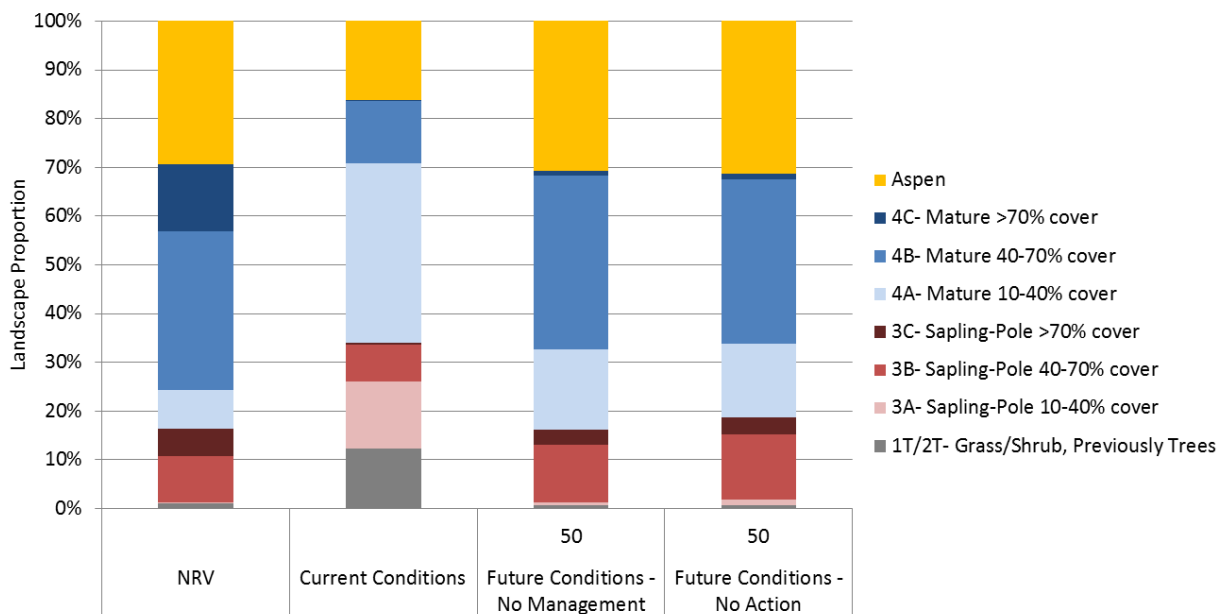

Figure 9. Comparison of HSS classes under NRV equilibrium, current conditions (time zero), and No Management and No Action scenarios (50 years in the future) in the Spruce-Fir Forest ecosystem.

System Drivers and Stressors

The dominant drivers of Spruce-Fir Forest dynamics under historic and contemporary conditions are stand-level growth and mortality (including endemic insect activity and disease) (Figure 10). Growth and mortality increase under future conditions relative to HRV, as the forest recovers from a large spruce beetle outbreak and multiple large wildfires. Wildfire is infrequent and often stand-replacing, with a historic rotation of 500 years and a contemporary rotation of 650 years. Spruce beetle insect outbreaks are modeled as cyclical drivers, with a 10 year duration and 100-200 year interval. In our projections, insect outbreaks affect slightly more area than wildfire under NRV, but influence slightly less area than wildfire under contemporary conditions because the current landscape composition has few large, dense stands that are susceptible to spruce beetle activity. This is largely due to the recent spruce beetle activity which has killed most of the spruce across the Forest. Management treatments modeled in Spruce-Fir under the No Action scenario include broadcast burning (101 ac/year), group selection (101 ac/year), planting of trees (105 ac/year), salvage harvest (842 ac/year), shelterwood harvest (81 ac/year), and stand clearcut (47 ac/year). In total, these treatments represent roughly 0.1% of the area occupied by spruce-fir on the RGNF, producing a similar level of disturbance as wildfire and insect outbreaks. Note that treatment rates in the No Action scenario are based on data compiled for treatments in the RGNF between 2004-2014. These reflect an increase in salvage logging over the past several years in areas affected by spruce beetle, but do not reflect any increasing future trend which may occur over the next several years across the large areas impacted by spruce beetle.
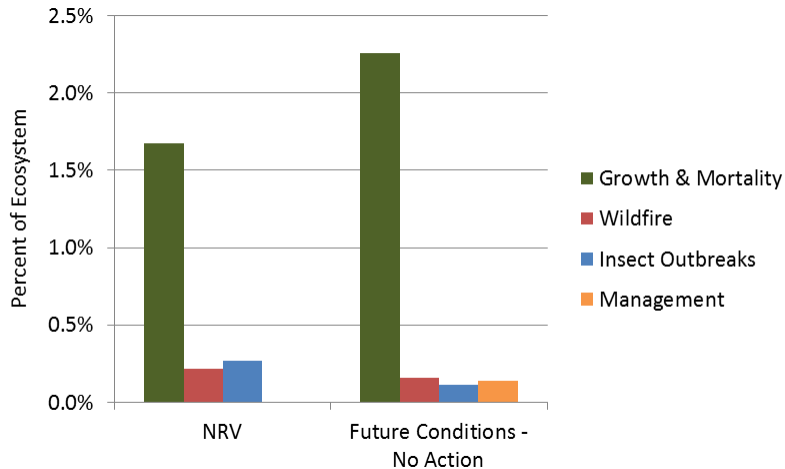
Figure 10. Average percent of the Spruce-Fir Forest ecosystem affected by drivers and stressors on the RGNF, compared between NRV equilibrium and average 100 year future projections under the No Action scenario.

Mixed Conifer-Wet Ecosystem

The mixed conifer-wet ecosystem encompasses the Aspen on Mountain Slopes LTA. This ecosystem is dominated by Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), and Colorado blue spruce (*Picea pungens*), with Ponderosa pine (*Pinus ponderosa*) occurring incidentally or absent. Significant areas within this type are dominated by quaking aspen (*Populus tremuloides*) which may have a significant conifer component. In the absence of fire, mixed conifers tend to replace the aspen community over long time frames. Elevation typically ranges from about 8,000 to 11,000 feet. Understory vegetation is comprised of a wide variety of shrubs, graminoids, and forbs depending on soil type, aspect, elevation, and other factors.

<u>Natural Range of Variation</u>

NRV projections for the Mixed Conifer-Wet ecosystem indicate a small proportion (2%) of the ecosystem in grass/shrub conditions, 13% comprised of aspen stands, and the remaining 85% dominated by conifers (Figure 11). However, aspen may be present in many of the other HSS classes; the aspen HSS class indicates stands dominated by aspen. Within the conifer-dominated areas, most of the trees are expected to be mature, with 72% of the ecosystem in mid to closed conifer cover.
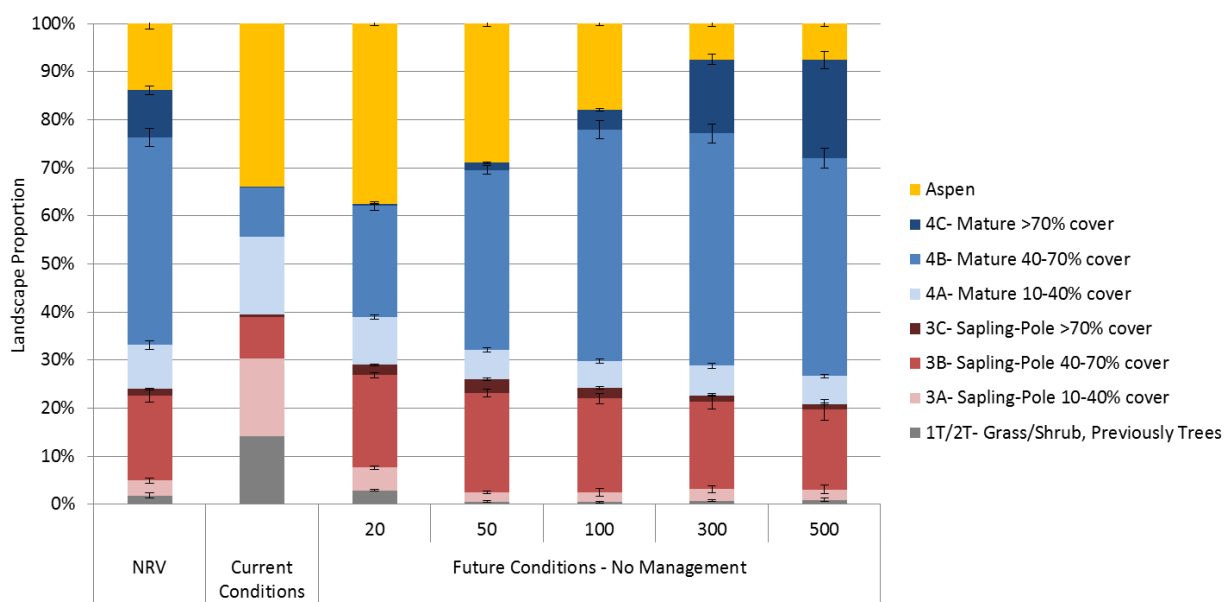
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Figure 11. Comparison of HSS classes under NRV equilibrium, current conditions (time zero) and future projections under No Management at 20, 50, 100, 300 and 500 year time steps in the Mixed Conifer-Wet ecosystem. Error bars show ± 1SD across 10 replicate simulations.

Status and Trends

Currently, the Mixed Conifer-Wet ecosystem is substantially departed from NRV. Only 20% of this ecosystem is currently dominated by conifers with mid- to high canopy cover, less than a third of the historic proportion (Figure 11). Current conditions also contain roughly 10-fold more grass/shrub (14%) and more than double the historic levels of aspen (34%) due to recent disturbances. The proportion of small (sapling-pole) trees is roughly similar to NRV but with a higher proportion under low canopy cover. Mature trees currently occupy half of their historic extent, with a greater proportion under low canopy cover.

Future projections show short-term increases in aspen-dominated stands as areas currently occupied by grass/shrub recover through seral aspen stages (Figure 11). The proportion of aspen gradually decreases to 8% under future equilibrium conditions (500 year projections), a lower level than the NRV equilibrium due to less wildfire in the contemporary disturbance regime. Over time, the projected proportion dominated by conifers increases and mature trees occupy a greater proportion of the landscape. Future equilibrium conditions (500 year projections) contain a similar proportion of small and large trees compared to NRV, but with more area in closed stands, particularly those with mature trees (HSS 4C). Overall, the Mixed Conifer-Wet ecosystem recovers toward NRV in our simulations, but ends up with less aspen and more closed forests than the NRV condition.

A comparison of No Management and No Action scenario projections 50 years into the future show that management treatments slightly increase the area in open canopy cover, making the distribution of HSS classes more similar to NRV (Figure 12). However, this effect is small, increasing open canopy cover by roughly 3% over 50 years. Although management affects a greater proportion of the landscape in this ecosystem than in the others, it still affects less than 1% of the ecosystem annually (see *System Drivers and Stressors*).
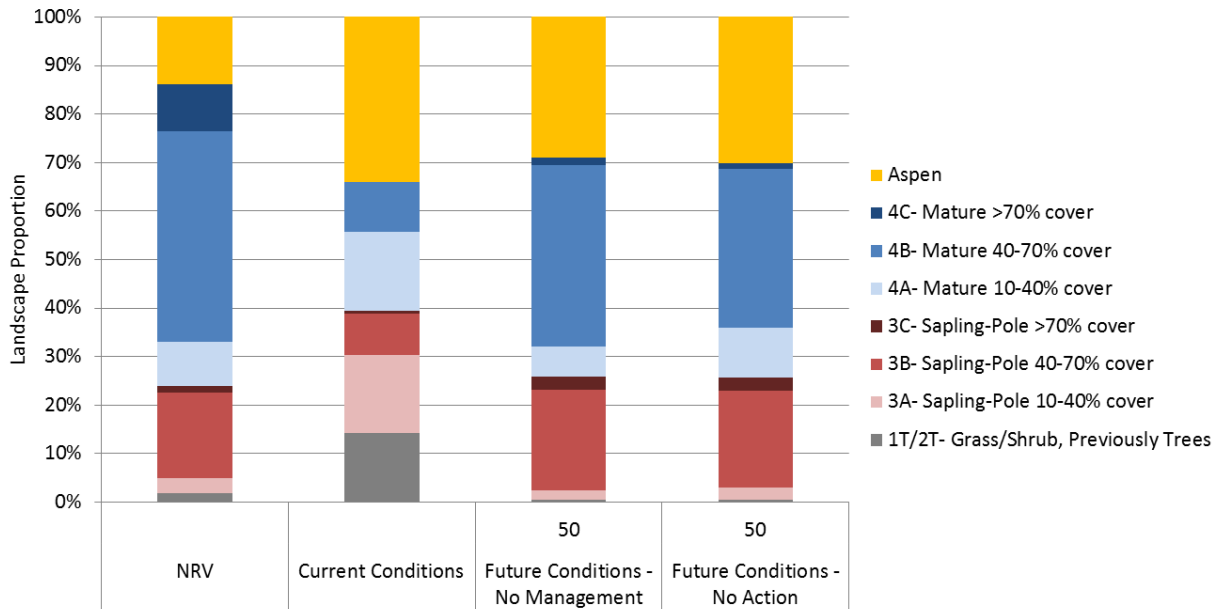
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Figure 12. Comparison of HSS classes under NRV equilibrium, current conditions (time zero), and No Management and No Action scenarios (50 years in the future) in the mixed conifer-wet ecosystem.

System Drivers and Stressors

Vegetation dynamics in the Mixed Conifer-Wet ecosystem are dominated by growth and mortality, affecting roughly 2.5% of the ecosystem each year (Figure 13). Wildfire had a 150 year rotation under NRV and 500 year rotation under contemporary conditions, resulting in projected future levels of wildfire substantially lower than under historic conditions. Insect outbreaks of Douglas-fir beetle were modeled as a cyclical transition, set at duration of 5 years and an interval of 35-50 years between outbreaks. Insect outbreaks also had lower impacts in future projections compared to NRV. This is due to the current and projected future stand composition over the next several decades, containing more aspen and smaller conifer trees, conditions which are less susceptible to insect outbreaks. Management treatments modeled in the No Action scenario include broadcast burning (37 ac/year), salvage harvest (54 ac/year), and thinning (191 ac/year). These treatments represent an annual treatment rate of 0.6% of the ecosystem each year, affecting more area than natural disturbances under contemporary conditions but still causing small changes to vegetation structure overall.
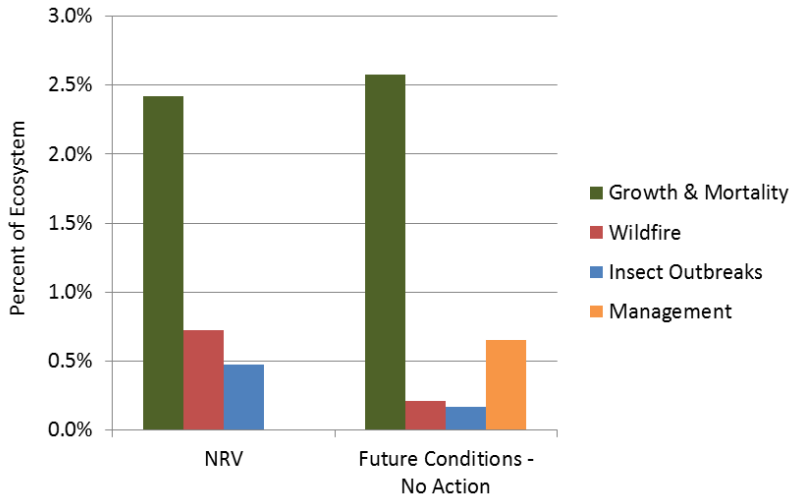
17

Figure 13. Average percent of the Mixed Conifer-Wet ecosystem affected by drivers and stressors on the RGNF, compared between NRV equilibrium and average 100 year future projections under the No Action scenario.

Mixed Conifer-Dry Ecosystem

The Mixed Conifer-Dry ecosystem encompasses two LTAs on the RGNF, including White Fir and Douglas-fir on Alpine Summits, and Ponderosa Pine and Douglas-fir on Mountain Slopes. This ecosystem contains a mix of conifer species, including ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), blue spruce (*Picea pungens)* and small amounts of aspen (*Populus tremuloides*). With fire suppression, more shade tolerant conifers (e.g., Douglas-fir, white fir, and blue spruce) tend to increase in cover in late successional stages. This ecosystem is generally found between 7,000-9,500 feet in elevation, and occupies higher elevations on south facing slopes than north facing slopes.

Natural Range of Variation

Under NRV, roughly 10% of the Mixed Conifer-Dry forest area was projected in grass/shrub condition (Figure 14). The remainder was in conifer-dominated stands, with 25% open cover, 57% in mid cover and 8% of the area in closed condition. A majority of the ecosystem contained mature trees (61%), while about 30% of the ecosystem was in sapling-pole stages.
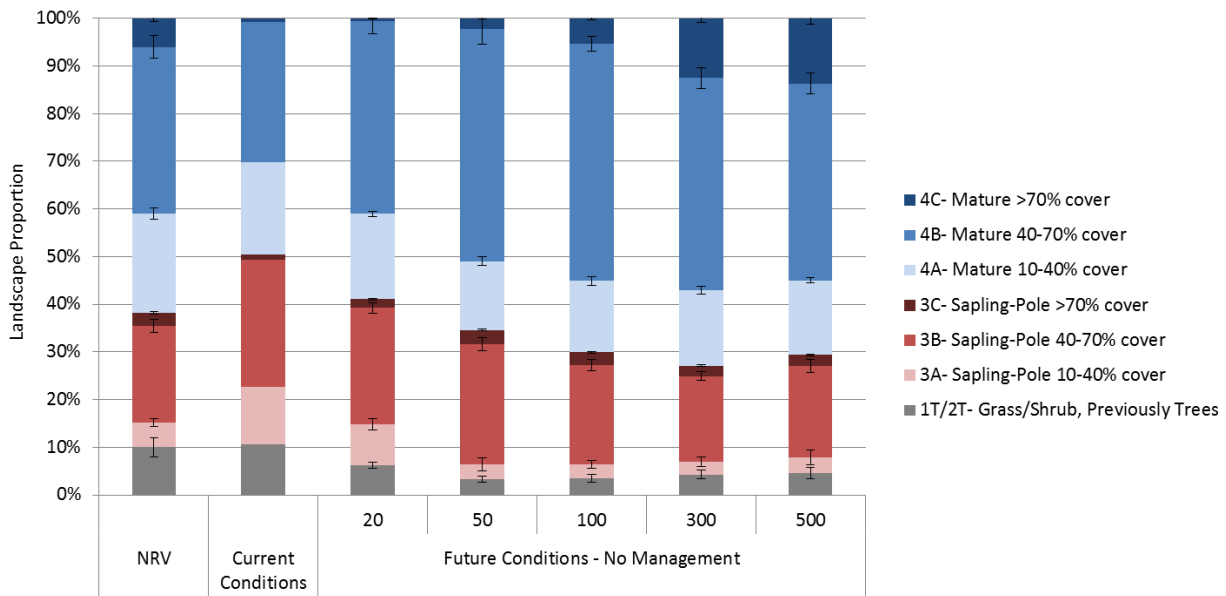
18

Figure 14. Comparison of HSS classes under NRV equilibrium, current conditions (time zero) and future projections under No Management at 20, 50, 100, 300 and 500 year time steps in the Mixed Conifer-Dry ecosystem. Error bars show ± 1SD across 10 replicate simulations.

Status and Trends

Current conditions in the Mixed Conifer-Dry ecosystem contain similar levels of grass/shrub conditions and similar area in open forest conditions, compared to NRV (Figure 14). There is currently a larger proportion of sapling-pole size trees than under NRV, and also slightly less closed forest. However, this ecosystem is currently only slightly departed from NRV.

Future projections indicate that growth and succession will likely increase the proportion of mature trees and mid-closed canopy cover in the Mixed Conifer-Dry ecosystem over time (Figure 14). Under future equilibrium (500 year), simulations project about half of the grass/shrub (5%) due to fewer wildfires, and a greater proportion of mature trees compared to NRV conditions. Overall, the Mixed Conifer-Dry ecosystem shows less current departure than many other ecosystems on the RGNF and a trajectory toward future conditions that are moderately departed from NRV.

50-year projections under the No Management and No Action scenarios in the Mixed Conifer-Dry ecosystem show that management increases the area of mature, open stands (Figure 15). These management effects are small but move the 50-year future projections closer to NRV proportions relative to No Management.
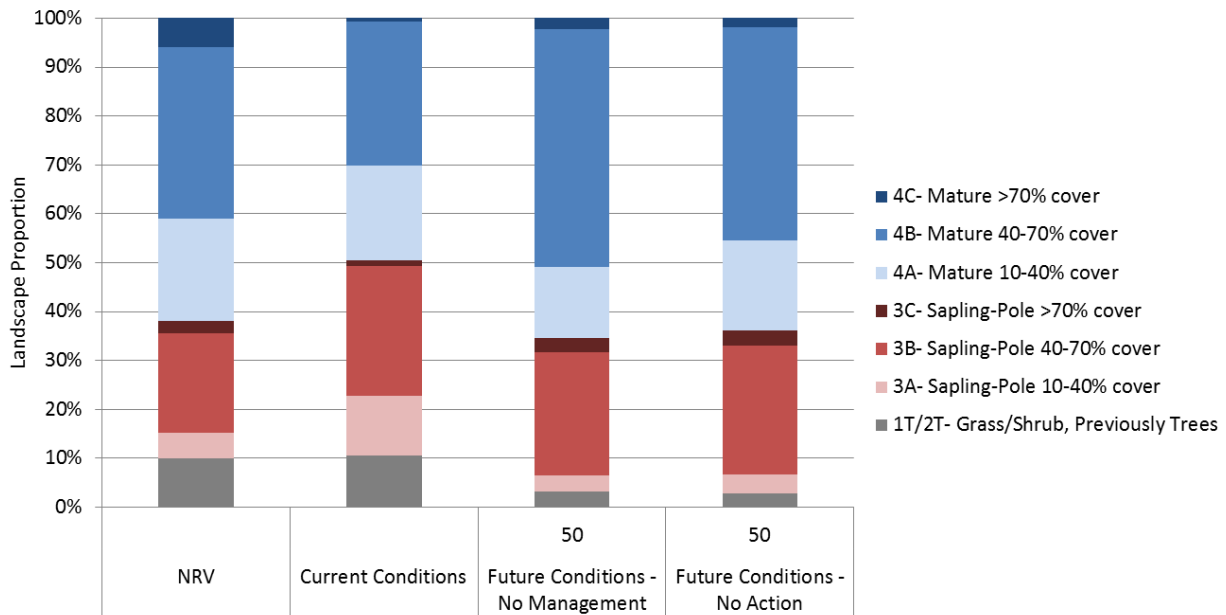
Figure 15. Comparison of HSS classes under NRV equilibrium, current conditions (time zero), and No Management and No Action scenarios (50 years in the future) in the Mixed Conifer-Dry ecosystem.

System Drivers and Stressors

The dominant drivers in the Mixed Conifer-Dry ecosystem are growth and mortality (Figure 16). Wildfire was moderately frequent under historical conditions, with an estimated 100 year rotation, but is more infrequent under contemporary conditions, with a 545 year rotation due to fire suppression. Through discussions with experts on the RGNF, we determined that the Mixed Conifer-Dry ecosystem on the RGNF differed from much of the southwest, where it is widely thought that dry conifer forests experienced surface fire every few years under historic conditions. Insect outbreaks in Mixed Conifer-Dry were modeled as two separate cyclical transitions, one each for Douglas-fir beetle and mountain pine beetle. Both were assigned a duration of 5 years, with an interval of 35-50 years between outbreaks for Douglas-fir beetle and 50-70 years for mountain pine beetle. Insect outbreaks affected an average of 0.5% of the Mixed Conifer-Dry ecosystem annually under NRV projections, whereas they affect almost double that area under future projections due to a greater area occupied by larger trees and more closed stands in future projections. This indicates that, under the current fire regime, a greater proportion of closed stands may lead to more insect outbreaks. Management treatments in the Mixed Conifer-Dry ecosystem include broadcast burning (41 ac/year), planting of trees (56 ac/year), salvage harvest (154 ac/year), and thinning (218 ac/year). In total, these treatments represent an annual treatment rate of 0.5% of the ecosystem.
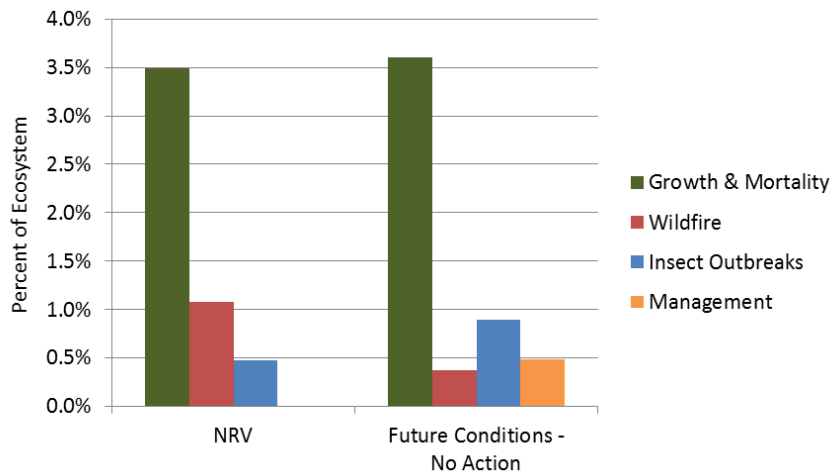
Figure 16. Average percent of the Mixed Conifer-Dry ecosystem affected by drivers and stressors on the RGNF, compared between NRV equilibrium and average 100 year future projections under the No Action scenario.

Rocky Mountain Alpine Turf Ecosystem

The Rocky Mountain Alpine Turf ecosystem is widespread above upper timberline at elevations that range from about 10,000 feet to over 12,000 feet. Dominant species include boreal sagebrush (*Artemisia arctica*), several *Carex* species, tufted hair grass (Deschampsia caespitosa), *Festuca* speciecs, Ross' avens (*Geum rosii*), Bellardi bog sedge (*Kobresia myosuroides*), cushion phlox (*Phlox pulvinata*), and alpine clover (*Trifolium dasyphyllum*). Alpine Turf is found on gentle to moderate slopes, flat ridges, valleys and basins, where the soil has become relatively stabilized and the water supply is relatively constant.

Natural Range of Variation

No graphs of NRV, current or future conditions are shown for the Rocky Mountain Alpine Turf ecosystem because HSS does not differentiate any alternative conditions within natural meadow ecosystems (HSS 1M). However, a qualitative assessment of NRV indicates most of this ecosystem type in late-seral conditions due to the low frequency of disturbances.

Status and Trends

Current conditions show a high proportion of late-seral conditions, similar to those under NRV. Future projections also maintain most of the ecosystem in late-seral conditions, with disturbances even more rare in future projections.

System Drivers and Stressors

The Rocky Mountain Alpine Turf model included only three processes growth and mortality (not shown), avalanches, and wildfire (Figure 17). Wildfire was modeled with a 500 year rotation under NRV and 7400 year rotation under contemporary conditions. Although the fire rotation lengthens substantially under contemporary conditions, fire is rare in all scenarios and does not exert much influence on the vegetation.
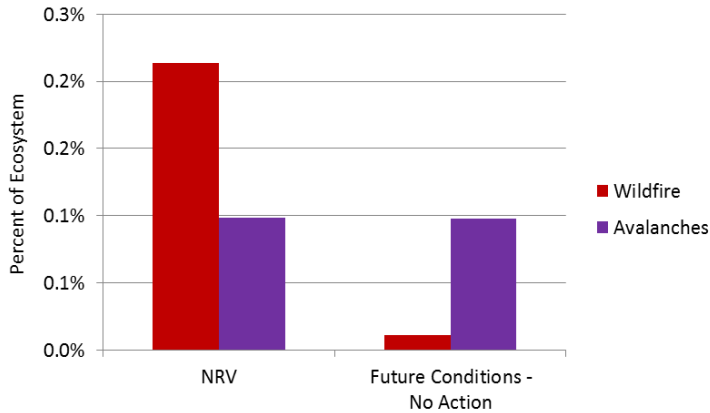
21

Figure 17. Average percent of the Rocky Mountain Alpine Turf ecosystem affected by drivers and stressors on the RGNF, compared between NRV equilibrium and average 100 year future projections under the No Action scenario.

Pinyon-Juniper Woodland Ecosystem

The Pinyon-Juniper Woodland ecosystem encompasses two LTAs, including Pinyon on Mountain Slopes, and Western Wheatgrass and Other Low-Elevation Grasslands on Alluvial Fans. In the Pinyon-Juniper Woodland ecosystem, common trees include two-needle pinyon (*Pinus edulis*), Utah juniper (*Juniperus osteosperma*), and a few other species. These woodlands occur on warm, dry sites on mountain slopes, mesas, plateaus and ridges, particularly those with rocky soil characteristics. Understory composition consists of sparse perennial grasses, annual and perennial forbs, and sparse shrubs.

Natural Range of Variation

Under NRV projections, 5% of the pinyon-juniper woodland was in grass/shrub, 35% in open canopy cover and 60% in mid canopy cover (Figure 18). Closed canopy cover state classes (>70%) were not included in this model, as Pinyon-Juniper Woodlands rarely reach closed cover. Most of the area was dominated by mature trees.
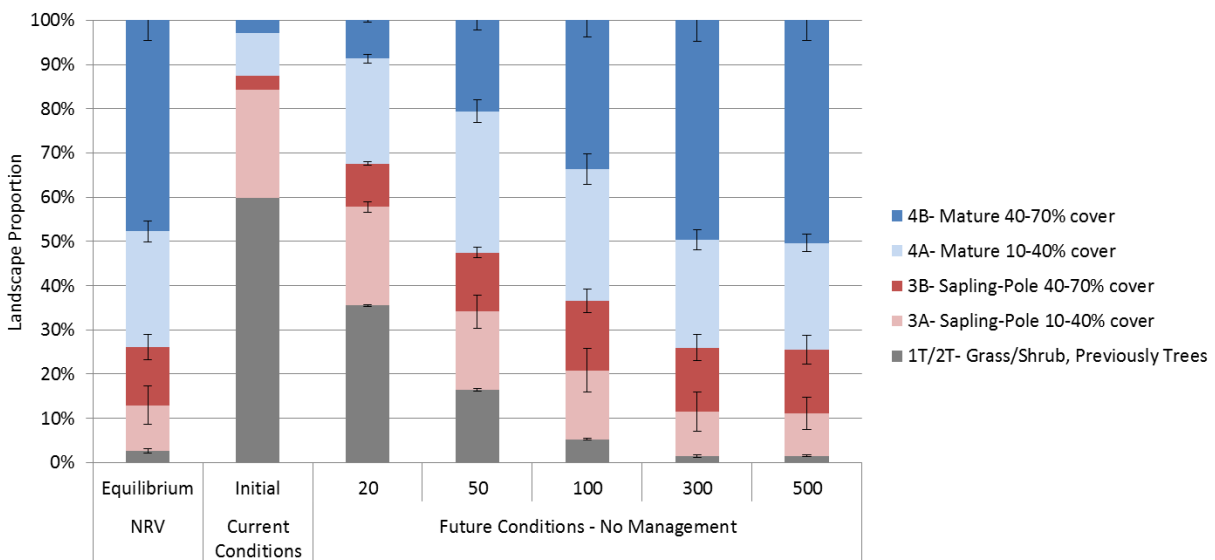
Figure 18. Comparison of HSS classes under NRV equilibrium, current conditions (time zero) and future projections under No Management at 20, 50, 100, 300 and 500 year time steps in the Pinyon-Juniper Woodland ecosystem. Error bars show ± 1SD across 10 replicate simulations.

Status and Trends

Current conditions are highly departed from NRV in the Pinyon Juniper Woodland ecosystem, with 60% of the area in grass/shrub, 12 times greater than projected under NRV (Figure 18). Of the remaining landscape, almost all contains open cover woodlands, with smaller sapling-pole trees dominant. The high level of departure is at least partially related to the assignment of the Low-Elevation Grasslands LTA to the Pinyon-Juniper Woodland ecosystem. This LTA was originally classified as a Colorado Plateau Grassland ecosystem type (assigned to another STSM), but was subsequently combined with Pinyon-Juniper Woodlands based on feedback from the RGNF. However, if some of the mapped grass/shrub areas are actually natural grasslands and had remained classified into a grassland ecosystem, some of the HSS 1T/2T would be considered HSS 1M, and the level of departure from NRV would be lower.

Under future projections, the Pinyon-Juniper Woodland recovers from highly departed current conditions over several centuries (Figure 18). Long-term projections indicate future conditions within NRV. However, the trend toward increasing tree cover may not actually occur if the Grassland LTA is not at least moderately susceptible to tree invasion.

Comparison of the No Management and No Action scenarios indicate a small increase in open canopy cover stands resulting from management activities (Figure 19). Both scenarios, however, remain departed from NRV over the next 50 years, with incomplete reforestation of grass/shrub-dominated areas under current conditions.
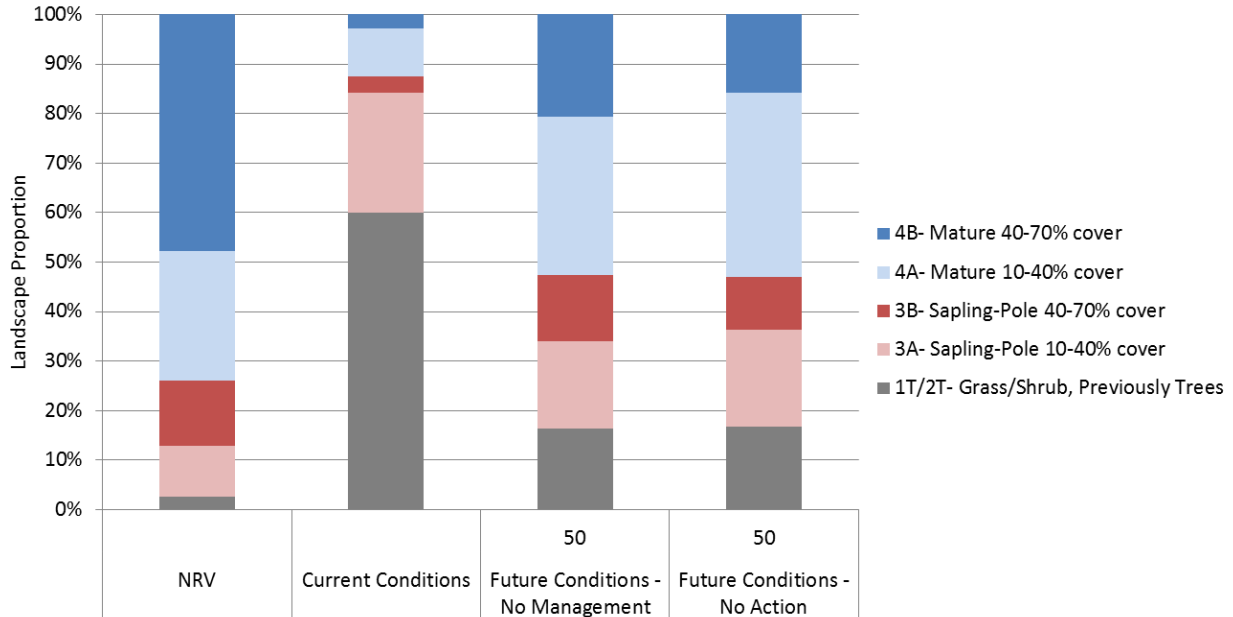

Figure 19. Comparison of HSS classes under NRV equilibrium, current conditions (time zero), and No Management and No Action scenarios (50 years in the future) in the Pinyon-Juniper Woodland ecosystem.

System Drivers and Stressors

Growth and mortality, along with insect outbreaks, were the most influential drivers of vegetation dynamics in the Pinyon-Juniper Woodland ecosystem (Figure 20). Growth and mortality rates were higher under future conditions than under NRV, as large areas in grass/shrub regained tree cover. Outbreaks of pinyon ips were modeled as a cyclical driver with a 5 year duration and 35-50 year interval between outbreaks. These outbreaks affected over 2.5% of the landscape per year under NRV, but under near-term contemporary conditions their influence was lower (1.6%) due to lack of susceptible stands with larger trees. The wildfire rotation under NRV was 400 years, and the contemporary wildfire rotation was 750 years, making wildfire relatively rare under all scenarios. Management treatments in the No Action scenario include broadcast burning (210 ac/year), mastication (156 ac/year), and thinning (77 ac/year), summing to an annual treatment rate of 0.4%.
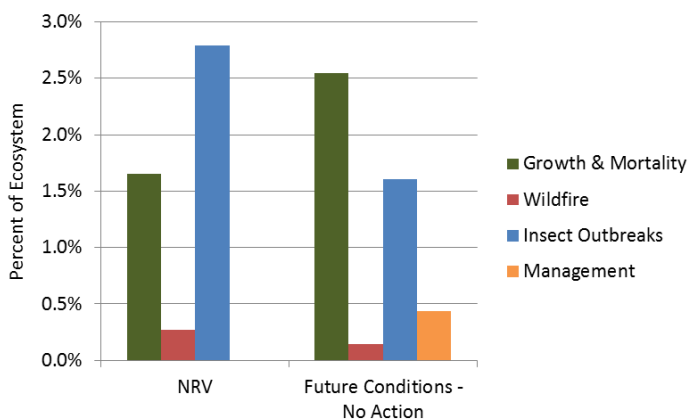

Figure 20. Average percent of the Pinyon-Juniper Woodland ecosystem affected by drivers and stressors on the RGNF, compared between NRV equilibrium and average 100 year future projections under the No Action scenario.

Rocky Mountain Gambel Oak Shrubland Ecosystem

The Rocky Mountain Gambel Oak Shrubland ecosystem encompasses the Gambel Oak on Mountain Slopes LTA. This ecosystem is relatively uncommon on the RGNF, occurring where Gambel oak (*Quercus gambelii*) is the dominant species, often associated with serviceberry (*Amelanchier* spp), sagebrush (*Artemisia* spp) and various additional species of shrubs, grasses, and forbs. It occurs at 6,600-9,570 feet elevation on all aspects.

Natural Range of Variation

No graphs of NRV, current or future conditions are shown for the Rocky Mountain Gambel Oak Shrubland ecosystem because HSS does not differentiate alternative conditions within natural shrubland ecosystems (HSS 2S). However, NRV projections indicate a high proportion of this system in late-seral, closed shrub conditions, with some open patches and a low proportion of early-seral conditions.

Status and Trends

Current conditions for the Rocky Mountain Gambel Oak Shrubland ecosystem indicate a roughly equal representation of seral stages. However, future projections under contemporary conditions show nearly all of the ecosystem moving to late-seral, closed conditions due to contemporary fire suppression.

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System Drivers and Stressors

Growth and mortality (not shown) and wildfire are the only drivers modeled in the Gambel Oak Shrubland ecosystem. The historic wildfire rotation was 100 years and the contemporary rotation 1650 years. Projections indicate much lower levels of wildfire under contemporary conditions compared to historic conditions, affecting 1.5% of the landscape annually under historic conditions and only 0.3% under the contemporary fire regime (Figure 21).
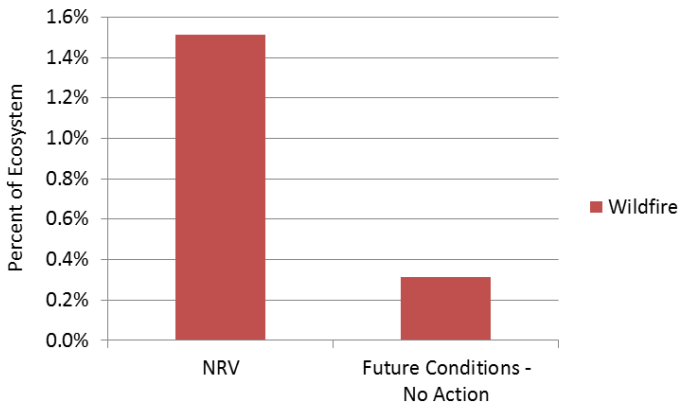

Figure 21. Average percent of the Rocky Mountain Gambel Oak Shrubland ecosystem affected by drivers and stressors on the RGNF, compared between NRV equilibrium and average 100 year future projections under the No Action scenario.

Southern Rocky Mountain Montane-Subalpine Grassland Ecosystem

The Southern Rocky Mountain Montane-Subalpine Grassland ecosystem represents two LTAs on the RGNF, including Arizona Fescue on Mountain Slopes and Thurber Fescue on Mountain Slopes. It occupies elevated plains, valleys, hills and mountain sideslopes ranging from nearly level to very steep topography. Dominant species include Thurber fescue (*Festuca thurberi*), Arizona fescue (*Festuca arizonica*), and several other grasses, forbs, and sedges. Elevation generally ranges from about 7,000-10,000 feet.

Natural Range of Variation

No projections of HSS are shown for the Rocky Mountain Montane-Subalpine Grassland ecosystem because HSS does not differentiate any alternative conditions within natural meadow ecosystems (HSS 1M). Under NRV, most of the landscape is occupied by grasses with some shrub and tree cover possible. Note that we have lower confidence in the projections for this ecosystem, as the underlying STSM was under revision when this work was started and some transition rates appear to be excessively high.

Status and Trends

Current conditions contain a greater proportion of early seral grasslands with lower shrub and tree cover than under NRV. Future projections indicate a return toward NRV conditions, unless expansion by ruderal seeded grass species affects the ecosystem, depending on site history.

25

System Drivers and Stressors

Drivers in the Montane-Subalpine Grassland ecosystem under NRV include growth & mortality (not shown), wildfire, and tree encroachment (Figure 22). Wildfire rotations were 200 years under NRV and 1300 years under future projections. In the future condition models, livestock grazing was the dominant driver, affecting over 5% of the landscape each year. However, note that livestock grazing has relatively minor impacts relative to many of the other disturbances; although it affects far greater area than other disturbances, it is does not cause as much vegetation change. Tree encroachment rates were higher under future conditions and management consisted of prescribed fire, applied to 471 ac/year. Insects and disease were included as stressors, but affected a very small proportion of the landscape (<0.1%) annually.
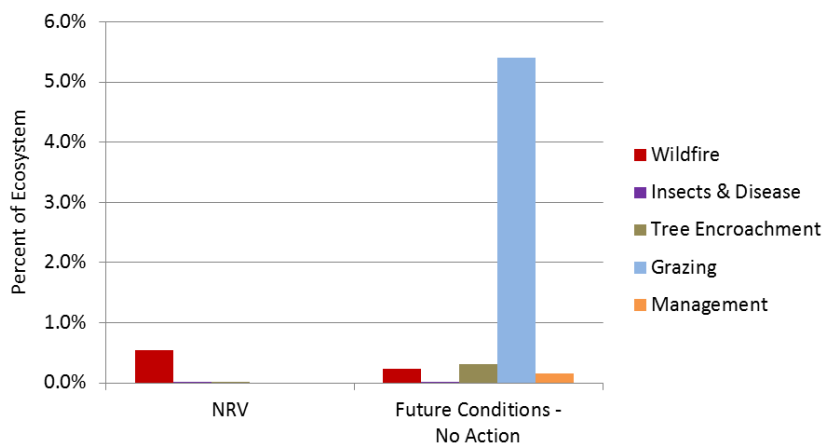

Figure 22. Average percent of the Southern Rocky Mountain Montane-Subalpine Grassland ecosystem affected by drivers and stressors on the RGNF, compared between NRV equilibrium and average 100 year future projections under the No Action scenario.

Rocky Mountain Montane Riparian Ecosystem

The Rocky Mountain Montane Riparian ecosystem corresponds to the Willows and Sedges on Floodplains LTA. This ecosystem represents numerous riparian types occurring as relatively small, linear stringers in the upper montane/subalpine zones. These systems are highly variable and generally consist of one or more of the following five basic vegetation forms cottonwoods, willows, sedges and other herbaceous vegetation, aspen, or conifers (primarily spruce and subalpine fir).

Natural Range of Variation

Under NRV, 63% of the ecosystem is projected as open to mid canopy cover, with the remaining 37% in closed cover (Figure 23). However, note that we have lower confidence in the projections for this ecosystem, as the model exhibited some unstable behavior and some transition rates appear to be excessively high.

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Figure 23. Comparison of HSS classes under NRV equilibrium, current conditions (time zero) and future projections under No Management at 20, 50, 100, 300 and 500 year time steps in the Montane Riparian ecosystem. Error bars show ± 1SD across 10 replicate simulations.

Status and Trends

Current conditions contain 30% of the riparian vegetation in mid canopy cover, substantially less than under NRV. Future projections indicate a gradual decline of mid cover areas over time to roughly 16%, four times lower than NRV (Figure 23). This trend away from NRV is due to the much longer fire rotation under contemporary conditions.

No management activities were modeled in the Montane Riparian ecosystem, as the management data indicated that <20 acres per year were treated in this ecosystem; therefore we do not compare the No Management and No Action scenarios because they do not differ.

System Drivers and Stressors

In the Montane Riparian ecosystem, growth and mortality were modeled as a deterministic transition based on age, and therefore are not reported in the model output. Other drivers and stressors in the model include wildfire, weather, impacts of beavers, and flooding. The fire rotation under NRV was 100 years, whereas the fire rotation under contemporary conditions was nearly 10 times longer, at 900 years (Figure 24). However, note that we have low confidence in this model, as it exhibited unstable behavior between model runs and did not appear to be reporting all drivers correctly; therefore only wildfire is shown in Figure 24. In addition, the wildfire rotation in this ecosystem has particularly high uncertainty due to the small extent and complex, linear shape of riparian zones.
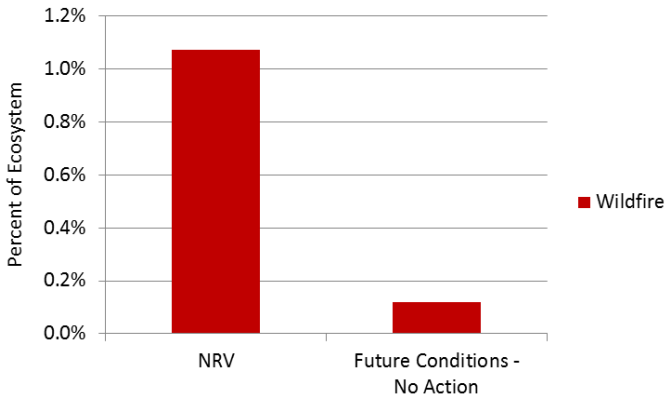
Figure 24. Average percent of the Rocky Mountain Montane Riparian ecosystem affected by drivers and stressors on the RGNF, compared between NRV equilibrium and average 100 year future projections under the No Action scenario. Note that other drivers besides wildfire are not shown due to unstable model reporting behavior.

Rio Grande National Forest Context Area

In this section, we address the RGNF landscape context area, including a 6.2 mi buffer around the RGNF. First we show projections for all ecosystems across the 4.1 million acre RGNF and landscape context area. Then we show two additional ecosystem types that are only peripherally present on the RGNF but are common in the landscape context area, including Sagebrush Shrubland and Intermountain Basins Greasewood Flat.

Natural Range of Variation

Across the RGNF and landscape context area, 31% of the landscape is in natural meadows and shrublands (Figure 25). The remainder of the landscape has forested potential, with 1% of the area under NRV in grass/shrub due to stand-replacing disturbance. Historically, conifer-dominated areas largely consisted of mature trees with mid to closed cover (34%) and sapling-pole trees encompassed 13% of the landscape. Open canopy cover comprised 11% of the landscape, and aspen was projected across 11% of the landscape. These NRV proportions are similar to NRV within the RGNF only, but are influenced by a different mix of ecosystem types (e.g., higher proportion of shrublands, Pinyon Juniper Woodlands and Mixed Conifer-Wet, and lower proportion of Spruce-Fir; see Figure 4).
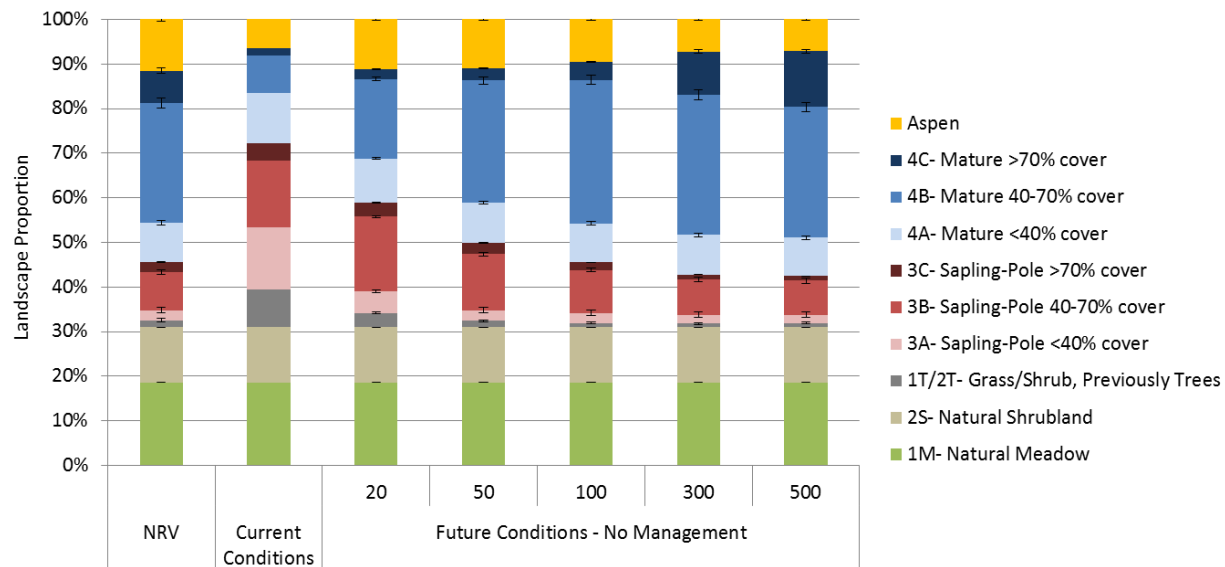
28

Figure 25. Comparison of HSS classes under NRV equilibrium, current conditions (time zero) and future projections under No Management at 20, 50, 100, 300 and 500 year time steps across the RGNF and landscape context area. Error bars show ± 1SD across 10 replicate simulations.

Status and Trends

Current conditions across the RGNF and landscape context area show 8% of the landscape in grass/shrub with forested potential, and 6% of the area dominated by aspen (Figure 25). Of the areas with coniferous species, most are in sapling-pole conditions, and structural conditions are open across 25% of the landscape. These conditions are significantly departed from HRV due to the abundance of grass/shrub, open conditions, and sapling-pole trees. However, note that current vegetation condition across the whole landscape should be interpreted cautiously. There are several differences between vegetation maps used within the RGNF and in the surrounding context area (6.2 mi buffer), which is at least partially due to the data source (see *Current Vegetation Condition*, above). The differences in underlying data result in a greater proportion of mature, open stands within the RGNF, and more sapling-pole, closed stands outside the Forest boundary.

Projected future conditions show a gradual shift from highly departed current conditions toward HRV. Future equilibrium (500 year) projections indicate a greater proportion of mature trees, particularly in closed cover stands, and less aspen than under HRV (Figure 25). This is largely due to lower levels of wildfire activity under contemporary conditions. Projections under the No Action scenario are not shown here because No Management and No Action scenarios were indistinguishable across the broader landscape context area.

System Drivers and Stressors

Under NRV, growth and mortality (not shown), wildfire, insects and disease, and weather were the primary drivers affecting the landscape. Under contemporary conditions, many of these drivers remained at roughly similar levels (Figure 26). However, note that most ecosystems actually experience much less fire under contemporary conditions. In a small subset of the non-forested ecosystems (Sagebrush Shrubland and Intermountain Basins Greasewood Flat), which comprise a substantial proportion of the landscape context area, wildfire increases substantially under contemporary

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conditions due to invasion by exotic annual grasses. These annual grasses form a dense layer of continuous, dry fuel in otherwise sparse systems and increase the fire frequency in those systems (see below), counterbalancing the lower contemporary levels of wildfire in other ecosystems. In addition, livestock grazing, exotic species invasion, tree encroachment, and management occurred in contemporary condition models, although at lower levels than other drivers. Although livestock grazing affects the largest proportion of the landscape each year, its impacts on the vegetation are more minor than many other drivers.
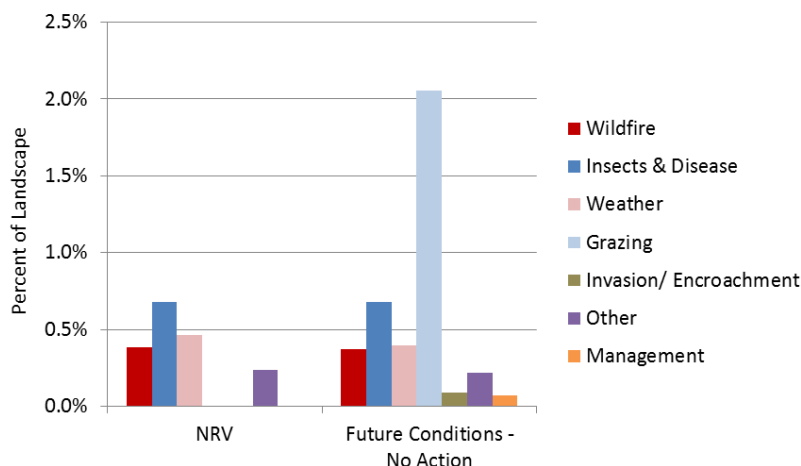

Figure 26. Average percent of the RGNF context landscape, including both the RGNF and the surrounding 6.2 mi buffer, affected by drivers and stressors, compared between NRV equilibrium and average 100 year future projections under the No Action scenario.

Sagebrush Shrubland Ecosystem

The Sagebrush Shrubland ecosystem is a dry shrubland type that occurs mostly adjacent to the RGNF. Dominant shrubs include big sagebrush (*Artemesia tridentata* ssp. *tridentata*, *wyomingensis*, or *vaseyana*), sometimes with *Gutierrezia, Ericameria,* or *Chrysothamnus* species and a variety of grasses and forbs. Invasion by exotic annual grass such as cheatgrass (*Bromus tectorum*) and/or encroachment by *Juniperus* tree species can occur on some sites.

Natural Range of Variation

No projections of NRV, current or future conditions are shown for the Sagebrush Shrubland ecosystem because HSS does not differentiate any alternative conditions within natural shrubland ecosystems (HSS 1S). However, a qualitative assessment of STSM projections show that much of the Sagebrush Shrubland ecosystem was historically comprised of mid- and late-successional classes, with roughly 20% containing some juniper cover.

Status and Trends

Currently, most of the Sagebrush Shrubland is mapped in early-successional classes with few exotic annual grasses present. Under future projections, exotic annual grass species and juniper expansion displace much of the native sagebrush. Projections also show an increase in early-seral shrubs such as rabbitbrush (*Chrysothamnus* and *Ericameria* species).

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System Drivers and Stressors

Drivers and stressors in the Sagebrush Shrubland include growth and mortality (not shown), wildfire, drought, tree encroachment, livestock grazing, and exotic invasion (Figure 27). Under historic conditions, wildfire was the dominant driver of vegetation dynamics. The wildfire rotation was 150 years historically and 2600 years under contemporary conditions, although patches with exotic grasses can burn at much higher frequency under contemporary conditions. Drought and tree encroachment affected <0.5% of the ecosystem each year. Under projected future conditions, livestock grazing was the dominant driver in this system, affecting almost 7% of the ecosystem on average each year. However, note that livestock grazing has relatively minor impacts relative to many of the other disturbances; although it affects far greater area than the others, it is not as influential on the vegetation. Exotic invasion also impacted 0.6% of the ecosystem on average per year, and tends to increase the frequency of wildfire where it occurs. No management treatments were modeled in this ecosystem, as it occurs mostly outside of the RGNF.
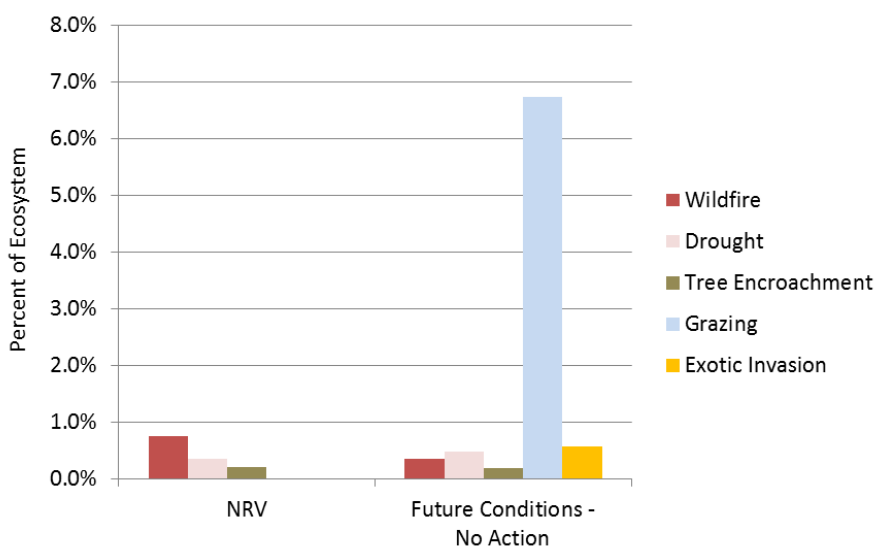

Figure 27. Drivers and stressors in the Sagebrush Shrubland ecosystem on the RGNF, compared between NRV and 100 year future projections under the No Action scenario.

Intermountain Basins Greasewood Flat Ecosystem

The Intermountain Basins Greasewood Flat ecosystem, also called Intermountain Salt Shrubland, is a dry shrubland system dominated by *Sarcobatus vermiculatus* and *Atriplex* species. It is found mostly adjacent to the RGNF and occupies substantial areas at low elevations around the Forest.

Natural Range of Variation

No projections of NRV, current or future conditions are shown for the Intermountain Basins Greasewood Flat ecosystem because HSS does not differentiate any alternative conditions within natural shrubland ecosystems (HSS 1S). However, a qualitative assessment of NRV indicates open grass and shrub conditions dominated this ecosystem historically, with some early-seral conditions containing sparse shrubs also present.

Status and Trends

Currently, a greater proportion of the Intermountain Basins Greasewood Flat ecosystem is mapped in open grass/shrub conditions than projected under NRV. Future projections show a large increase in exotic species and an introduction of wildfire into this ecosystem, which naturally experiences little or no fire due to lack of fuels (see *System Drivers and Stressors*).

System Drivers and Stressors

Under NRV, only growth and mortality (not shown) and weather-related disturbances are modeled in this ecosystem, including impacts of drought and very wet years, which affects 5.7% of the ecosystem annually on average (Figure 28). Under contemporary conditions, livestock grazing is the primary driver, followed by wildfire, weather, and exotic invasion. Wildfire is modeled in exotic-invaded state classes only, and therefore wildfire projections are highly dependent on the prevalence of exotic grasses on the landscape. Note that livestock grazing has relatively minor impacts relative to many of the other disturbances; although it affects far greater area than the others, it is not as influential on the vegetation.
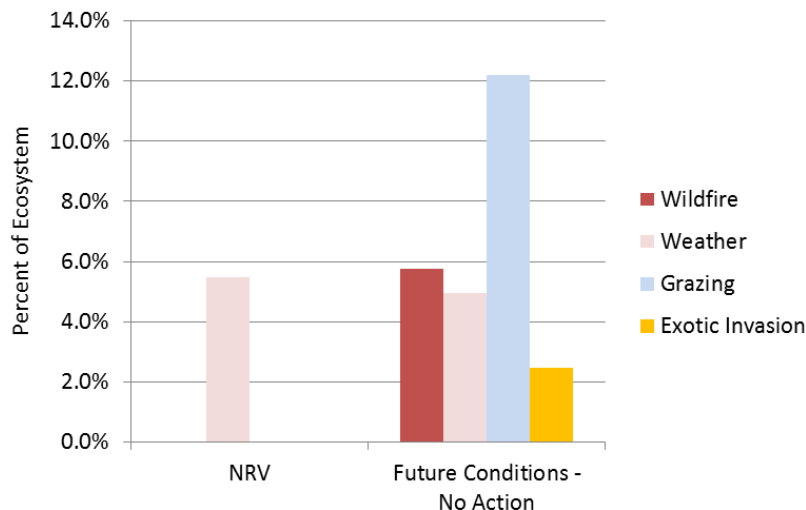

Figure 28. Drivers and stressors in the Intermountain Greasewood Flat ecosystem on the RGNF, compared between NRV and 100 year future projections under the No Action scenario.

Summary

Ecosystems on the RGNF are, in general, moderately departed from the natural range of variation. The spruce-fir and aspen forests are, in particular, undergoing rapid change due to a recent, large outbreak of spruce beetle and large wildfires. High levels of mortality in mature Engelmann spruce in many areas have produced abundant open stands and dead standing and down wood. This, in turn, is allowing regeneration of aspen and an increasing trend in aspen forests. Over the long term (many decades to hundreds of years), our models project the recovery of most forested ecosystems toward NRV. However, due to fire suppression, we may expect to see somewhat less aspen in the future than would likely exist under NRV, as well as other changes in the structural composition of forests. Our surveys of

the literature, discussions with local experts, and model probabilities indicate that the recent spruce mortality is an unusual event in the time frame for which information exists. This is not to say that the level of spruce mortality is unprecedented or not natural, but that it is unlikely and not within the expected range of events for the time frame we modeled. However, given the possible impacts of climate change in future decades, such events may become more common in the future, and, perhaps, affect other ecosystems.