DRAFT

IFTDSS (2.0 Beta) Carson City Pilot Project Final Report April 2016

EVALUATION OF THE INTERAGENCY FUELS TREATMENT DECISION SUPPORT SYSTEM (IFTDSS) AS AN ANALYSIS TOOL FOR SUPPORTING FIRE MANAGEMENT DECISIONS IN SAGE-GROUSE HABITAT MANAGEMENT

Tonja Opperman: USFS Lead Fire Applications Specialist, Wildland Fire Management RD&A
tsopperman@fs.fed.us

Dan Mindar: NPS Technology Transfer Specialist, Wildland Fire Management RD&A
dan_mindar@nps.gov

Ryan Elliott: Carson City District Fire Planner/ESR Coordinator, BLM Nevada
r1elliot@blm.gov

Erin Noonan: USFS Technology Transfer Specialist, Wildland Fire Management RD&A
enoonan02@fs.fed.us

Stacy Drury: Senior Fire Ecologist, Sonoma Technology, Inc.
sdrury@sonomatech.com

Caroline Noble: USFS IFTDSS Technical Lead, Wildland Fire Management RD&A
carolinelnoble@fs.fed.us

Table of Contents

Purpose 2

Introduction 3

Report Goals 3

Pilot Project Analysis Objectives 3

Pilot Project Orientation 4

Findings 6

Report Goal 1: Develop methods to inform strategic location of fuels treatments to achieve the least loss to sage-grouse habitat. 6

Report Goal 2: Highlight issues identified during the pilot project that inform discussions regarding IFTDSS (2.0 Beta) application development priorities. 32

IFTDSS Development Timeline and Future Priorities 32

Knowledge and Skills Needed to Complete Analyses 33

Report Goal 3: Articulate data and modeling limitations encountered (not necessarily unique to IFTDSS 2.0 Beta) that highlight future research and development priorities. 35

Data Inconsistencies 35

Fire Modeling Systems—Limitations and Assumptions 35

Conclusion 37

Analysis Objectives Report Summary 37

Bibliography 42

Appendix A: NEPA-Identified Treatments 43

Appendix B: Unedited Landscape Analysis 46

Purpose

In coordination with BLM staff, the Wildland Fire Management Research Development and Application group (WFM RD&A) staff volunteered to test the Beta 2.0 version of the Interagency Fuels Decision Support System (IFTDSS) to evaluate its capacity to use fire behavior modeling tools in development of strategies to reduce threats to sage-grouse habitat. IFTDSS (2.0 Beta) provides modeling tools, workflow pathways, and reporting features that facilitate science-based approaches to identify priority treatment areas over landscapes up to 400,000 acres. IFTDSS (2.0 Beta) can evaluate proposed treatment impacts to habitat based on user-specified impacts, and can inform proposed sequencing of treatments to facilitate prioritization decisions. These analyses can be successfully conducted at the field level provided that local staff possess knowledge of local vegetation and fire behavior, and sufficiently understand the principles of fire modeling to evaluate model inputs and interpret model outputs. The unique design of IFTDSS to guide users through fire behavior modeling and spatial analysis via pathways excludes the need for local users to be highly proficient in GIS or adept at using numerous desktop fire modeling software packages.

For this analysis, the outputs provide spatial and graphical summaries of habitat loss and benefit associated with modeled fire behavior and informed by the Fire and Invasive Assessment Team (FIAT) resistance and resilience classifications. This project evaluated both model-informed treatment locations and NEPA-proposed treatment locations to describe the analysis process and strive to answer basic management questions regarding how fire may interact with important values:

- Where are the areas of highest fire probability on this landscape?
- If the proposed NEPA fuel treatments were implemented, would burn probability decrease in the habitat polygons and lek locations under a 90^{th} percentile fire scenario (constant SW wind at 13 mph lasting for 6 hours, initiated for 2500 random ignitions)?
- What is the Net Value Change in habitat if the landscape is treated? In other words, since response of assets (sage-grouse habitat) varies with flame length, can we translate positive and negative fire effects under various fire intensity scenarios (flame length categories) into one number (NVC)? Do treatments provide a net benefit or a net loss?

Additionally, this Report highlights issues to inform application development priorities, and modeling limitations (not unique to IFTDSS) that may highlight future research and development needs.

Introduction

In response to the Department of the Interior Secretarial Order 3336 (SO 3336) regarding utilization of science-based strategies to reduce the threat of large-scale rangeland fire to sage-grouse habitat, the Bureau of Land Management (BLM) is investigating risk-based landscape-scale approaches to assist in decision support for fuels management. The report, "*An Integrated Rangeland Fire Management Strategy; Final Report to the Secretary of the Interior*" (U.S. DOI, 2015) Section 7(b) iii Fuels - Action item 4A states, "Initiate a pilot project to test existing tools and/or prototype versions of new tools." In coordination with BLM staff, the Wildland Fire Management Research Development and Application group (WFM RD&A) volunteered to test the Interagency Fuels Decision Support System (IFTDSS Beta 2.0) to evaluate its capacity to accomplish this type of analysis and a preliminary report was provided in July 2015.

This report also address, in part, additional SO 3336 Section 7(b)iii fuels-related tasking, including providing modeling outputs to be used as common interagency metrics to validate fuels management activities (Action Item 2); providing a science-based process in a format available for field application (Action Item 5); and using risk-based landscape scale approaches to identify and facilitate investments in fuels treatments in the Great Basin (Action Item 8) from the *Integrated Rangeland Fire Management Strategy Final Report* (U.S. DOI, 2015).

Report Goals

1. Report pilot project findings evaluating current IFTDSS (2.0 Beta) application capabilities to support SO 3336.
2. Highlight issues identified during the pilot project that inform discussions regarding IFTDSS (2.0 Beta) application development priorities.
3. Articulate data and modeling limitations encountered, not necessarily unique to IFTDSS (2.0 Beta), that highlight future research and development priorities.

Pilot Project Analysis Objectives

1. Develop a method to inform strategic location of fuels treatments in order to achieve the least loss to sage-grouse habitat.
2. Assess proposed fuels and restoration treatments within the project area to determine which treatments will result in least habitat lost. Fuel treatments located and identified through the NEPA planning process were also tested for efficiency at limiting burn probability and major fire paths impacting lek sites and desirable habitat (Appendix A).
3. Assess the proposed treatments to inform prioritization and sequence of project/treatment implementation related to wildfire threat, using habitat restoration and fuels management strategies.
4. Assess the need for and prioritization of restoration and fuels treatments focused on areas outside of the project area in order to prevent impacts of large-scale and fast moving fires within the project area to sage-grouse habitat.

Pilot Project Orientation

The pilot project area is within the Warm Springs Valley Nevada, Western Great Basin Management Zone V as delineated by soil temperature and moisture regimes (Miller at al. 2014). Specifically, the BLM Nevada, Carson City District, Virginia Mountains project area was selected for this pilot assessment because the area not only has a high density of sage-grouse but also because NEPA planning had already been initiated, including proposed fuels and vegetation treatment locations. The project area (Figure 2) around known lek sites has proposed treatments from a recent NEPA analysis.

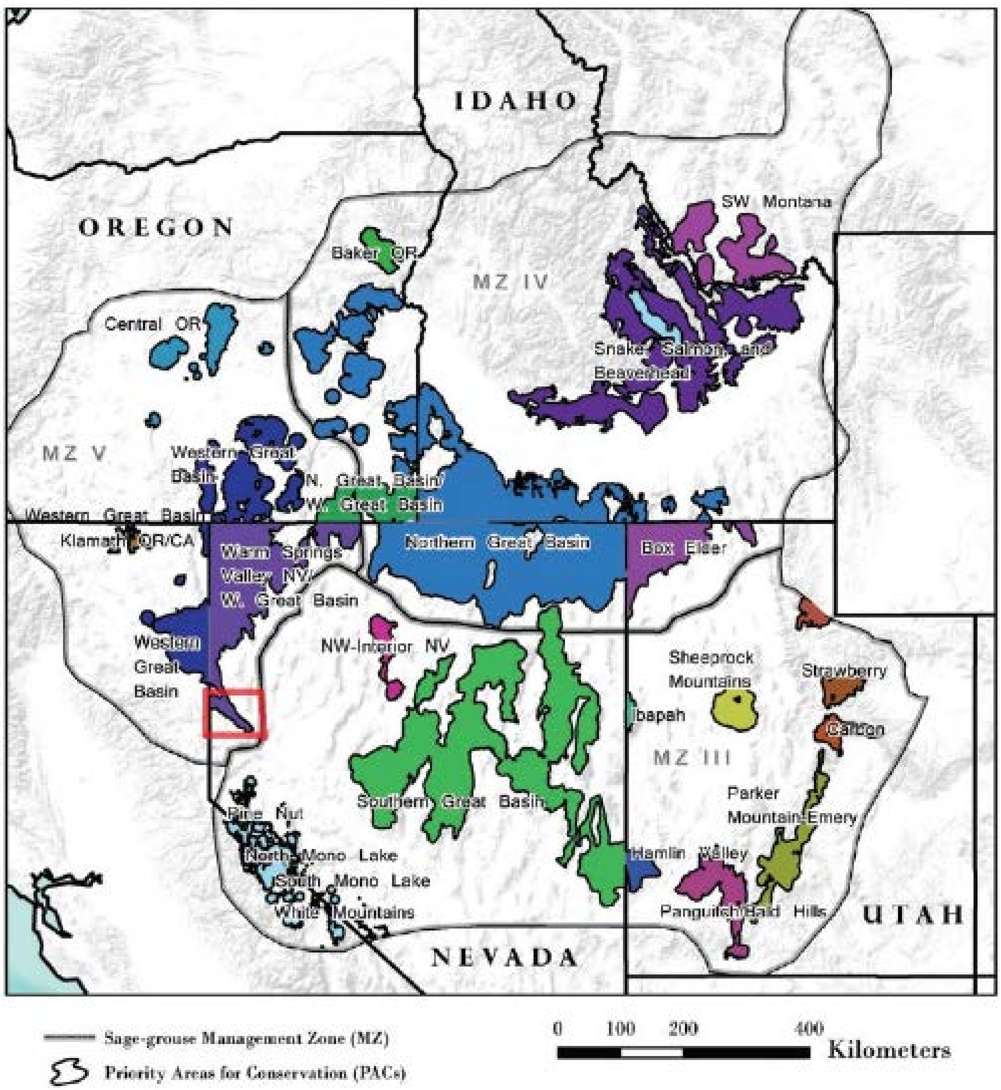


Figure 1. The pilot project is located on the Carson City BLM District in western Nevada, shown here with a red square.

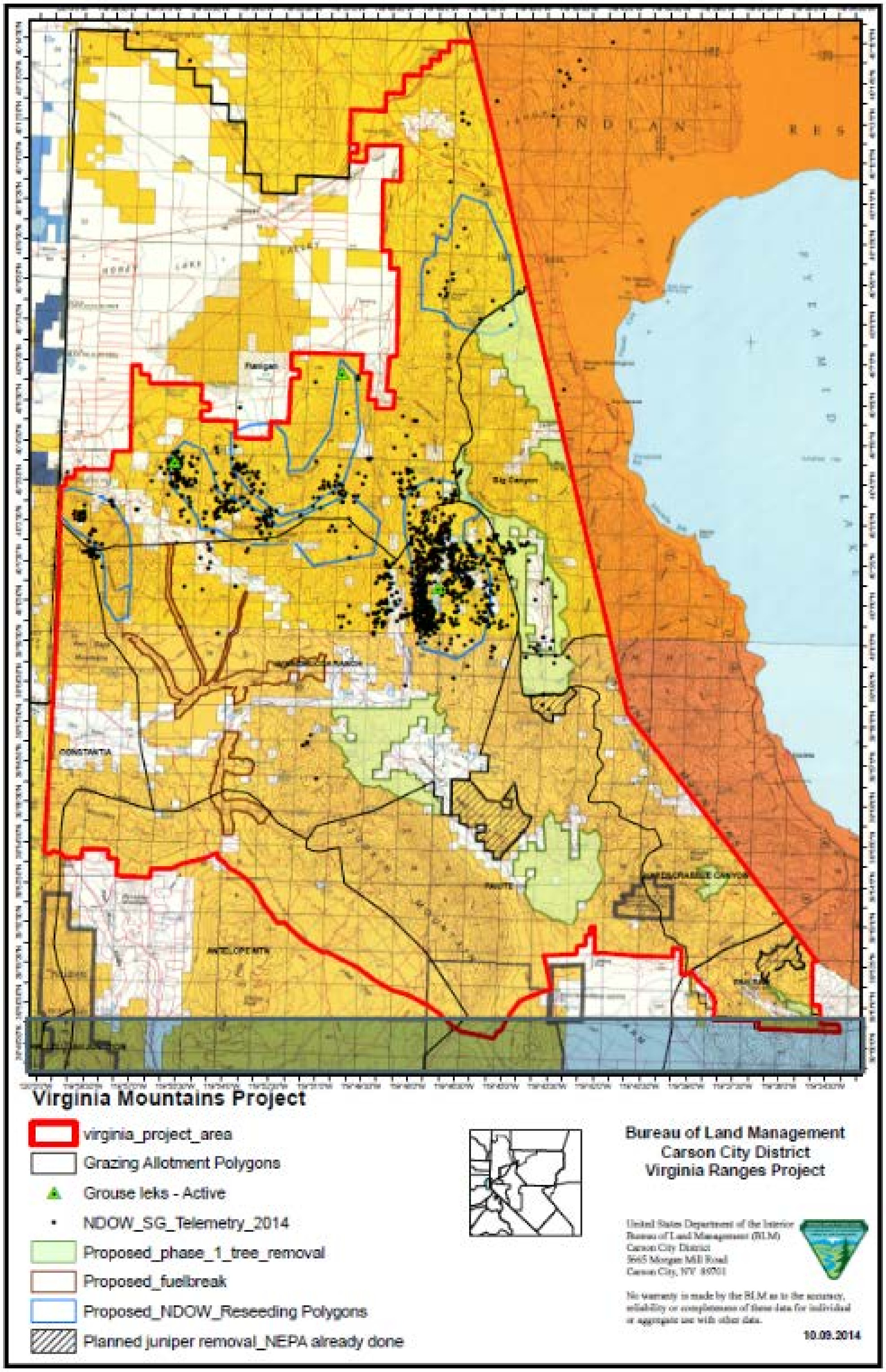


Figure 2. Project area showing telemetry points and lek sites. Dashed red oval is primary sage-grouse habitat area used in the analysis. Project map provided by the BLM Carson City BLM, October 2014.

Findings

Report Goal 1: Develop methods to inform strategic location of fuels treatments to achieve the least loss to sage-grouse habitat.

IFTDSS provides a combination of modeling approaches to identify locations on the landscape with the highest potential for fire hazard and risk. This section will outline a five-step process. While hazard is characterized by a physical property of wildland fire such as fire intensity or flame length (modeled with IFT-FLAMMAP), risk is characterized by the probability or likelihood that a wildfire will occur and impact values at various levels of fire intensity or flame length (as modeled by IFT-RANDIG). By overlaying values at risk (such as active lek locations or desired resistance/resilience habitat polygons) with fire hazard and burn probability, one can begin to evaluate the landscape for potential fuel treatment locations by examining fuel and vegetation conditions within and adjacent to desired habitat to be protected around the leks. Local knowledge must be applied in order to verify vegetation and fuel characteristics, affirm modeled high fire hazard areas, identify weather and lightning scenarios, and compare model results to historic fire frequency and spread patterns.

IFT-MTT can then be used to test effectiveness of various treatment locations based on ignition scenarios by modeling changes in fire behavior and spread patterns as a result of proposed treatments. Once proposed treatment locations are selected, the treatment impacts on sage-grouse habitat can be evaluated through a process by which local experts assign response functions based on anticipated fire impacts. Some "values" represented by resistance/resilience polygons could benefit from certain levels of fire intensity, and thus would be assigned a positive value for a response function, while other values would degrade with fire and be assigned a negative response function. Response functions assigned to each value are combined with burn probabilities to inform a quantitative value for risk, termed conditional net value change (NVC); conditional on a wildland fire occurring. This IFTDSS Risk Assessment process is based on the first approximation of Wildfire Risk and Hazard (Calkin 2010) and outputs are quantified by acres in various categories of user-defined "net value change" classifications ranging from Greatest Loss/Least Benefit to Least Loss/Greatest Benefit.

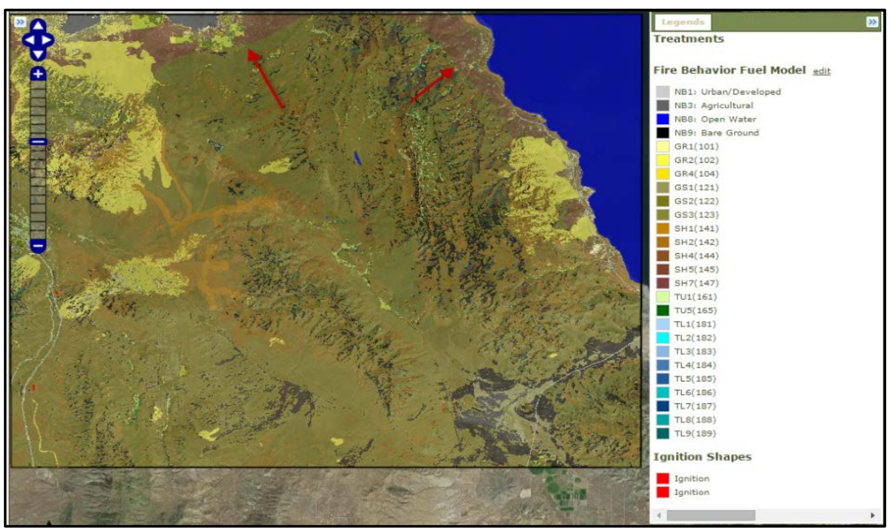


Figure 3. Critique of the LANDFIRE 2010 (v1.2.0) in IFTDSS (2.0 BETA) discovered a strong pattern in the northern portion of the project area assigned to a surface fuel model dominated by a different fuel model compared to the rest of the landscape as shown by the red arrows, resulting in unrealistic modeled fire behavior. Adjacent LANDFIRE Zones represented sagebrush fuel models with different fuel models. North of the arrows, sagebrush fuel models are represented by shrubs (SH5) compared to grass (GS2) for the remainder of the landscape. The final landscape used for the analysis was changed to represent sagebrush fuel types as shrubs (SH5).

Step 1. Assemble Data

Landscape

Geospatial models require a landscape file that contains fire behavior fuel models, canopy characteristics, and topography information. As is standard practice, analysts started with an existing LANDFIRE landscape file and modified it based on local data. Large wind driven fires are typical in rangeland fuels. For this analysis, the landscape extent was set to 400,000 acres to accommodate large fire spread that could occur during one burn period. LANDFIRE 2010 (v1.2.0, the most current available in IFTDSS Beta 2.0) was uploaded as the base landscape data set (including surface fuel models, canopy fuels, and topography data layers). Although a newer version of LANDFIRE is currently available with disturbance updated through 2012 (v1.3.0) the study location lacked any major disturbance events between 2010 and 2012; therefore, 2010 data was used. Users can upload landscape files into IFTDSS if different data are needed.

Landscape evaluation is necessary to calibrate national scale data to a landscape level. In this case, a zonal difference between LANDFIRE zone 6 and 12 (Figure 3) resulted in the need for a global fuel model replacement: the Moderate Load, Dry Climate Grass-Shrub 2 (GS2 – 122) fuel model was replaced by the High Load, Dry Climate Shrub 5 (SH5 – 145) fuel model using the IFTDSS interface. Given historical large fire spread and local expertise of fire behavior, sage brush fuel types were deemed better represented as a high spread, high flame length fuel model (SH5) rather than a more moderate rate of spread and flame length fuel model (GS 2) (Figure 3). For more information, see Appendix B.

Modeling Parameters

IFTDSS modules (IFT-RANDIG, IFT-MTT, IFT-FLAMMAP) require users to define inputs for burn period, live and dead fuel moistures, wind speed, and wind direction. IFTDSS 2.0 Beta holds weather and wind constant throughout the simulation. Inputs used in the modeling reflected the 90th percentile wind and weather historical data from the Doyle RAWS station. Weather data was assembled using Fire Family Plus software, and manually entered in IFTDSS. The number of fires to simulate is chosen so that each pixel in the landscape file burns at least one time and is a function of how much variation the user wants to capture, considering processing time (more ignitions require longer processing time). In this project, 2500 fire simulations was determined to capture most of the possible variation in outputs. Inputs were as follows:

- Dead fuel moistures: 1-hr:2%, 10-hr: 2%, 100-hr 4%
- Live fuel moistures: grasses (live herbaceous), 30%; shrubs (live woody), 60% (fully cured)
- Wind: Constant 13 mph Southwest wind (225 degrees)
- Burn Period: 6 hours
- Crown Fire Method: Finney Crown Fire Model
- Number of simulations: 2500

Step 2. Analyze Burn Probability

The IFT-RANDIG model was used to ignite 2500 random fires across the untreated landscape with a 6-hour burn period under constant 90th percentile weather and wind conditions. Each ignition starts independently on an unburned landscape; results are compiled after all simulated ignitions are complete. Burn probability is calculated by determining the frequency of each pixel burning during the simulations. Winds, slope, flammability of fuels, and the flammability of adjacent fuels all factor into Overall Burn Probability.

In IFT-RANDIG, the Overall Burn Probability output is a *conditional* probability, which assumes a fire has already started; or given a fire start, it is the probability that a given pixel will burn. High burn probabilities are related to both the size and frequency with which large fires occur on a given landscape. Thus, fire size is a function of the high spread rate in dry, tall, sage brush fuel types and duration of the fire (in this case 6 hours), while frequency is a function of the number of ignitions (n = 2500) and how many of those ignitions resulted in large fires (in this case, probably most, given the constant Southwest 13 mph wind in flammable shrub fuel models). Treatments or conditions that reduce rate of spread would lower the Overall Burn Probabilities. IFT-RANDIG was used to test if the proposed fuel treatments would result in lower Overall Burn Probabilities under static 90th percentile wind, weather, and fuel moisture conditions by running the model with and without treatment polygons.

IFT-RANDIG results in Figure 4 indicate high Overall Burn Probabilities across the Virginia Range landscape (warmer colors), as well as in core sage-grouse habitat (represented by the red oval) under 90th percentile fuel moisture and wind conditions.

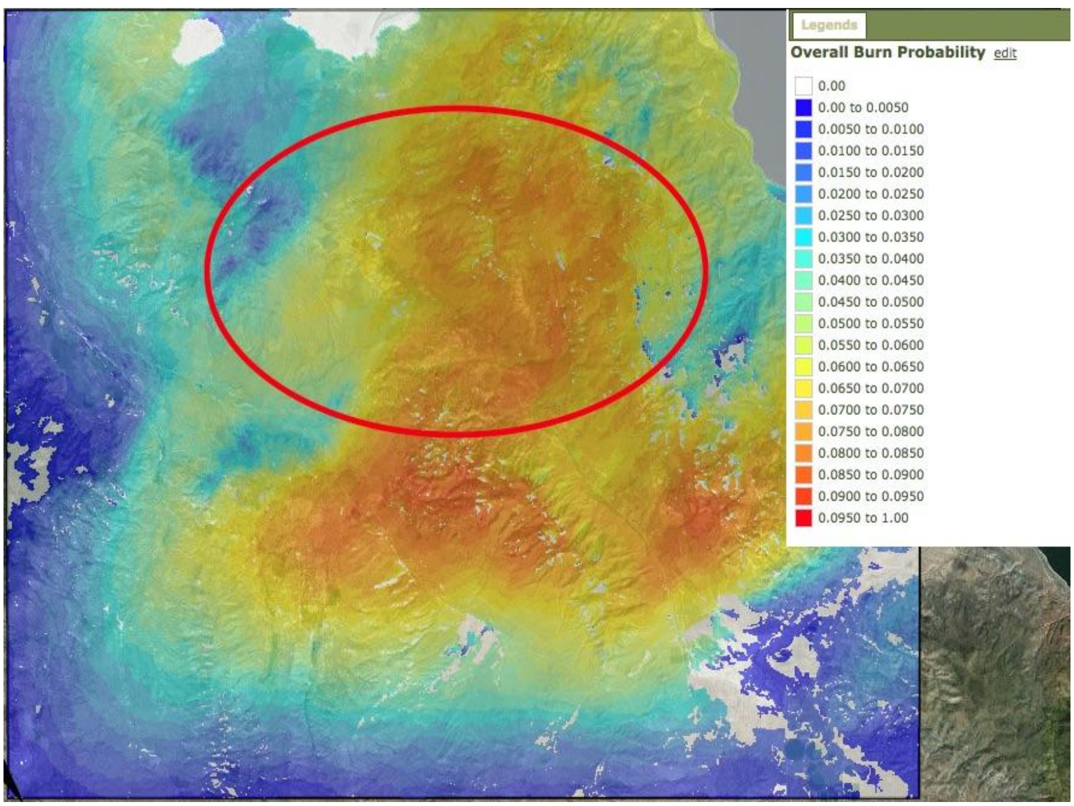


Figure 4. Overall Burn Probability for the existing condition. Warmer colors indicate higher burn probabilities. The red oval is a reference for the location of the core of the sage-grouse habitat in the larger Virginia Ranges project area. (Project reference: Sage grouse Set Up>> 90th percentile 2500 RANDIG fuels treatment no 395).

Step 3. Design Fuel Treatments and Test Effectiveness

Locating Potential Fuel Treatment locations based on Burn Probability Outputs

The landscape Overall Burn Probability pattern (Figure 4) was evaluated in concert with existing natural or manufactured fuel breaks, roads, rivers, dry washes, or areas with sparse vegetation to strategically locate potential fuel treatments using local knowledge and expert judgment. Several sparsely vegetated roads, pipelines, and washes exist in the Virginia Range, indicated by arrows in Figure 5. Road access to fuel treatments assists with successful implementation. Proposed treatment areas were drawn as polygons to modify the IFTDSS landscape file to a sparse shrub model (SH1), simulating a post-treatment fuel condition where fire behavior would be expected to have low rates of spread and low flame lengths, and fires are carried by shrub litter and sparse grass.

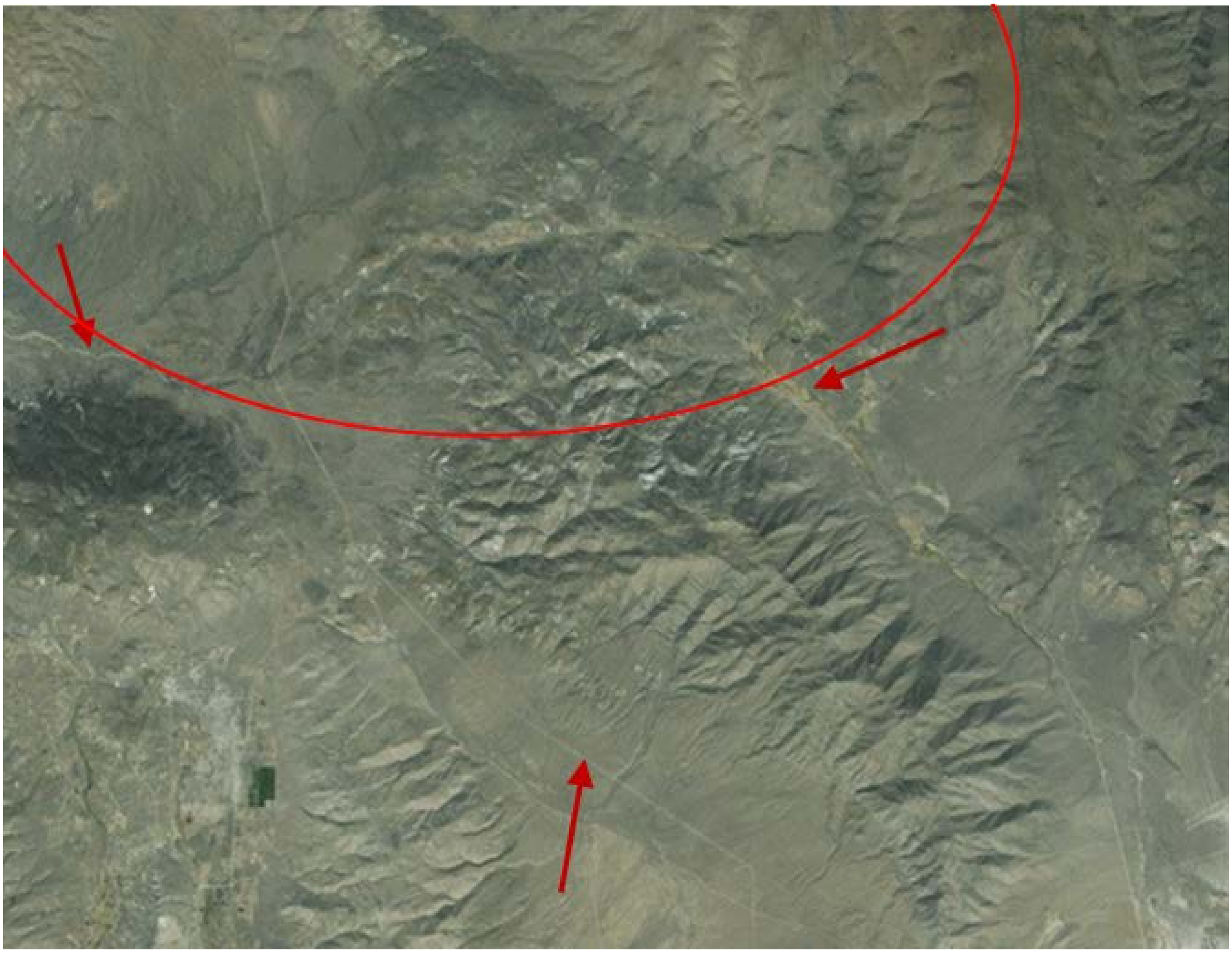


Figure 5. Proposed linear fuel treatments were drawn in the IFTDSS user interface along the roads and washes since these are the most logical areas to expand upon the existing vegetative condition to slow fire growth.

Testing Initial Treatment Effectiveness

Linear fuel treatments were drawn along roads and assessed for effectiveness. The more southerly road treatment was called “Segment 1” and the more northerly treatment was called “Segment 2.” Fuel treatments were drawn in IFTDSS after a number of analyses suggested ideal locations to place fuel treatments in order to protect lek locations. When the same 90th percentile wind, weather, and fuel moisture parameters are run in IFT-RANDIG, Overall Burn Probability is reduced (Figure 6a) compared to the existing, untreated condition (Figure 4) when evaluated qualitatively. Landscape statistics and other more quantitative methods from IFTDSS show a 2 to 6% decrease of Overall Burn Probability as a function of implementing these two segmented fuel treatments (Figure 6b).

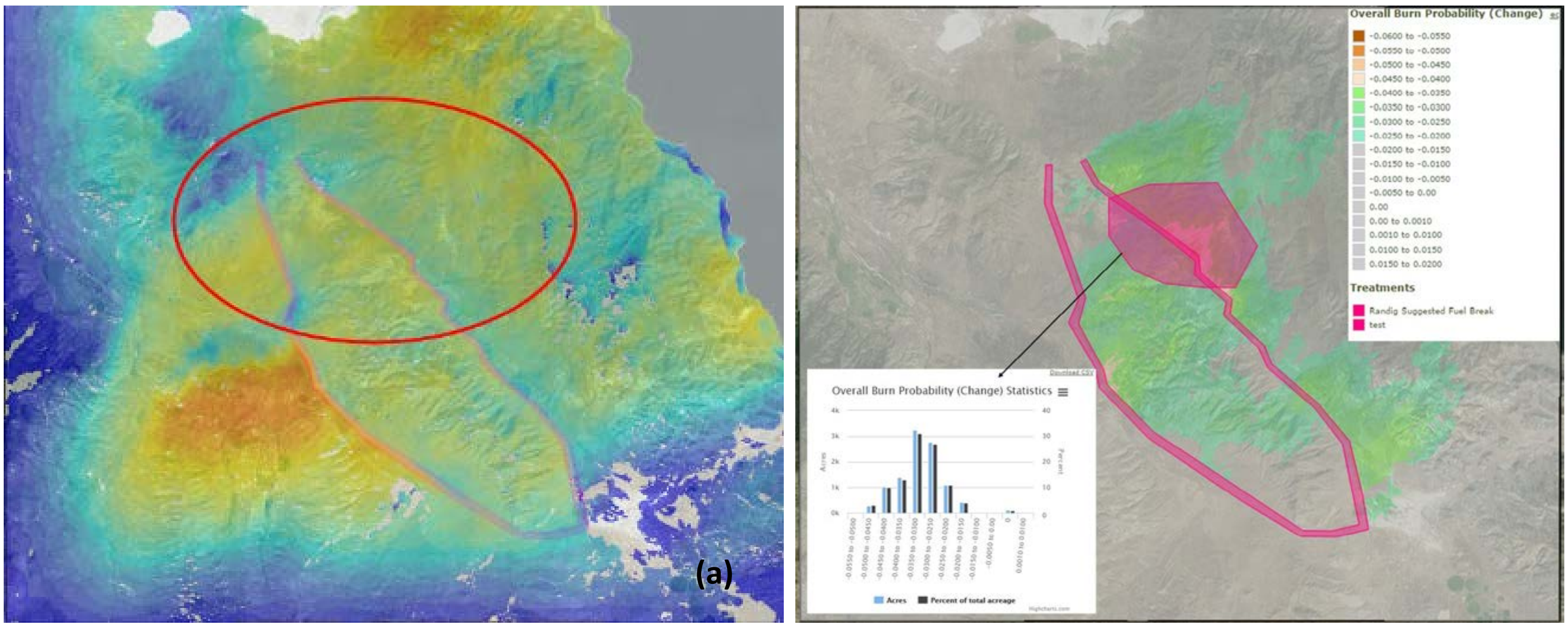


Figure 6. Overall Burn Probability (a) changes when fuel treatments along existing landscape features are modeled. Warmer colors indicate higher burn probability. Change in overall burn probability (b) for the landscape given the implementation of the segment 1 & 2 fuel treatments. Burn probabilities > 2% are represented. The graph shows landscape statistics displaying the distribution and magnitude of the change in burn probability within only the “test” polygon, which represents suitable sage grouse habitat in acres and percent.

Address Known Problem Fire Scenarios

The previous section describes how initial treatments along roads indeed reduces Overall Burn Probability with 2500 randomly placed ignitions. However, in reality, ignitions are not random. Therefore, initial fuel treatments were tested using a different IFTDSS model—IFT-MTT—which simulates fire spread for 6 hours under the same 90th percentile wind, weather and fuel moisture conditions used for the previous analysis. However, unlike IFT-RANDIG, this model produces spatial outputs depicting flame length, fireline intensity, rate of spread, crown fire behavior, time of arrival (how many hours it takes the fire to arrive at each pixel), and other fire behavior attributes, *given user-specified ignition locations*. IFT-MTT was used to evaluate if fuel treatments would result in delayed fire arrival times after treatment, i.e., if the fuel treatments were implemented, how much more time (relatively) would that allow fire response personnel to manage the fire? Two likely ignition scenarios were evaluated: human ignitions along a well-traveled highway, and lightning ignitions. Historic fire ignitions were assessed (Short, 2013) and refined using local expertise in order to create lightning (Figure 7) and human-caused (Figure 8) fire starts for the purpose of the scenarios.

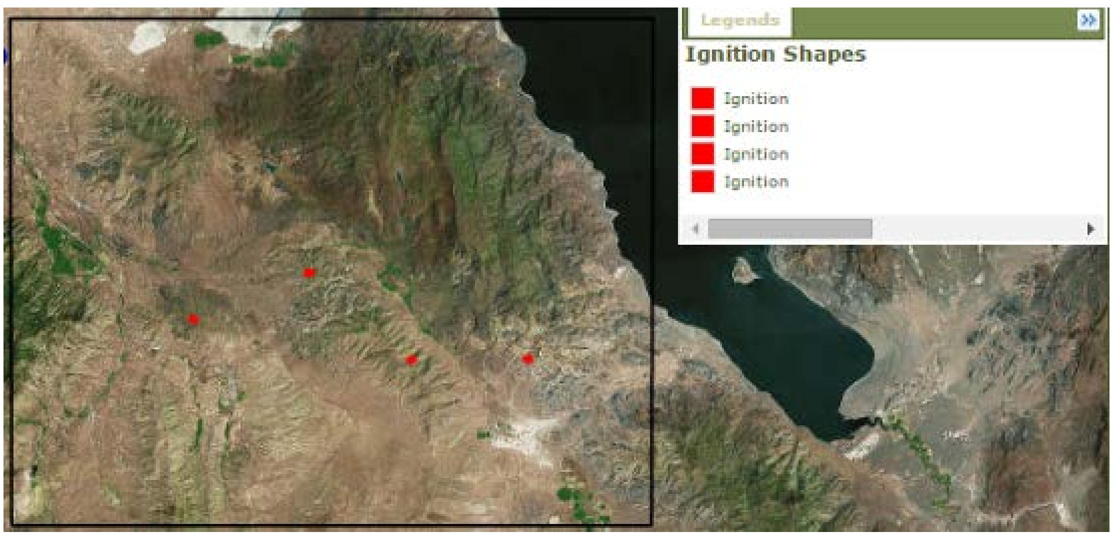


Figure 7. Lightning ignition locations (red dots) used for IFT-MTT analyses.

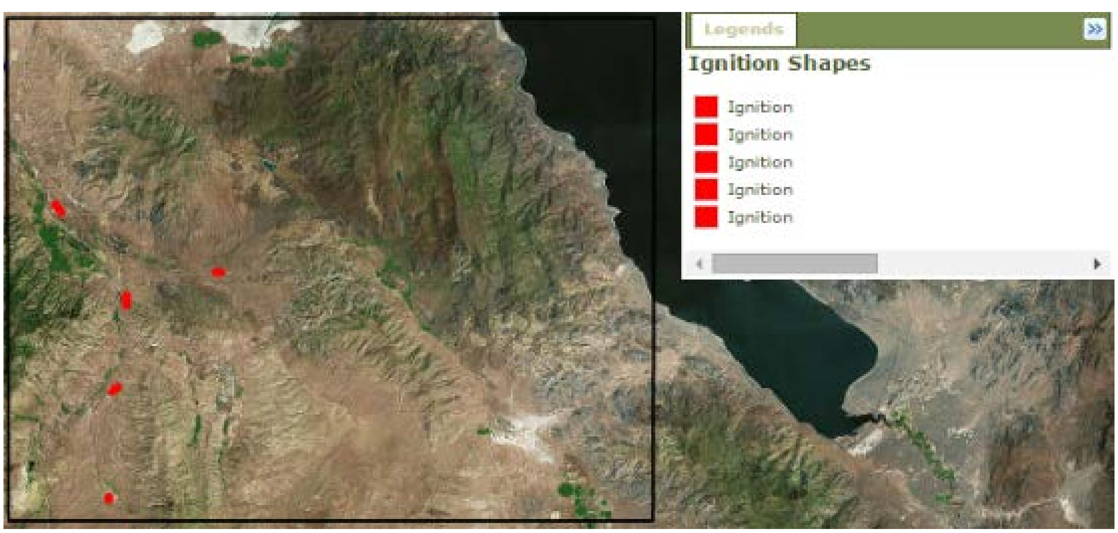


Figure 8. Human ignition locations (red dots) used for IFT-MTT analyses. These ignitions are adjacent to Highway 395.

IFT-MTT keeps conditions consistent for every hour of the burn period. Ignition of spot fires is stochastic in each run, and are generated from locations where canopy cover is high. Spot fires grow ahead of the main fire. In IFT-MTT scenarios, torching or passive crown fire occurred on approximately 10% of the landscape, depicting areas from which new spot fires could be generated. The color bands in IFT-MTT outputs represent 1-hour spread intervals (Figure 9). Fire spread in these scenarios is absent of any suppression efforts.

For the first scenario, multiple human-caused ignitions occur along Highway 395 (Figure 9), a north-south road that is west of the primary habitat area. This situation is not unusual, and local expertise indicates that vehicles with malfunctioning trailer brakes have thrown sparks, igniting multiple fires along this highway. On a low-to-moderate fire weather day, suppression resources might be able to suppress these fires, but on a 90th percentile or greater weather day, these ignitions would likely overwhelm local suppression resources and spread until out-of-area personnel arrived.

IFT-MTT was run with the first iteration of fuel treatments in place (Segment 1 and Segment 2), and the same 90th percentile weather conditions as in previous analyses. Treatments are effective at slowing fire spread without suppression when qualitatively comparing the outputs without (Figure 9a) and with (Figure 9b) fuel treatments. In Figure 10b, the second fire from the top of the image breaches the first fuels treatments by spotting.[1] The fires ignited along the road have a long distance to spread unimpeded before reaching the fuels treatment area. Based on the results for Segments 1 and 2, enhanced suppression capability was needed along the highway; therefore, a fuel treatment some distance from the core habitat was added along Highway 395. The same analysis was repeated with this added fuel treatment, demonstrating a further reduction in fire spread (Figure 9c). In this scenario, the mechanism for spotting still exists even with a fuel treatment along Highway 395, but the fires do not grow as large. This demonstration illustrates how analysts may assess the need for treatments *outside of immediate project area* to mitigate large, fast-moving fires that could enter a project area; continuous LANDFIRE data available in IFTDSS allows this type of analysis outside of federal boundaries. Analyses outside of immediate sage-grouse habitat areas could be useful in identifying needs for fire protection on adjacent state or local government lands (Douglas, n.d. [Memorandum, 2016-06]).

[1] If these treatments were actually implemented, it is likely that Pinyon-juniper would be mechanically removed. However, when modeling treated fuels, this team did not set canopy cover to zero to simulate removal of all Pinyon-juniper from the treated area. Doing this would have prevented the model from spotting across a barrier. Based on personal fire experience, the modeling team thought that leaving some form of stochastic spotting in the modeling would more accurately depict sagebrush fire behavior, which indeed spots across barriers. The only way to keep spotting in the model is to have some amount of canopy fuels.

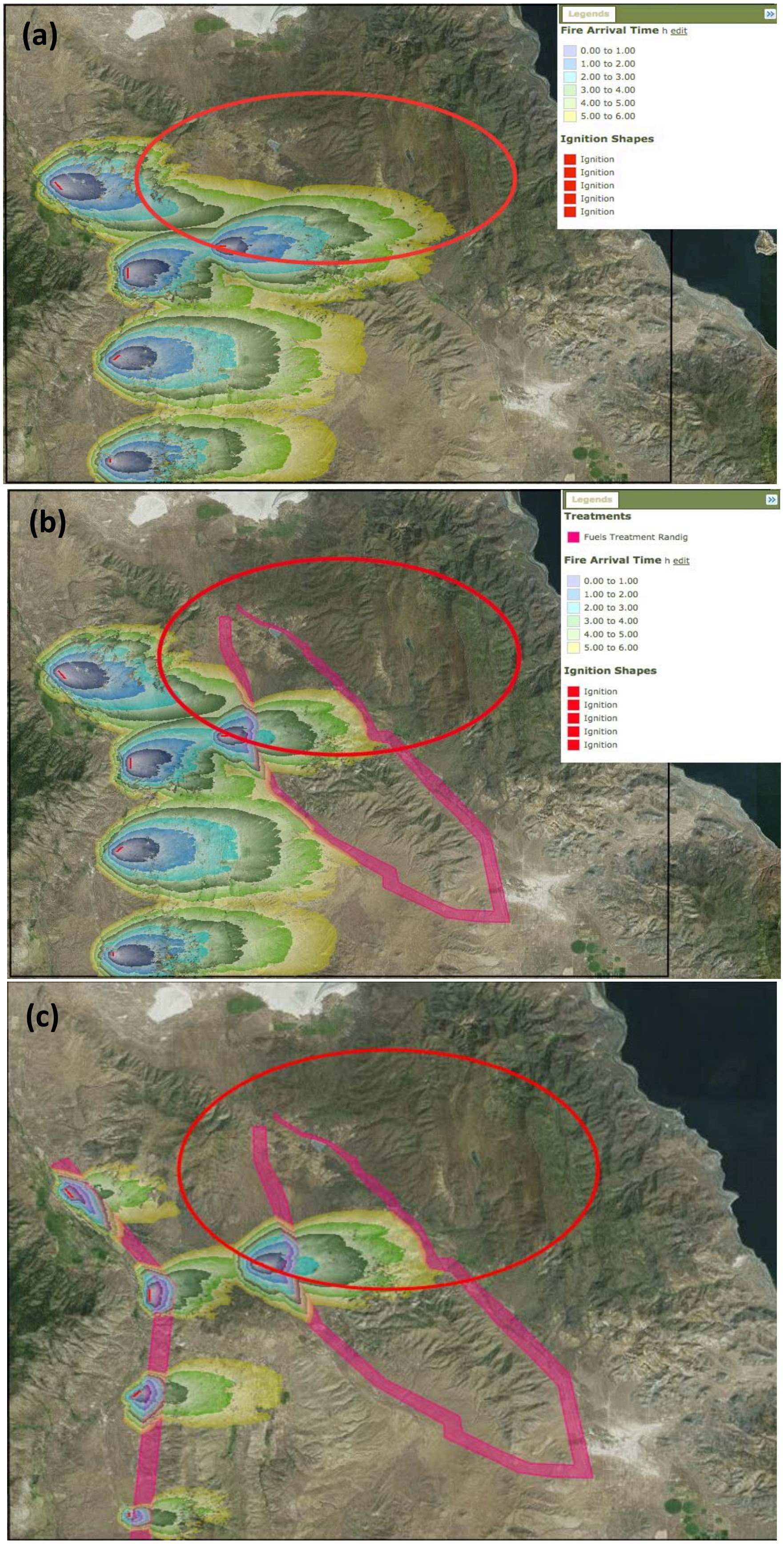


Figure 9. IFT-MTT fire arrival time output using human-caused ignition scenario and no suppression. Primary sage-grouse habitat area shown as red oval, and fuel treatments (Segment 1 and Segment 2) shown in pink. If no fuel treatments are implemented (a), fire spreads into the primary sage grouse habitat. When Segment 1 and Segment 2 fuel treatments are implemented (b), fire spread is slowed, but breaches the barrier through spotting. With the addition of another fuel treatment along Highway 395 (c), fire spread is further slowed. The legend for panel c is the same as the legend for panel b. IFTDSS Ref: (Sage Grouse Set Up>> 90th Percentile Human Starts) Human Ignitions; post treatment image).

The change in arrival times suggest that implementing the Segment 1, Segment 2, and Highway 395 surface fuel treatments would decrease fire arrival time by 2 hours across over 18,000 acres, which could aid a suppression response to multiple simultaneous ignitions (Figure 10). Landscape statistics from the IFTDSS user interface further illustrate this point (Figure 11). It is worth noting that arrival times in these scenarios would not be used for tactical planning—the value here is in the comparisons among scenarios.

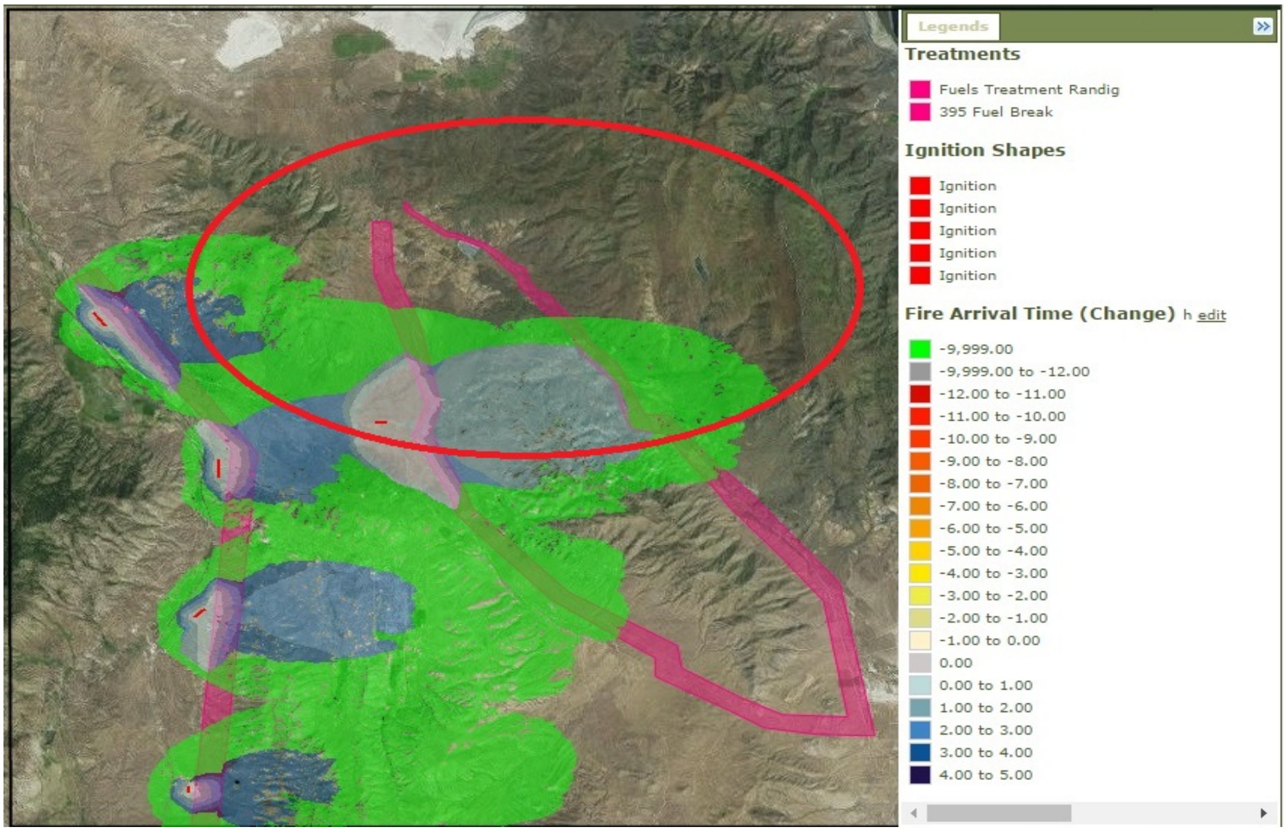


Figure 10. The green area shows where fire no longer spreads after fuel treatment (for the duration of the 6-hour scenario). Light pink areas represent very little change between pre- and post-treatment and blue areas show an increase of 1 to 4 hours in the time it would take the fire to arrive to those locations. The blue and green areas show where fire arrival is slowed after treatments. IFTDSS Ref: 90th Percentile Human Starts fuelbreak edits.

Row	Bin	Acreage	Percent
1	-9999	66991.5	17%
2	-1.00 to 0.00	5.1	0%
3	0	2463.5	1%
4	0.00 to 1.00	3303.2	1%
5	1.00 to 2.00	11940.6	3%
6	2.00 to 3.00	10416.9	3%
7	3.00 to 4.00	7411.3	2%
8	4.00 to 5.00	209.9	0%

Download CSV

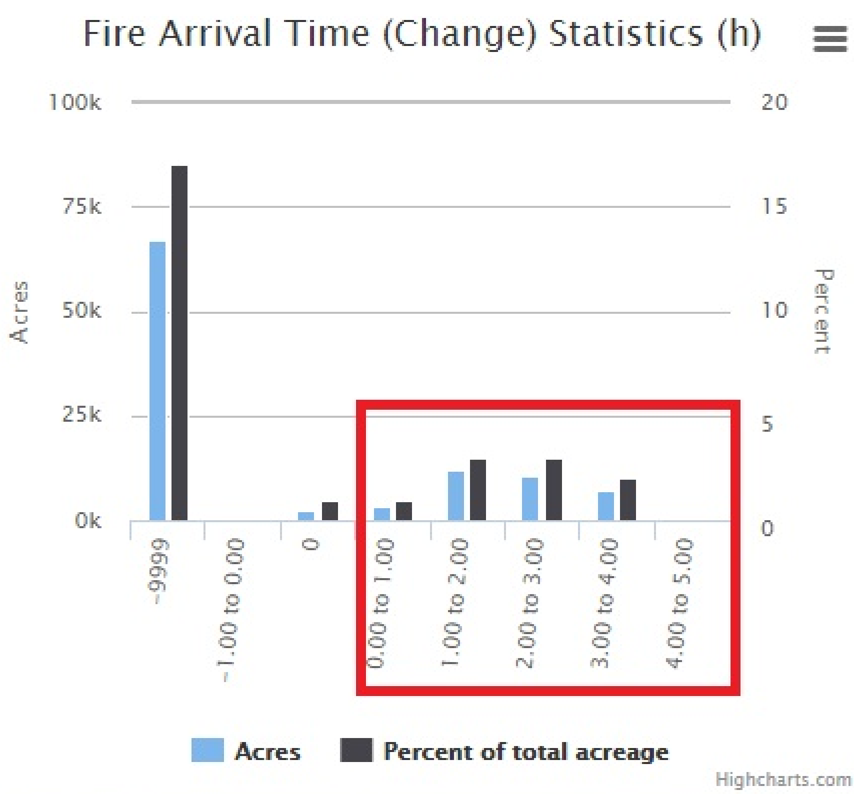


Figure 11. Change in fire arrival time landscape statistics pre- and post-treatment in the human-ignition scenario, which models 6 hours of fire spread without suppression under 90th percentile weather conditions. The upper portion of this figure shows 33,282 acres highlighted in a red box indicating fire arrival time is increased from 0-5 hours. Additionally, 66,991.5 acres no longer have fire spread, represented by -9999 in the graph. This demonstrates how the suppression response may be facilitated with fuels treatments.

The second scenario is multiple lightning-caused ignitions along the lee side of the mountains, south of the primary habitat area. Lightning in this area is usually accompanied by southerly winds. Again, on a low-to-moderate fire weather day, suppression resources might be able to suppress these fires, but on a 90th percentile or greater weather day, these ignitions would likely overwhelm local suppression resources and spread until outside resources arrived.

IFT-MTT was run with the same parameters: 90th percentile fuel moisture conditions, a southerly wind, a 6-hour burn period without suppression, and no fuel treatments to determine the likelihood of these fires impacting the habitat area. Results show fires would burn a significant portion of the primary habitat area in 6 hours under existing landscape conditions (Figure 12).

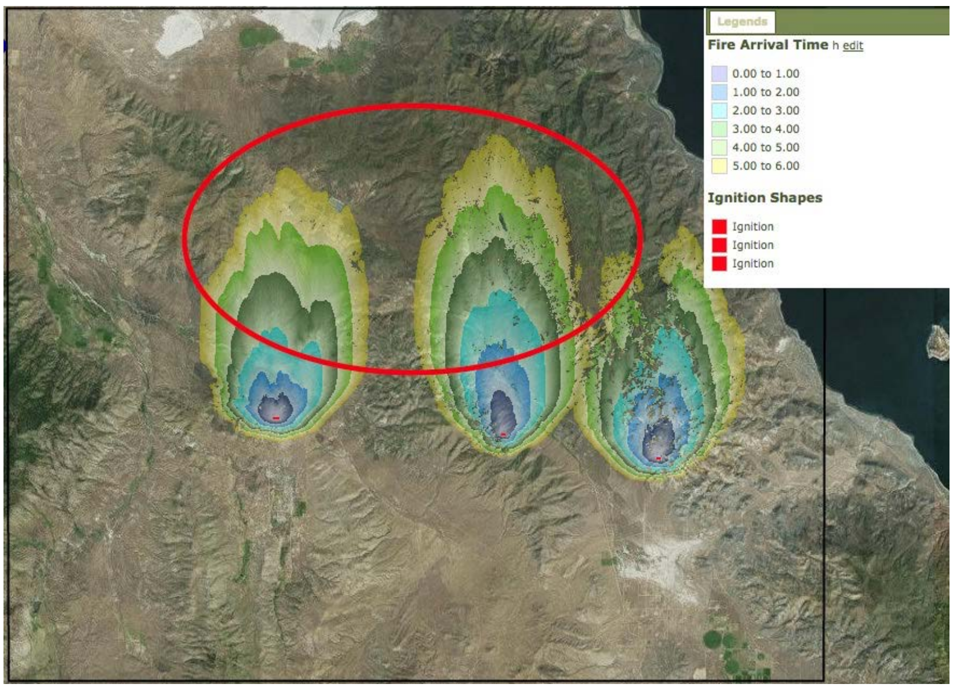


Figure 12. IFT-MTT results using lightning ignitions, no suppression, and no fuel treatments. Red oval indicates primary sage-grouse habitat area. IFTDSS REF: (Sage Grouse Set Up>> 90th Percentile 2 Lightning scenario Fuel Break edits) Pre Treatment.

If the fuel treatments that were designed to address Overall Burn Probability are used (Segment 1 and Segment 2), the lightning fires are slightly reduced, but the treatments are not very effective in this scenario (Figure 13). Because strong, southerly winds tend to accompany lightning storms in this area, an east-west barrier was deemed necessary for reducing fire growth into core sage-grouse habitat areas during these situations. Treatments to address lightning were added to the original “Segment 1” and “Segment 2” fuel treatment shapes and called “arms”. The “arms” were used to modify the landscape file, and the IFT-MTT analysis was repeated. With this addition, the fire footprints are significantly reduced and fewer acres are burned inside of the primary habitat zone (Figure 14).

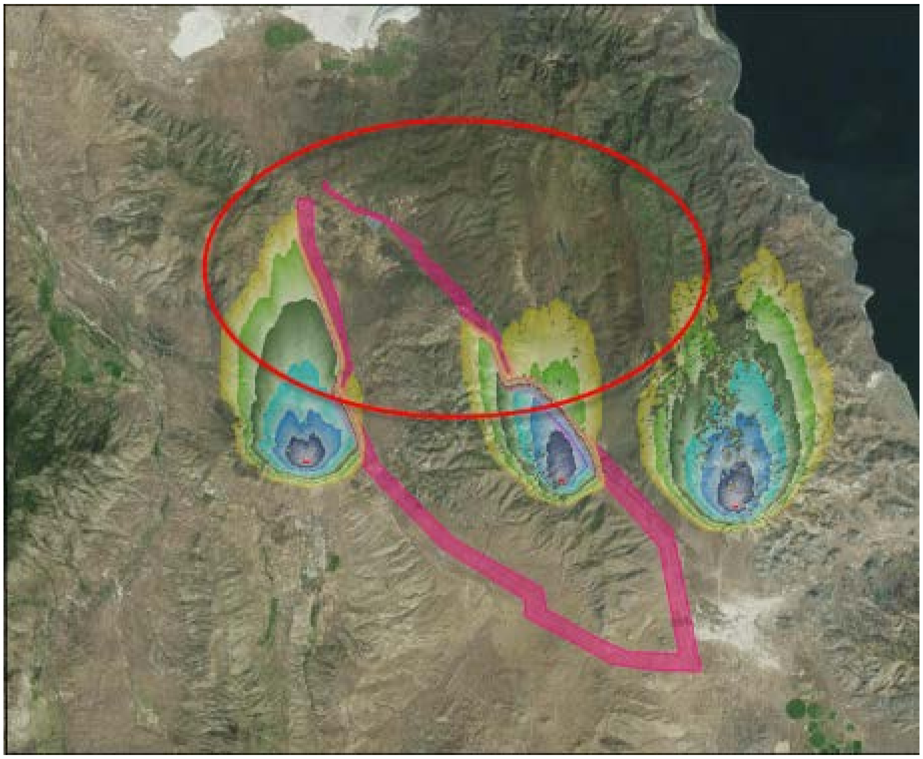


Figure 13. IFT-MTT results using lightning ignitions, no suppression, and only the Segment 1 and Segment 2 fuel treatments (pink). Red oval indicates primary sage-grouse habitat area.

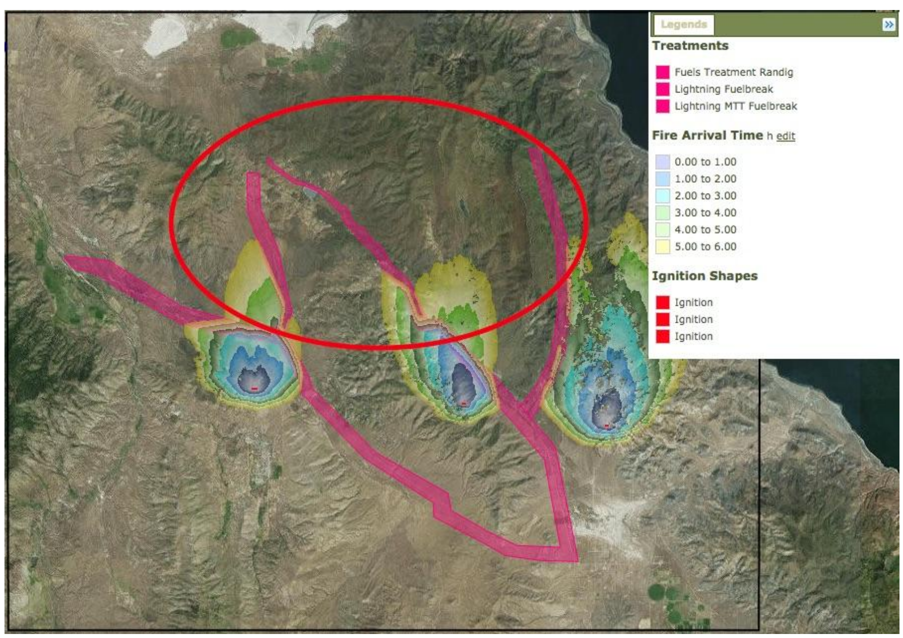


Figure 14. IFT-MTT results using lightning ignitions, no suppression, and only the Segment 1 and Segment 2 fuel treatments (pink). Red oval indicates primary sage-grouse habitat area. IFTDSS REF: (Sage Grouse Set Up>> 90th Percentile 2 Lightning scenario Fuel Break edits) Post Treatment.

Finally, IFT-RANDIG was re-run with all proposed fuel treatments (Figure 15), showing a significant reduction in Overall Burn Probability within the primary habitat area compared to the existing (no treatment) condition (Figure 16).

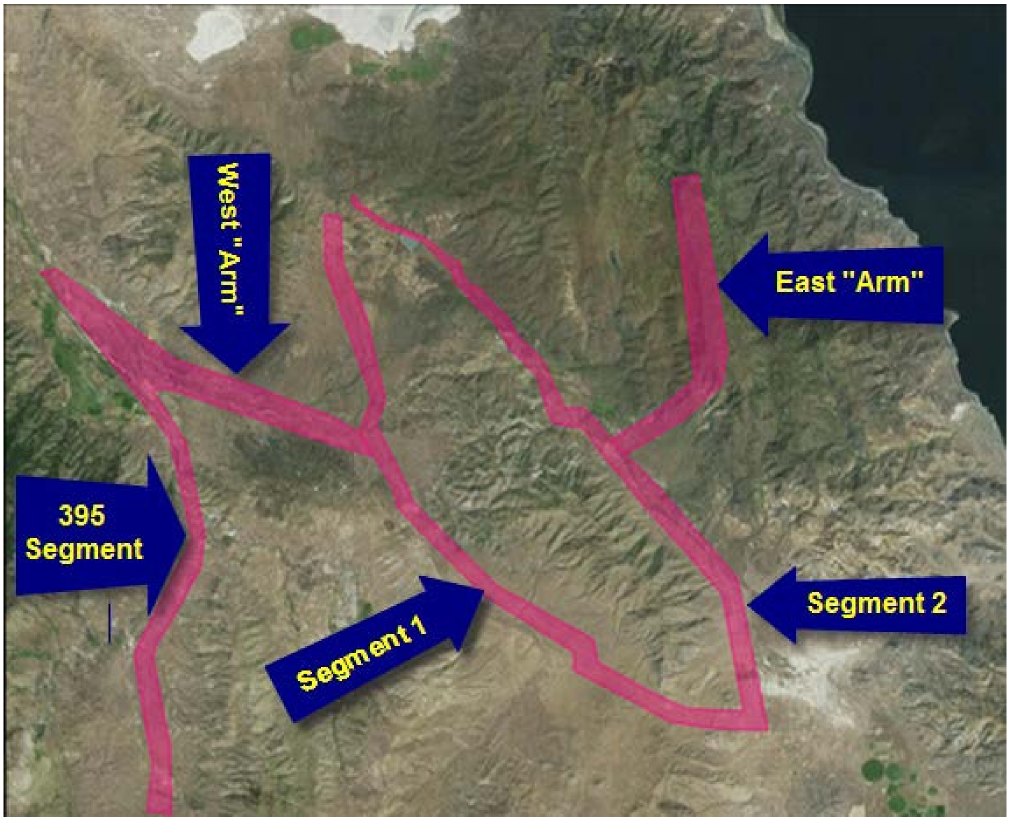


Figure 15. Final suite of treatments include Segments 1 and 2, the East and West "arms" and the Highway 395 segment.

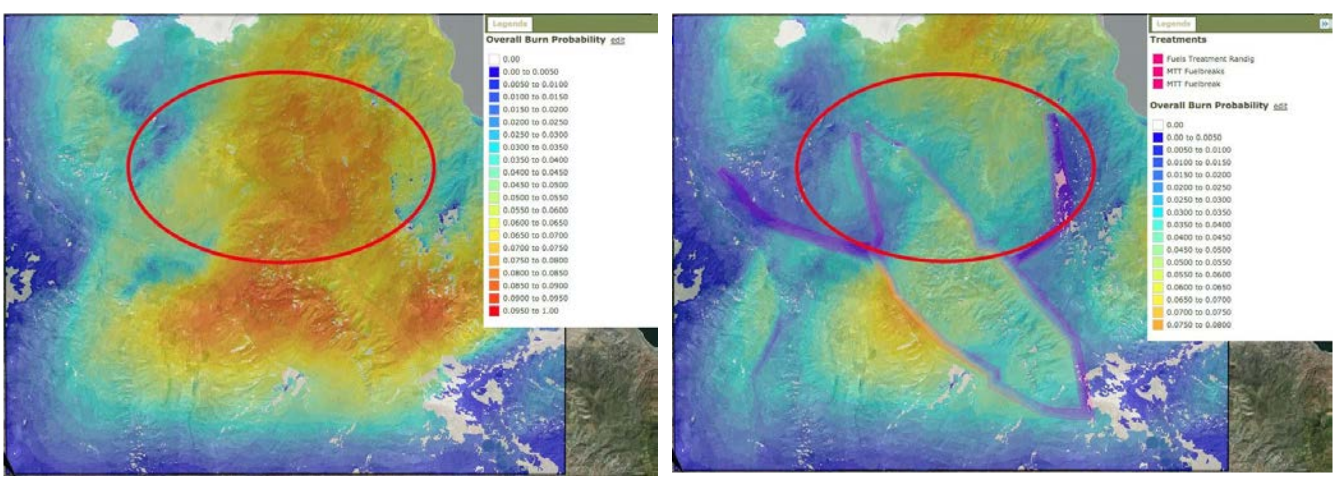


Figure 16. Left figure shows Overall Burn Probability for the existing landscape condition and no fuel treatments. Image on the right shows all fuel treatments identified through the IFTDSS process and resulting Overall Burn Probability. IFTDSS REF: (Sage Grouse SetUp >> 90th percentile 2500 RANDIG fuels treatments no 395) Pre-Treatment/Post-Treatment.

The IFTDSS interface allows users to draw and test several iterations of fuel treatments and build various scenarios before deciding on a final set of treatments. For example, only the center fuel treatments (Segment 1, Segment 2) were considered at first; a treatment along Highway 395 was added, then the right and left "arms" were added. Each addition further reduced overall burn probability in the area of highest concern represented by the red oval. The entire analysis area, which is much larger than the red oval, also had an overall reduction in burn probability, although some areas had an increased probability. This increase is likely due to the difference in randomly generated ignition locations for pre- and post-treatment scenarios (Table 1). However, Figure 17 indicates that where burn probability is lowered, there is a large variety among all the negative numbers ranging up to -0.065, while the 13% of increased burn probability, represented by numbers greater than zero, is slight, with increases less than or equal to 0.01.

Table 1. shows acres and percent of entire analysis area (400,000 acres) where Overall Burn Probability was lowered, increased, or had no change when IFTDSS-informed treatments were modeled.

Change	Lower Burn Probability	Higher Burn Probability[2]	No Burn Probability
Acres	292,737	52,641	53,033
Percent of Landscape	74%	13%	13%

[2] IFT-RANDIG cannot re-use the randomly generated ignition locations from the first non-treated scenario when modeling the post-treatment scenario; the 2500 ignitions are always random. Therefore, analysts decided to discount all burn probabilities greater than or less than 2%, considering this as "noise" associated with having merely different ignition locations pre and post. The graph confirms that most of the pixels showing higher burn probabilities are indeed very close to zero, while lower burn probabilities exhibit much more variation, ranging to -6%. When an ignition occurs in the post-treatment scenario in an area that hadn't burned in the pre-treatment scenario, burn probability can increase; based on model inputs it is unlikely that the treatment itself would increase burn probabilities. IFTDSS developers are working on the ability to hold ignition locations constant for pre- and post-treatment modeling.

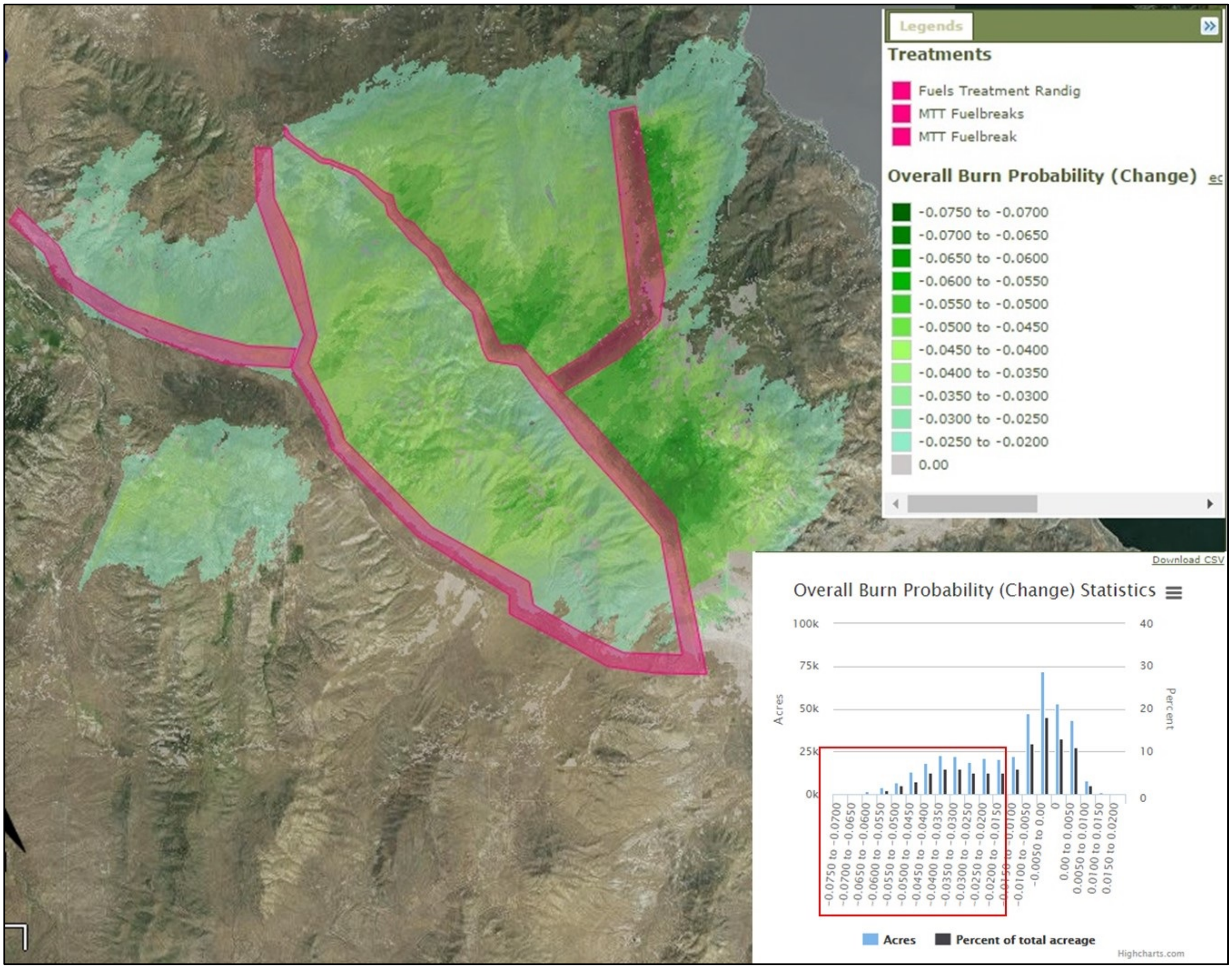


Figure 17. Green represents the change in Overall Burn Probability across the entire analysis area using a southwest wind scenario. The map legend is constrained by burn probabilities greater than 2% because increased burn probability is likely due to differences in the randomly placed ignitions for pre- and post-treatment scenarios. The inset graph shows no change with or without fuel treatments on much of the landscape (values at or near 0). Negative numbers indicate lower burn probability with treatments than without (green area). Numbers greater than zero indicate locations where fire burned during the post treatment scenario but did not burn in the pre-treatment scenario, again, likely due to difference in the randomly placed ignition locations (see Footnote 2).

Finally, the “drawn” fuel treatment polygons in IFTDSS were later re-created using ArcGIS and imported into IFTDSS for a consistent width of 180 meters (Figure 18). This is an optional step that was done make all treatments a consistent width for the pilot study. Fuel treatments were represented in the landscape file by a slower rate of spread shrub fuel model called SH1.

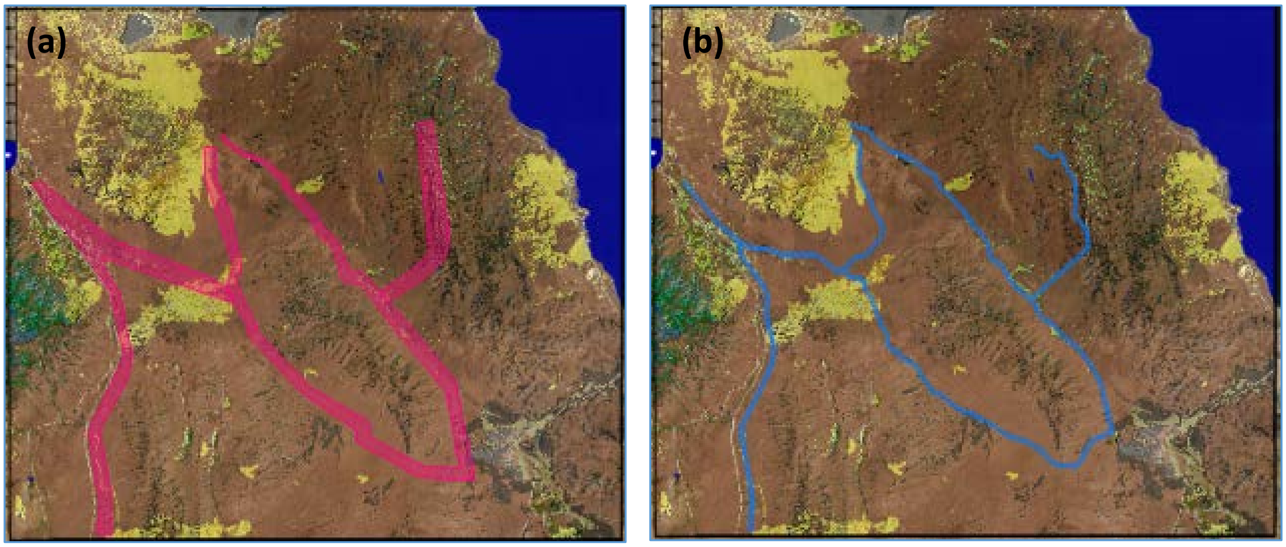


Figure 18. Fuel treatments evaluated in IFTDSS (a) were hand-drawn treatments reflecting the best placement given results of the IFT-RANDIG and IFT-MTT analysis results. Later, the same fuel treatments were created using ArcGIS to standardize a treatment width of 180 meters (b). This was an optional step to make treatments a consistent width for the analysis.

Step 4. Prioritizing Sequence of Treatments

Treatments cannot realistically be accomplished all at the same time, and funds for implementation are often limited. Therefore, assessing effectiveness of partial treatments can inform prioritization of treatments over time. Rather than simply looking at reduced acres burned as the metric for assessing treatment effectiveness, the IFTDSS Risk Assessment workflow was used to demonstrate potential for positive, negative, or neutral effects on the habitat based on flame length (intensity) probabilities and how a particular Resistance/Resilience (RR) polygon responds to that type of fire intensity.

Information for Values at Risk Workflow

The important values at risk, in this case represented by the RR polygons, need to be assigned a response function that describe how those values will interact with varying intensities of wildfire. Not all values degrade when burned. For instance, some Pinyon-juniper encroachment areas respond favorably to moderate- to high-intensity fire because tree mortality allows for restoration of sagebrush. Response functions were created to describe the benefit (1 to 100) or loss (-1 to -100) or no effect (0) to values (as defined by the respective RR polygons) when burned with different fire intensities (represented by flame length classes).

- Low Flame length (0 to 4 feet)
- Medium Flame length (4 to 8 feet)
- High Flame length (8 to 11 feet)
- Very High Flame length (> 11 feet)

The BLM fire planner provided information as to how each of the RR polygons are expected to respond to fires. These polygons represent a sage-grouse habitat matrix based on resilience and resistance concepts from Chambers and others (2014). Resistance to disturbance is defined by codes 1-3 (Figure 19):

- 1 = high resilience and resistance
- 2 = moderate resilience and resistance
- 3 = low resilience and resistance

Resistance to invasive annual grasslands are defined by codes A-C representing the current proportion of the landscape (5-km rolling window) dominated by sagebrush (A = 1-25% land cover; B = 26-65% land cover; 3 = >65% land cover).

Each polygon combination was assigned a response function (Figure 19); for example, 1A locations have 0 to 25% sagebrush, but are the most resilient. A response function value of 10 reflects that low flame lengths would not kill or consume the overstory (Pinyon-juniper-PJ) but still have a mild positive effect; while medium to high flame lengths would kill the PJ so a higher positive value was assigned (50). The very high flame lengths would result in burn severity that could alter the soil chemistry, thus this level of fire intensity would be undesirable, yet it could also eliminate the PJ, so a mild positive value was assigned (20). Assigning a value to each resistance/resilience polygon allows IFTDSS to calculate conditional Net Value Change as a quantitative measure of risk.

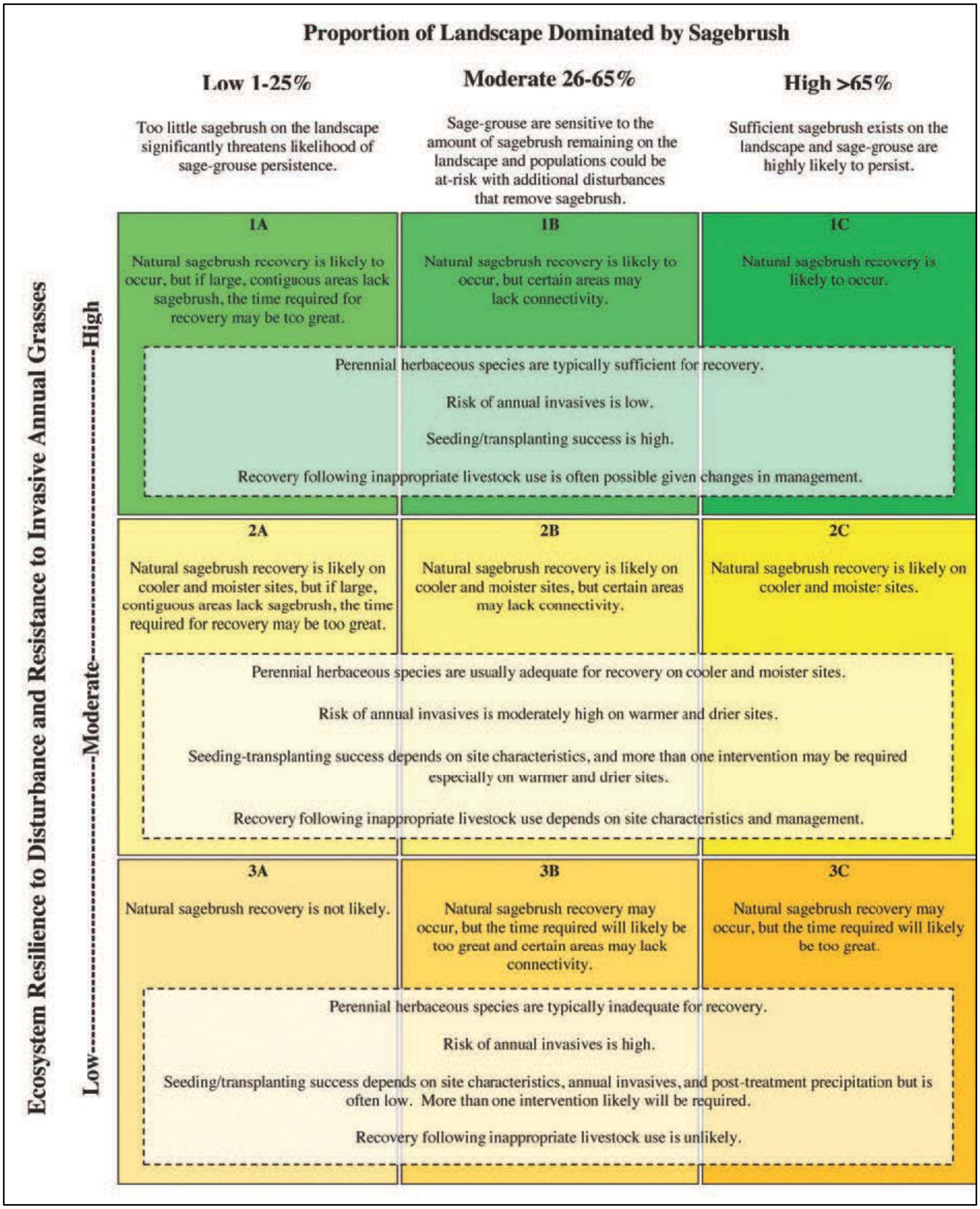


Figure 19. Resilience/Resistance matrix from Chambers and others (2014). This information was used to populate the response functions in the values analysis (USDA Forest Service Gen. Tech. Rep. RMRS-GTR-326).

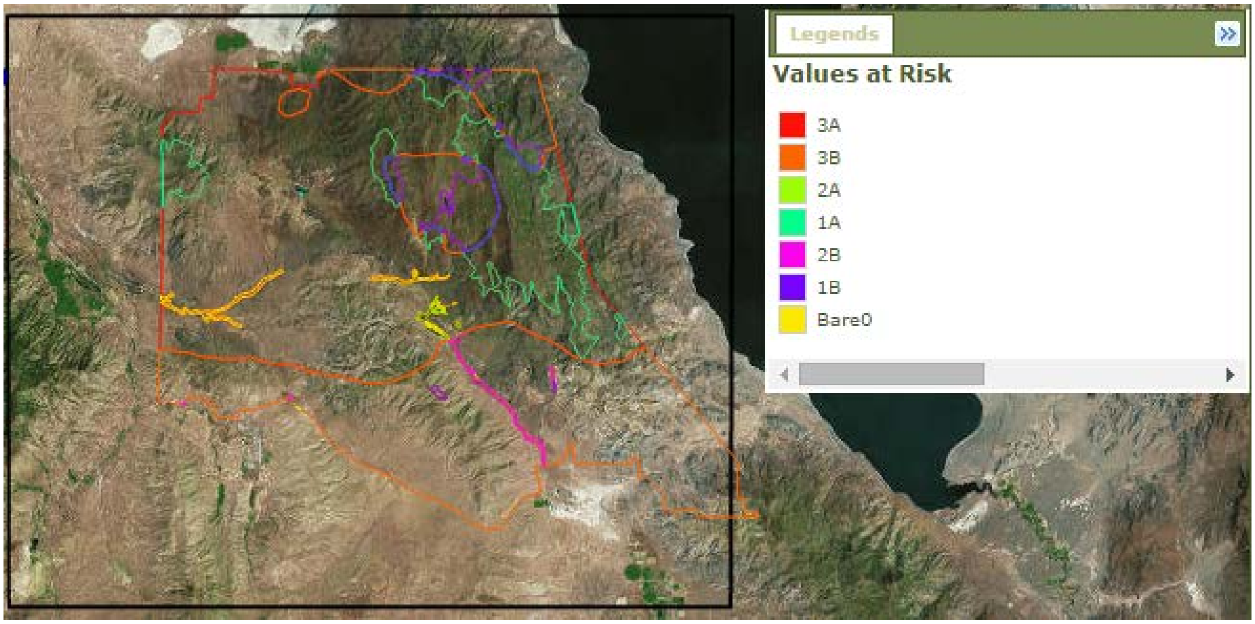


Figure 20. IFTDSS (2.0 Beta) displays all the Resistance/Resilience (RR) polygons. Each type of polygon was assigned a response function based on discussions about fire effects for those locations based on attributes described in Figure 19.

Analyzing Values—IFTDSS Risk Assessment Workflow

The analysis team used the IFTDSS Risk Assessment Workflow for this pilot project; however, because there is only *one* identified value on the landscape (sage-grouse habitat), and most fire responses are overwhelmingly negative, the results are not as informative as they might be in situations with more variability. Nonetheless, the results are still valuable in illustrating the process.

Expected change in value to the sage-grouse habitat types (Figures 19 and 20) was assigned locally based on the flame length categories (Table 2). It is important to note that response function values are specific to the Virginia Range project area and should not be copied wholesale for use in other geographic areas; assessment teams need to derive their own positive/negative relative values. The values in this matrix and location of RR polygons on the landscape drive the results in many of the following landscape graphics, and results must be interpreted with this in mind.

Table 2. Assigned change in value (or "response functions") from -100 to +100 for sage-grouse habitat types based on four flame length categories. Only habitat 1A and 2A show potential for fire benefits with values greater than zero.

Sage-grouse Habitat Type	Low Flame Length (0-4 feet)	Medium Flame Length (4-8 feet)	High Flame Length (8-11 feet)	Very High Flame Length (>11 feet)
1A	10	50	50	20
1B	-30	-10	0	-30
1C	-30	-30	-30	-30
2A	0	30	30	10
2B	-50	-30	-20	-50
3A	-80	-80	-80	-80
3B	-80	-80	-80	-80

The Values at Risk (VAR) portion of the IFTDSS Risk Assessment Workflow used 2500 random ignitions that each burned for 6 hours (IFT-RANDIG). The mean flame length results are compiled assuming a heading fire for each pixel (two risk assessment methodologies exist in IFTDSS; here, the “Risk Assessment by Worst-Case Flame Length” method was used). The mean flame length and habitat type (from RR polygons, Figure 20) determine the appropriate response function from Table 2. Response functions are multiplied by the Overall Burn Probability on each pixel to create a map of Relative Net Value Change. It is important to understand that analysts for this project used the Relative Net Value Change *breakpoint defaults* in IFTDSS, meaning that for all calculated Net Value Change integers across the landscape, values were binned at 20% breakpoints. Therefore, the lowest 20% of values are in the bin labeled, “Least Loss/Greatest Benefit”, while the highest 20% of values are in the bin labeled, “Greatest Loss/Least Benefit”. This is why it is called *Relative* Net Value Change—the areas shown in green are not necessarily a “benefit,” in many cases they represent the “least loss,” which can still be an unacceptable loss.

By this stage in the analysis, the entire suite of fuel treatment polygons were refined in ArcGIS and made into a single shapefile; they now appear blue in some screen captures to represent a 180m wide fuels treatment.

The VAR IFTDSS Risk Assessment Workflow was run with no fuel treatments (Figure 21). While the 2500 random ignitions are dispersed across the entire landscape, the VAR output does not cover the entire Virginia Range landscape. Local resource specialists identified VAR only in and around the primary sage-grouse habitat area and previously proposed NEPA treatment areas; therefore, VAR outputs exist only for those areas (150,200 acres or 39% of the entire landscape) shown in Figure 20.

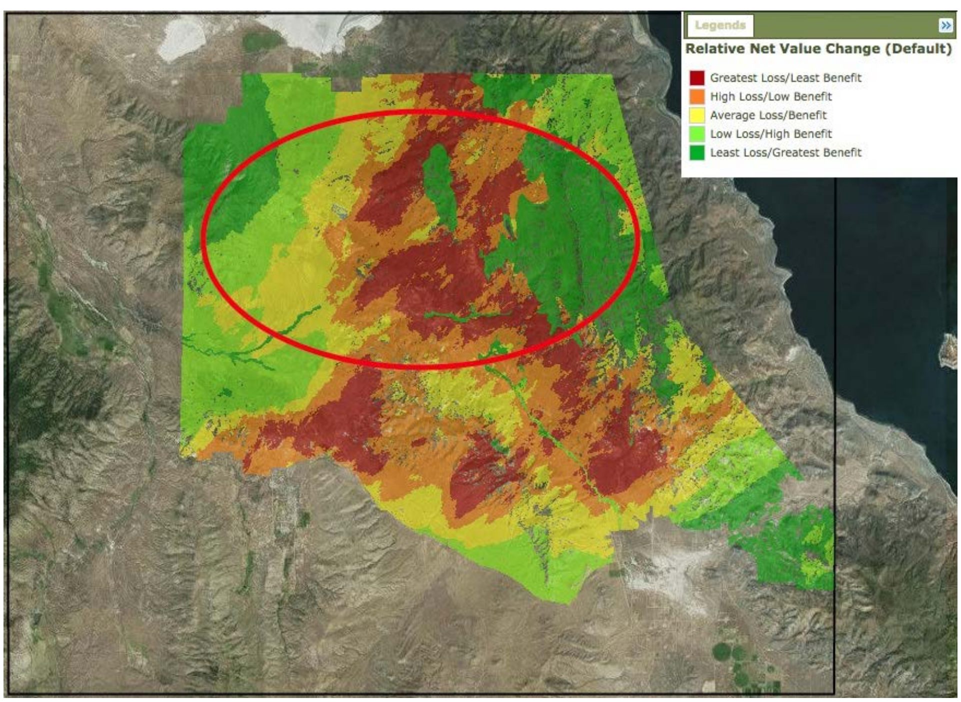


Figure 21. Relative Net Value change on the existing landscape with no fuel treatments. Based on flame lengths, burn probability, and the response functions, the calculated Net Value Change is mapped in five categories representing Greatest Loss/Least Benefit (red) to Least Loss/Greatest Benefit (green).

Next, comparisons were made by adding fuel treatments to the workflow. First, Segment 1 was the only fuel treatment made active in the VAR run. Results (Figure 22a) show five equal bins of Relative Net Value Change after treatment. Figure 22b shows the *change* in Relative NVC pre- and post-treatment; this map allows users to more easily discern where a change in Net Value is at least trending in the right direction. The green areas show how Segment 1 affects the landscape by decreasing the loss during a SW wind event under 90th percentile weather conditions.

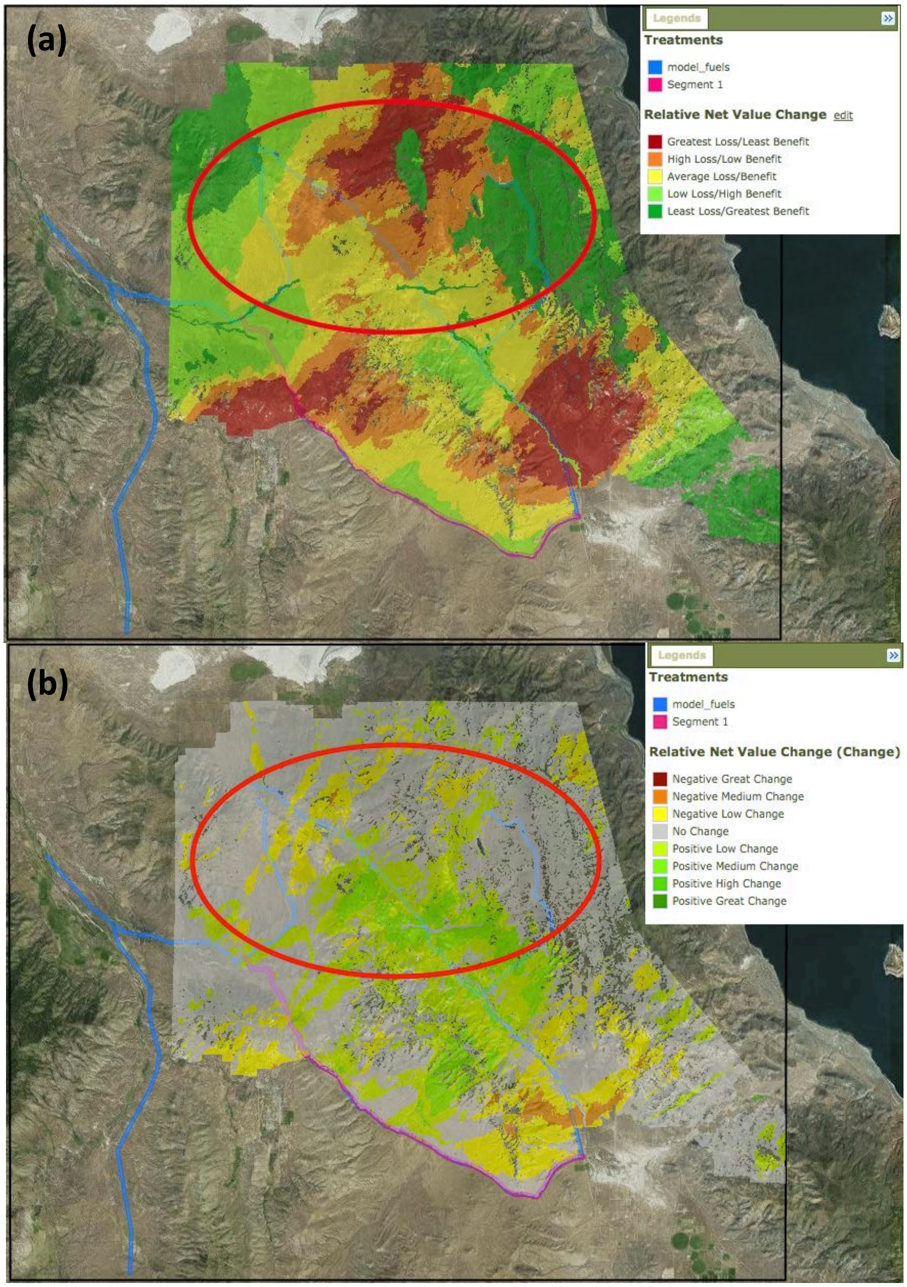
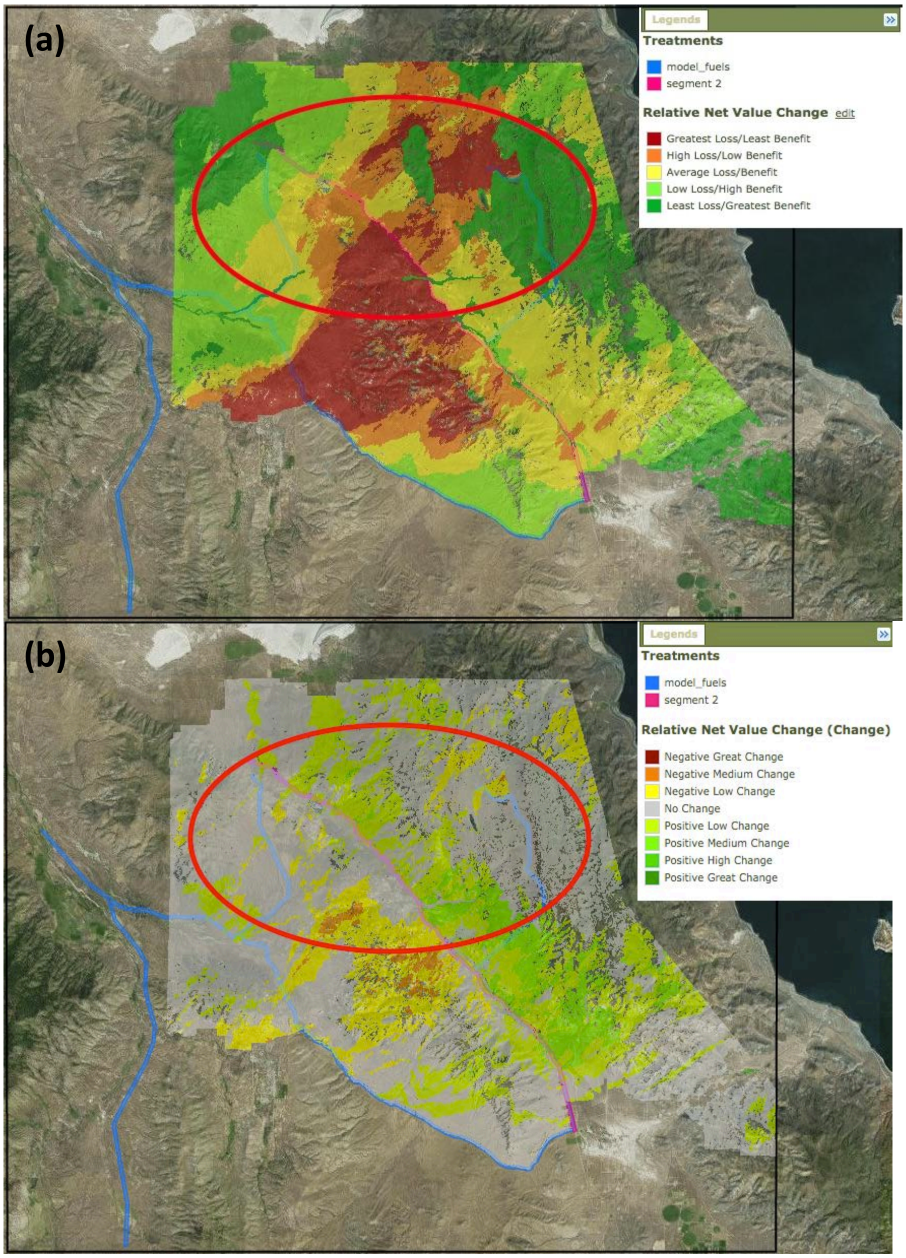


Figure 22. Relative VAR Analysis results (a) show loss and benefit when only the Segment 1 (pink line) fuel treatment is modeled. Red oval indicates primary sage-grouse habitat. Blue lines represent all the identified treatments, but all are not used as actual treatments in this analysis. Because true losses and benefits are difficult to discern on the Relative NVC assessment map, the change in Relative NVC map (b) shows how the values shifted positively or negatively after treatment, compared to the current condition. Green indicates the area has moved in a positive direction as a result of the treatment. IFTDSS REF: (Values At Risk Iterations>> VAR Segment 1) Segment 1 fuel treatment only.

Second, Segment 2 was made the only active fuel treatment (Figure 23). Again, results are shown in five equal bins that represent Relative Net Value Change, as well as the *change* in Relative Net Value Change. When only Segment 2 is implemented, results inside the red circle are similar to Segment 1, but the greatest losses appear in different areas of the landscape. Because the scenario is a strong SW wind under 90th percentile weather conditions, a large part of the landscape southwest of Segment 2 shows little to no change in value between pre- and post-treatment.



Note the isolated bright green polygon in the top center of the red circle. Figure 20 identifies this as a "1A" polygon. Table 2 shows all fires in 1A have a benefit. This benefit is seen in Figure 21 when there is no treatment, and again in Figures 22a and 23a when there IS treatment. Figures 22b and 23b show this same area as grey because there is "no change" from the current condition to the treated condition. But green also shows in areas outside of 1A or 2A polygons. This is due to either a change in burn probability or change in flame length, depending on Table 2 values. Sometimes green represents beneficial fire, and sometimes it represents fire effects trending in a desirable direction.

*Figure 23. VAR Analysis results (a) show loss and benefit when only the Segment 2 fuel treatment is modeled. Blue lines represent all the identified treatments, but are not used as actual treatments in this analysis. Red oval indicates primary sage-grouse habitat. Because true losses and benefits are difficult to discern on the Relative NVC assessment map, the change in Relative NVC map (b) shows how the values shifted positively or negatively after treatment, compared to the current condition. Green indicates the area has moved in a positive direction as a result of the treatment IFTDSS REF: (Values At Risk Iterations >> VAR segment 2)***.**

Third, only the two lightning “arm” segments were activated as fuel treatments for a VAR run (Figure 24). In this case, the results show a higher overall area that is burned with the greatest loss (red), compared to when only the Segment 1 or Segment 2 treatments were tested (Figures 22a, 23a). However, with a southwest wind used in the scenario (not the southerly lightning storm wind), it is not a surprise that the “arm” segments would not impede a fire from spreading up through the middle of the primary habitat area since winds could easily push a fire between segments.

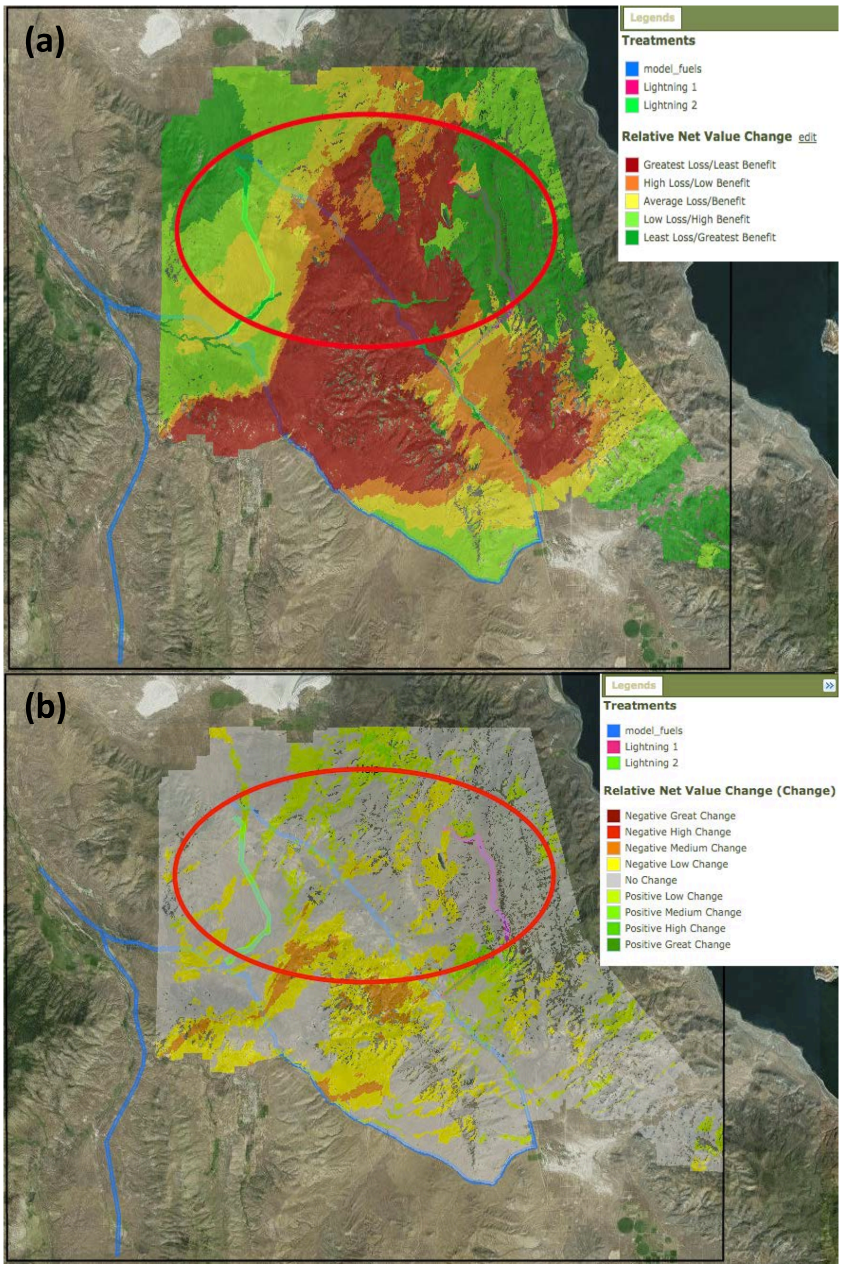


Figure 24. VAR Analysis results show loss and benefit when only the Lightning “arm” fuel treatments are modeled. Blue lines represent all the identified treatments, but are not used as actual treatments in this analysis. Red oval indicates primary sage-grouse habitat. Comparing this with analyses for Segments 1 or 2, results here show the least positive shift in value (green) in the core habitat area. IFTDSS REF: (Values At Risk Iterations >> VAR lightning) Two Segments Lightning.

Finally, all three fuel treatments were run in a VAR analysis (Segments 1 and 2, Lightning Arms) with results displayed in five equal Relative Net Value change bins (Figure 25a). Figure 25b shows the difference between the treated and untreated landscapes. In this case, 46% of the landscape inside the core habitat shows a less negative response after treatment. However, it is difficult to discern whether the result is truly beneficial versus only less negative.

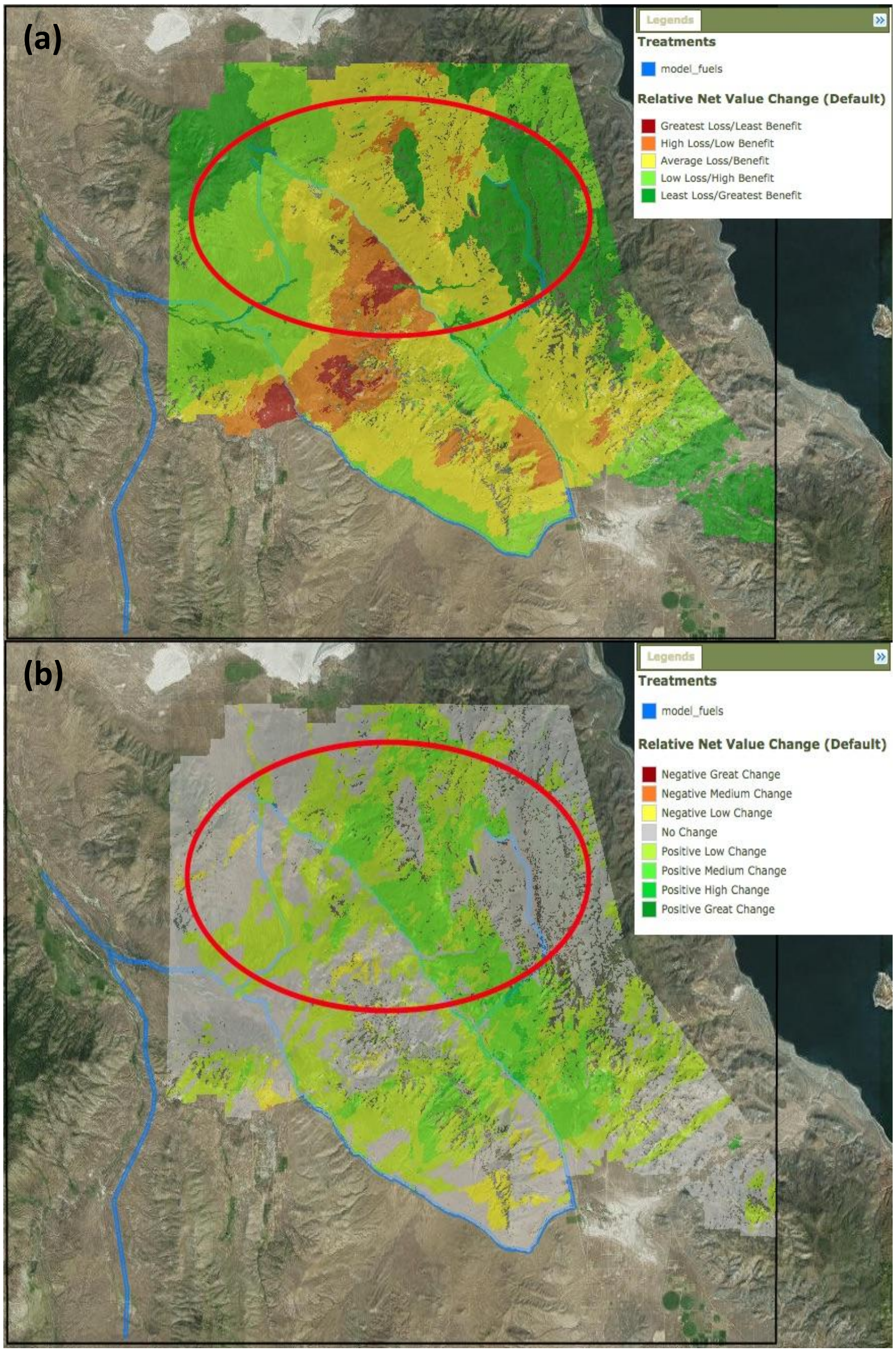


Figure 25. The Relative Values at Risk results (a) show five equal bins of Net Value Change when all three treatments (Segment 1, Segment 2, and Lightning Arms) are implemented. The difference in Net Value Change (b) between the existing condition and the treated landscape shows a large area inside the core sage-grouse habitat (red oval) exhibiting a less negative change than without treatment. IFTDSS REF: Values At Risk >> VAR all fuels) Post treatment>Relative Net Value Change (Default).

Sequencing of fuel treatments can be informed by comparing results from Figures 21, 22, 23, and 24. It would not be wise to implement the Lightning Arms treatments without also implementing Segments 1 and 2. Segments 1 and 2 have a similar positive impact (36701 acres, 39500 acres, respectively). Therefore, a logical conclusion would be that Segment 2 should be implemented first, followed by Segment 1, followed by the Lightning Arms segments (16471 acres impacted in a positive direction) (Figure 26). Of course, this is an illustration of how the analysis can be accomplished, and it would be appropriate to run more analyses with treatments combined in different ways, or test different weather scenarios to see if the results change. IFTDSS can be used to run any number of scenarios until the analysis team decides results are sufficient.

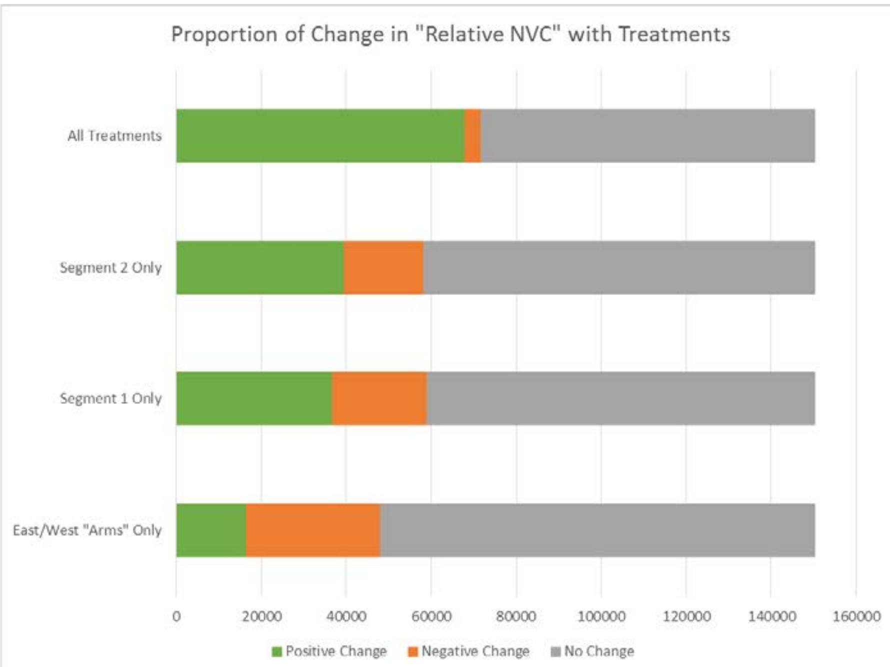


Figure 26. Proportion of the change in "Relative Net Value Change" after treatment ONLY for 150,000 acres of core habitat that had RR polygons delineated. Four scenarios were evaluated. The "All Treatment" scenario shows that 68,000 acres (green) were moved in a positive direction from pre- to post-treatment, 4,000 acres had a more negative outcome, and 79,000 acres did not change. When comparing results from these four scenarios, users can conclude that, based only on NVC, Segment 2 would be a good choice to implement first, Segment 1 next, and East/West arms last. Implementing "All Treatments" is better than any single treatment. This graphic was created in Excel using numerical values output from IFTDSS.

Step 5. Analysis Conclusions

Three products were produced in this pilot study from which analysis conclusions can be drawn: Overall Burn Probability (IFT-RANDIG), Minimum Travel Time (IFT-MTT), and the Values at Risk workflow.

In this pilot study, where sage-grouse is the one highly valued asset and fire is overwhelmingly negative, simply reducing the Overall Burn Probability is one way to assess treatment effectiveness. Figure 17 spatially displayed Overall Burn Probability with and without treatment. Table 1 quantified that reduction across 74% of the landscape, which is nearly 293,000 acres. To more clearly see where on the landscape the desired outcome occurred, Figure 18 spatially displayed the *reduction* in Overall Burn Probability. Local managers can assess the Overall Burn Probability maps and statistics to determine if the fuel treatments would be effective.

Slowing fire spread, as illustrated in IFT-MTT results (Figures 10, 13, and 14), can certainly enhance suppression capability so that unwanted fires are smaller or can be steered away from core habitat. This type of analysis is useful to confirm that fuel treatments will perform as intended under certain, specific scenarios. Since all scenarios cannot be tested, use of this tool may be limited to just a few, key scenarios. However, IFT-MTT displays potential fire spread with and without treatment, and can be used to game-out fuel management solutions.

The Values at Risk Workflow demonstrates that the potential landscape fire effects in core sage-grouse habitat are influenced in a positive *direction* when treatments are applied. Again, these categories represent equal bins of the change in NVC; therefore, the "Positive Great Change" in dark green could represent pixels that changed from -100 to -10 for a positive change of 90, yet still represent negative fire effects. In this pilot study, it is difficult to know if that positive direction is truly *beneficial* or if it is *less bad*. Based on the response functions in Table 2 where nearly all fires have a negative impact, fire can only benefit the landscape in small, discrete areas defined by polygons 1A and 2A. In Figure 21 we see "green" on the untreated landscape outside of 1A and 2A polygons. This is because user inputs impact how results are displayed and interpreted. In this case, modelers retained the five even breakpoint bins (default) for displaying the change in NVC; therefore, the range of calculated NVC values across the landscape simply has the top 20% of values (values closest to +100) display as "Least Loss/Greatest Benefit" and the bottom 20% of values (values closest to -100) display as "Greatest Loss/Least Benefit". In this case, because of the way the breakpoints and range of values coincided, some of the *less bad* pixels are categorized in the same bin as the *beneficial* pixels.

In Figures 22a-25a, which display change in NVC with treatments, the same display rules apply as described above. More green on these maps (than in Figure 25) suggest more pixels are being categorized in the 20% bins closest to +100 (positive change in Net Value). Again, it is difficult to discern beneficial from "less bad" except in areas we know are inside of 1A and 2A polygons, since Table 2 shows that fire in these areas is never detrimental. Figures 22b-25b aid viewers in seeing where on the landscape the NVC is trending in a positive direction.

Treatment prioritization was also evaluated with the Values at Risk Workflow output. These maps show that it would not be wise to implement the Lightning Arms treatments without also implementing Segments 1 and 2, and that Segment 2 appears to have slightly more positive impact than Segment 1. Therefore, a logical conclusion would be that Segment 2 would be the priority, followed by Segment 1, followed by the Lightning Arms segments. Since treatments do not all happen in the same year, and funds are limited, this can be helpful in making prioritization decisions.

With a number of different highly valued assets, or more variability in values' responses to fire, the results of the Values at Risk Workflow could lend more clarity to an assessment of trade-offs among competing priorities. In this case, a decision-maker can see spatial representations of the landscape changes in Net Value as they pertain to sage-grouse habitat with and without treatment.

Report Goal 2: Highlight issues identified during the pilot project that inform discussions regarding IFTDSS (2.0 Beta) application development priorities.

This Pilot Project confirms that the IFTDSS 2.0 Beta application, in its current state of development, can fully perform pre- and post-treatment evaluations and risk assessments to facilitate evaluation and quantification of treatment effectiveness on sage-grouse habitat.

The current status of IFTDSS as a beta application under active development provided both opportunities and obstacles in evaluating its capability to perform sage-grouse habitat analyses as requested (Table 3). Not only did the Pilot Project aid the team in identifying many application technical bugs and shortcomings, it allowed fixes to be immediately developed, applied to the application, and re-tested. Additionally, for those desired enhancements not able to be addressed immediately, the IFTDSS team was able to add them to a list of potential enhancements for future development priorities (see development priorities discussion below).

The most evident obstacle regarding working in the IFTDSS beta environment was working with underlying fire behavior modeling systems that did not incorporate the most recent model enhancements. The Pilot Project underscored the importance of upgrading modeling systems in IFTDSS as soon as possible, which the IFTDSS team has now identified as a high development priority. Additional desired functionality includes the ability to utilize multiple shapefiles rather than require external GIS work to create a single shapefile with all desired information for uploading. Enhancements are also needed to facilitate calculation of percentile weather, which is currently done externally in Fire Family Plus software. Finally, exporting tabular data for more robust graphing and summary reporting would aid users in completing comparisons for reports. Each of these items are listed as potential enhancements for future development.

IFTDSS Development Timeline and Future Priorities

Discussions among BLM leadership regarding field readiness or applicability of IFTDSS in its current state to perform sage-grouse analyses should consider IFTDSS development timelines and future priorities, as well as the desired scale of analysis, and the knowledge and skills needed to complete these analyses using methodologies outlined in Report Goal 1. Considerations are:

- IFTDSS development will continue in Beta status through 2017/2018 (next 12-24 months).
    - In March 2016, a new vendor contract addressed current development priorities (as funded):
        - Improved workflow configuration and intuitiveness,
        - User interface enhancements,
        - Improved map functionality,
        - Upgraded underlying fire behavior models.
    - Development priorities beyond those listed above are undecided and funding-dependent.
    - The IFTDSS Team is currently discussing establishment of a development priority list with the NWCG Fuels Management Committee and the IFTDSS Oversight Group.
    - Clear articulation of development desires and intentions from the BLM with regard to how the application may be used by their field personnel can help influence Development Priority direction;

for example, FTEM reporting may be facilitated through the IFTDSS graphical interface to assist in reporting efforts (Douglas, n.d. [Memorandum, 2016-07]).

- Desired scale of analysis:
  - IFTDSS (2.0 Beta) was designed to be implemented at the project scale (30m resolution) and can conduct complex analyses up to 400,000 acres in a reasonable computational timeframe (24 hours for the most computationally complex analyses).
  - Any proposed decision to accommodate significantly larger analysis landscapes or resample for analysis at higher landscape resolution would need to be evaluated as an IFTDSS (2.0 Beta) development priority and discussed with agency leadership and the IFTDSS Oversight Group.
  - BLM's definition of a specific target analysis scale (landscape acreage) will facilitate identifying proposed development options (e.g. resampling to a coarser landscape resolution, utilizing shape files to accommodate irregularly shaped project area boundaries, modification of model algorithms) as IFTDSS development moves forward under a new vendor contract.

Knowledge and Skills Needed to Complete Analyses

The IFTDSS sage-grouse project team identified a process to complete quantitative risk assessments within IFTDSS (2.0 Beta). The process currently includes some tasks that must be completed outside of IFTDSS with software programs familiar to most fire analysts. Specific knowledge and skills needed to run IFTDSS and other fire behavior or weather applications are a combination of traditional fire behavior or long-term analysts and fire ecologists and include these suggested skills:

- Ability to identify known problematic fire scenarios and appropriate weather and fuel moisture conditions for analysis based on percentile weather for the area; advanced understanding of populating and using a Fire Family Plus database.
- Ability to critique and calibrate a LANDFIRE Landscape ensuring surface and canopy fuels represent local conditions and fire modeling outputs represent local observed and historic fire characteristics, spread rates, and spread patterns; facilitated by use of Compare Models.xls spreadsheet, and local knowledge of historic fire spread events.
- Ability to associate fire behavior and effects with resistance and resilience habitat information, and create response functions for identified values at risk based on resilience and resistance concepts from Chambers et al. 2014
- Ability to work in a dynamic software environment; ongoing Beta development status of IFTDSS will result in continuous improvements but also will cause changes in interface, outputs, and functionality.

It remains critical in any modeling effort to calibrate the model. In this pilot project, there were no current active fires to use in calibrating this exercise; therefore, calibration was based on historic fire sizes (Appendix B).

The Pilot Project Team has begun the process of developing a step-by-step guidebook to facilitate field implementation of the methodology that is detailed in this report. Completion of such a guidebook, if desired, would require engagement of BLM staff to assist by providing feedback and testing the process with other project area datasets.

Table 3. Opportunities and Obstacles When Working in IFTDSS Beta Environment.

Opportunities	**Obstacles**
Identification of technical bugs allowed developers to work with analysts to quickly understand the nature of the problem and get them fixed.	The number of technical bugs delayed early progress on the Pilot Project workflow.
Identification of model, map interface, and application shortcomings to inform future development needs.	Application shortcomings necessitated "workarounds" or work external to the application: ● Limited map display functionality ● Limited shapefile capacity and manipulation functionality ● Limited historic weather analysis functionality requires use of Fire Family Plus software outside of IFTDSS application ● Limited tabular and graphical reporting functionality
Immediate fixes to identified bugs allowed application updates to be made quickly and tested by a group of dedicated analysts, including some updates that resulted in a 20-fold increase in processing time.	Outdated models resulted in some reduced functionality. Replacing FlamMap 3 with FlamMap 5 and IFT-RANDIG with FConst MTT/nodespread will provide the following enhancements: ● Repeatable ignition scenarios to facilitate pre- and post-treatment risk assessment comparisons ● Incorporation of spotting option into all fire behavior and spread modules ● Incorporating Wind Ninja to capture gridded winds taking into account terrain and vegetation effect on wind (instead of single speed and direction) ● Dead fuel moisture conditioning capability ● Additional interim outputs available for advanced users

Report Goal 3: Articulate data and modeling limitations encountered (not necessarily unique to IFTDSS 2.0 Beta) that highlight future research and development priorities.

Fire modeling at a landscape level requires landscape data and mathematically-based modeling systems. Both have limitations. LANDFIRE data are the best currently available and any landscape-level modeling (IFTDSS or other) would be severely hampered without it; nevertheless, limitations are highlighted here. Efforts underway within both the LANDFIRE community and the IFTDSS development community may mitigate these data issues in the future.

Data Inconsistencies

LANDFIRE data are assembled by stitching together several map zones where fuel models are interpreted through a variety of processes and refreshed periodically (Nelson, et al. 2013). LANDFIRE Fuel Model inconsistencies across map zone boundaries precludes the ability to aggregate results to broader scales without first critiquing and editing to ensure consistency. Failing to address these inconsistencies and using the data "out of the box" will result in erroneous analyses. This issue is not unique to IFTDSS. Deciding whether to address these fuel model assignment discrepancies and fuel treatment characterization definitions universally across project planning areas or locally within focal areas will influence the scale at which the results can be interpreted. Subject matter expertise is needed whether addressed universally or locally.

LANDFIRE canopy cover values in the project area typically under-represent the actual amount of canopy present. Therefore, simulating a "conifer removal" treatments cannot be represented by removing the canopy data if it didn't exist in the LANDFIRE data in the first place. Adding it (height and canopy density values) would require a judgement call that is difficult to justify without field data. In this case, surface fuels were modified in post-treatment LANDFIRE data rather than attempting to quantify actual changes in canopy. Because spotting in the models requires a canopy component in the landscape file, having such little canopy can limit the frequency of spot fires across areas of unburnable fuels, including fuel breaks or roads.

Fire Modeling Systems—Limitations and Assumptions

IFTDSS inherits all the limitations and assumptions of the fire modeling equations and systems embedded in the user interface such as FlamMap 3, RANDIG, and Minimum Travel Time (McHugh 2014). Some assumptions are that fire spread is elliptical, and burns in a free-burning steady-state. Limitations include no ability to model rolling material, no ability to model firing patterns, and a homogenized, rasterized spatial data that may be too coarse to represent fine-scale variability, among others. At this time, IFTDSS does not condition fuel moistures based on slope and aspect, and only simulates spot fire potential in the Minimum Travel Time modules.

There can be disagreement among analysts about how to characterize potential fire weather used in analyses. Here, 90^{th} percentiles were used. It is the opinion of this team that analysis at 97^{th} percentile weather conditions tend to "wash out" any potential effectiveness of fuels treatments due to the fast burning nature of the shrub and grass fuels. Additional modeling using 80^{th} percentile weather scenarios would help stratify outputs to demonstrate relative fuels treatment effectiveness.

When modeling currently burning fires, analysts spend a considerable amount of time making adjustments to fuel models to get acceptable outcomes from fire models based on fire behavior observations. A recent analysis of 9,780 incidents entered in the Wildland Fire Decision Support System (WFDSS) revealed that more than 50% of all changes made to existing fuel maps were within non-forest fuel types. The large seasonal/annual climate response in rangeland fuel loads substantially alters fire behavior as well as associated emissions, with profound implications for firefighter safety, fuel treatment effectiveness, and air quality throughout much of the country. Yet current fuel mapping processes, such as LANDFIRE, are unresponsive to these annual or seasonal fuel changes. Consequently, this disconnect between high inter-annual climate variation and existing fuel data creates confusion, decreases the efficacy of decision support, puts lives and property at risk, and reduces the likelihood of positive outcomes. The inability to incorporate the inter-annual weather response of rangeland fuel loads into decisions support systems significantly limits the effectiveness of efforts critical to core agency goals (pers. Comm. Dr. Matt Reeves). This disconnect can be addressed using state-of-the-art fuel mapping methods and more timely remote sensing information developed by Dr. Matt Reeves at the Rocky Mountain Research Station in Missoula, Montana. These advancements have led to improved fuel data that may be useful in major decision support systems in the future.

Gaps remain in our collective understanding of sagebrush-steppe ecosystems, fire effects, invasive species, and management techniques. Although considerable research is ongoing, successful application of that science in risk modeling will continue to evolve as we understand what makes landscape resistant and resilient (U.S. DOI, 2015). Improvements are needed in: (1) developing better understanding of vegetation dynamics in non-forested systems, (2) developing better characterization of sagebrush-steppe and invasive annual grass fuels, treatment actions, effects, and associated changes in potential fire behavior, (3) linkages between fuels and habitat quality for key species, and (4) developing economic models (such as avoided cost) to describe the cost-effective return of investments. To ensure progress in this arena, there are opportunities to develop new, integrated modeling systems, built from current systems or developed as new systems.

Conclusion

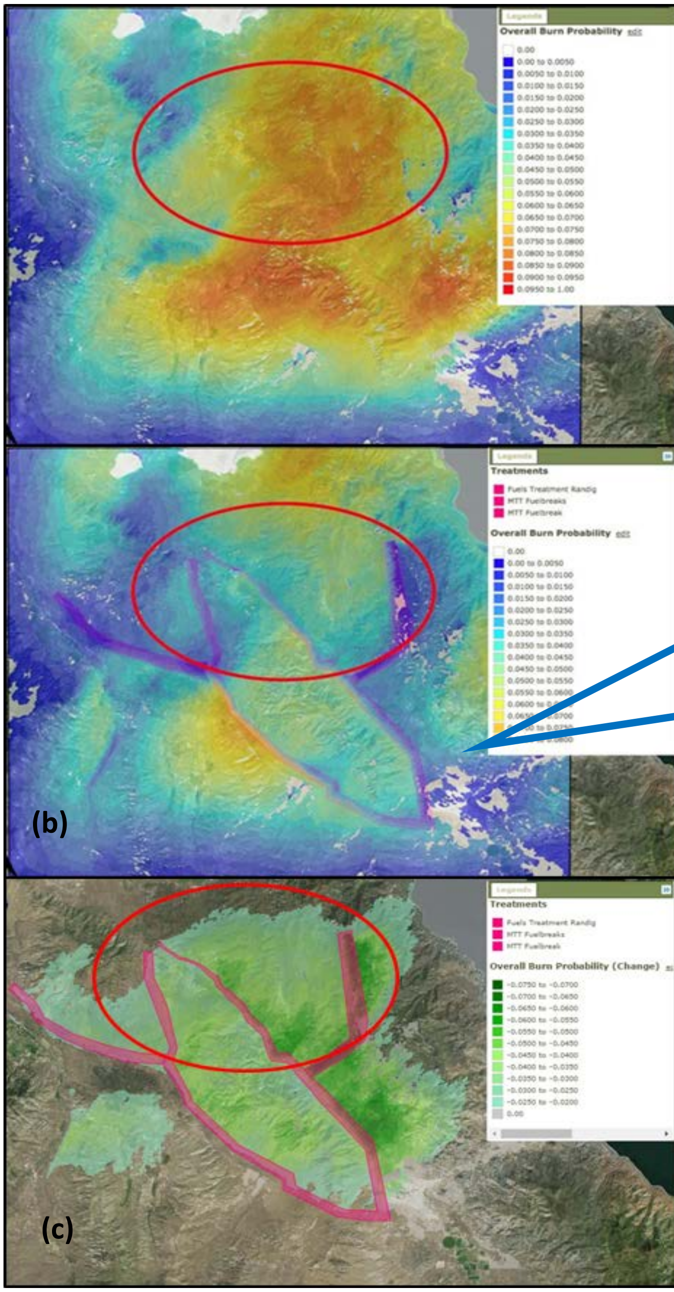
The goals of this Report were to evaluate the capability of IFTDSS (2.0 Beta) to perform analyses supporting SO 3336, identify future IFTDSS application development priorities, and articulate modeling limitations encountered during this type of analysis. To fulfill these goals, a group of analysts used IFTDSS with data from the BLM Nevada, Carson City District, Virginia Mountains project area to seek a modeling methodology that would illustrate how fuel treatments might reduce threats to sage-grouse habitat. This report describes the analysis process at a unit level, describing how fire behavior and effects on this highly valued habitat can be assessed with maps and data generated in IFTDSS.

Results demonstrate that multiple workflows in IFTDSS can effectively be applied to generate spatial and graphical summary outputs to quantify effects on sage-grouse habitat associated with modeled fire behavior (Report Goal 1). In the process of developing an analysis methodology, issues were identified to inform future IFTDSS development priorities including an enhanced interface, improved map functionality, and use of updated fire behavior modeling systems (Report Goal 2). Finally, overarching modeling limitations were articulated so as to aid future research priorities in the field of fire modeling, including landscape-level data acquisition and ecological understanding of sagebrush-steppe ecosystems' responses to fire, invasive species, or management techniques (Report Goal 3).

Analysis Objectives Report Summary

The four pilot project *analysis* objectives that serve to answer management questions about fire behavior, treatments, and values were to (1) develop a method to inform location of fuels treatments to achieve least loss to habitat, (2) assess proposed treatments to determine which result in least habitat lost, (3) inform prioritization and sequence of treatments, and (4) assess need for treatment outside of project area to prevent impacts of large, fast-moving fires within the project area.

1. A five-step process was developed to illustrate how IFTDSS users at the unit level would assemble modeling data, analyze current landscape burn probability using IFT-RANDIG, design treatments within IFTDSS, quantify treatment effectiveness, use IFT-MTT to further test realistic fire scenarios, and prioritize/sequence the treatments using a risk assessment workflow that quantifies Net Value Change. A basic understanding of fire behavior models and calibration, combined with use of online tutorials, would allow most unit-level fire/fuels specialists to complete this type of analysis.
2. Proposed treatments were analyzed using Burn Probability, producing maps of pre- and post-treatment results, maps of the change in Burn Probability, and statistical charts displaying change in Burn Probability for a specific lek area (Analysis Steps 2 and 3). IFT-RANDIG model results are spatially displayed on maps, indicating where Burn Probability changed. Overall Burn Probability was reduced across 74% of the treated landscape (293,000 acres), compared to the untreated landscape (Figure 27).

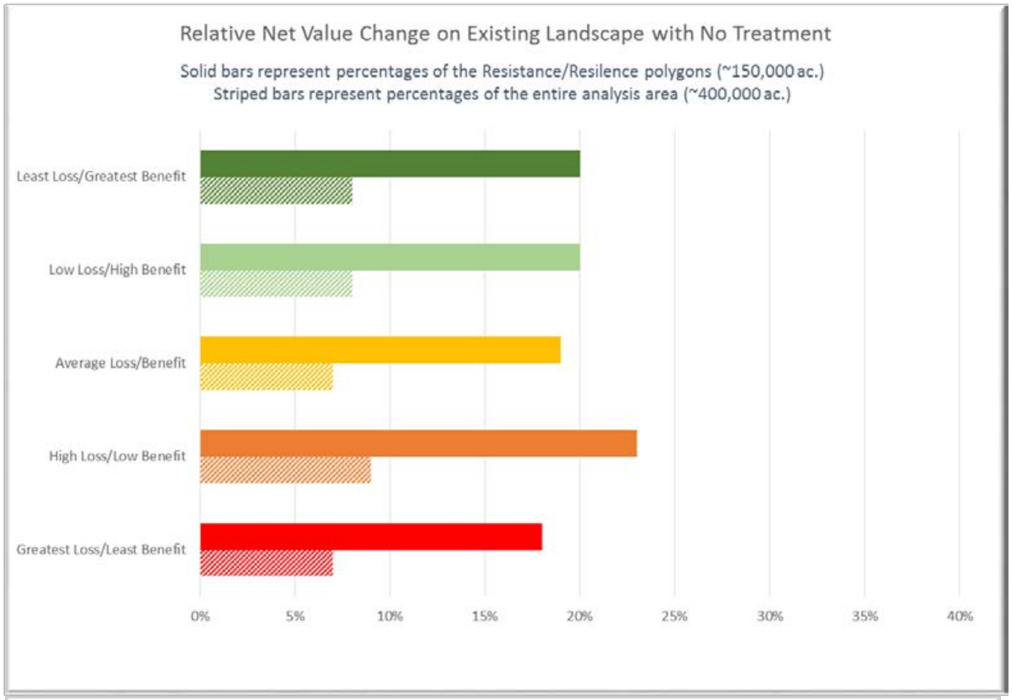


	Acres	%Landscape
Lower Burn Probability	292,737	74%
Higher Burn Probability	52,641	13%
No Change	53,033	13%

Figure 27. Examples from the body of the Report showing (a) spatial depiction of Overall Burn Probability without treatments, (b) spatial depiction of Overall Burn Probability with three treatments, and (c), spatial depiction of the change in Overall Burn Probability with three treatments. Call-out box shows post-treatment tabular data in a table created outside of the IFTDSS interface.

3. Prioritization and sequencing of treatments was evaluated with the IFTDSS Risk Assessment Workflow whereby response functions were assigned for four flame length categories, and resistance/resilience polygons were identified in the area of interest (Analysis Step 4). Results included landscape-scale maps of Net Value Change (NVC) without treatments, landscape NVC results with only one treatment applied at a time, with all treatments, and maps of *change* in the landscape NVC. By comparing NVC for the various treatment scenarios, conclusions were drawn as to the highest priority treatment, and the order of additional treatments. The analyses indicated that every treatment indeed improved NVC to varying degrees, but

simultaneously implementing three of the treatments resulted in 46% of the landscape with a *less negative* fire response than before treatment (Figure 28). This is not the same as a *beneficial* fire response (reference discussion on page 31 of this report). Results from the Values at Risk Workflow provide decision makers powerful visual landscape images of where NVC trends in a positive direction when influenced by various levels of treatment. It is important to note that these results are based on the spatial representation of values at risk and assigned “response functions,” which are critical inputs used in conjunction with Burn Probability to derive final outputs. In this pilot project, values included *only* sage-grouse habitat polygons identified through the FIAT process, and response functions were based on local opinion regarding subsequent vegetation response to those flame lengths and associated fire intensities. The Pilot Project model outputs must be viewed in the context of these inputs.



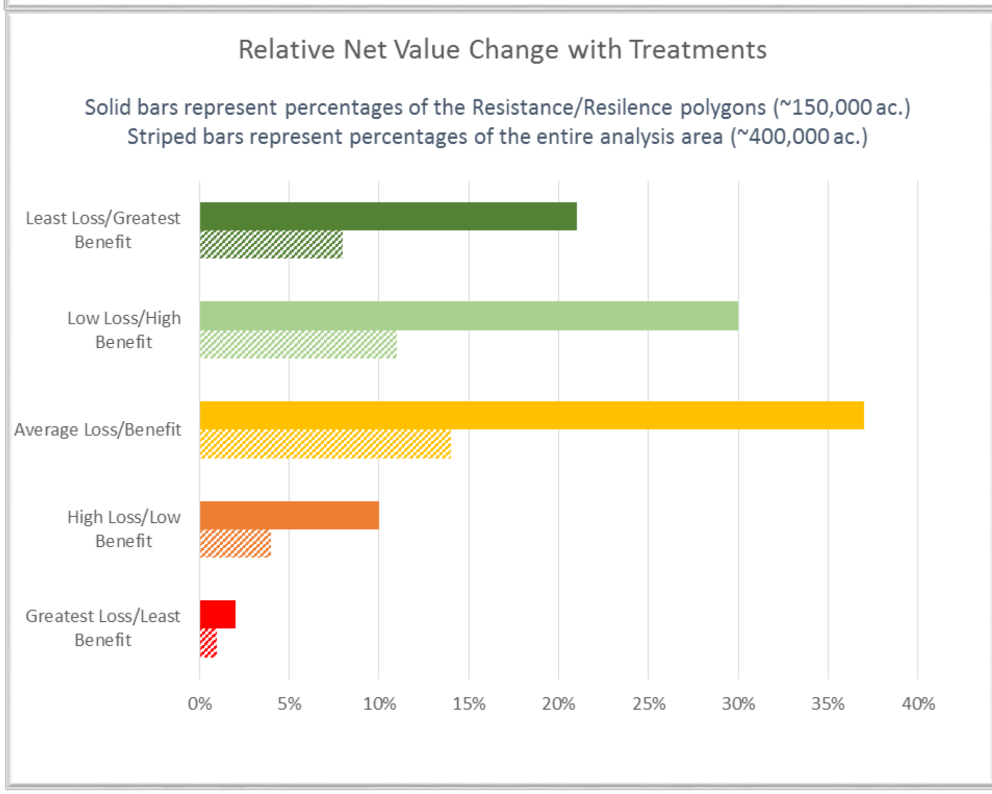


Figure 28. Net Value change (NVC) results with no treatments (top) and all treatments applied (bottom). Note Greatest Loss/Least Benefit and High Loss/Low Benefit acres are reduced across the landscape for the entire area and for only the core sage-grouse habitat acres. These acres move to the Average, Low Loss/High Benefit, or Least Loss/Greatest Benefit categories after treatment. Graphics were generated outside of IFTDSS using model results.

4. The need for treatments outside of the project area was illustrated using a common fire scenario in the area where vehicles start multiple fires along a roadway some distance from the core sage-grouse habitat (Analysis Step 3). IFT-MTT results showed maps of fire arrival time, indicating the size and shape of fires, as well as potential to reach the sage-grouse habitat area. An additional fuel treatment designed outside of the core habitat was tested, showing slower fire arrival times and fire sizes. A map of the change in fire arrival times illustrated treatment effectiveness with fire arrival time delayed by 2 hours across 18,000 acres, facilitating a suppression response.

The analysis considered both fuel treatments generated during the IFTDSS process, and treatments already proposed by the local unit. The body of this report uses IFTDSS-generated treatments to illustrate concepts and results. Current NEPA-proposed treatments from the local unit were also analyzed, but reported only in Appendix A to facilitate explanation of the process through a single example in the body of the report.

Combined, IFT-RANDIG, IFT-MTT, and the Values at Risk Workflow were effective in assessing proposed treatments, uncovering the need for additional treatments, and informing prioritization and sequencing of implementation. Although there were data inconsistencies that had to be remedied, and limitations and assumptions inherent in any fire behavior modeling system, results of this pilot study are positive. These analyses show that fire modeling tools in IFTDSS can be applied to assess landscape burn probability, generate burn statistics for leks under specific scenarios, model effects of existing fuel treatment designs on fire travel time, display results that suggest new fuel treatment designs, support drawing of new fuel treatment polygons, address sequencing of treatments, and determine change in Net Value through a risk assessment process. Additionally, IFTDSS is cloud-based to allow sharing of analyses among a team of individuals to facilitate communication and interpretation. Finally, IFTDSS takes little expertise to run beyond what is already required of fire and fuels analysts at local and regional levels, and a comprehensive help system can guide users as they progress through any analysis.

This Pilot project was extremely beneficial to the IFTDSS Development Team in both identifying application issues and understanding field analysis needs. Feedback from BLM Fire Management Leadership and follow up discussions based on these preliminary findings are necessary to ensure future actions meet the project’s desired intent.

Bibliography

Calkin, David E.; Ager, Alan A.; Gilbertson-Day, Julie, eds. 2010. Wildfire risk and hazard: procedures for the first approximation. Gen. Tech. Rep. RMRS-GTR-235. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 62 p.

Chambers, Jeanne C.; Pyke, David A.; Maestas, Jeremy D.; Pellant, Mike; Boyd, Chad S.; Campbell, Steven B.; Espinosa, Shawn; Havlina, Douglas W.; Mayer, Kenneth E.; Wuenschel, Amarina. 2014. Using resistance and resilience concepts to reduce impacts of invasive annual grasses and altered fire regimes on the sagebrush ecosystem and greater sage-grouse: A strategic multi-scale approach. Gen. Tech. Rep. RMRS-GTR-326. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 73 p.

Douglas, J. (n.d.). *Unprotected Lands; Identifying Wildland Fire Protection Responsibilities in Sagebrush-Steppe Ecosystems*, OWF Policy Memorandum 2016-06. Washington, DC. Office of the Secretary, US Dept. of the Interior. 2p.

Douglas, J. (n.d.). *Performance Metrics to Validate Fuels Management Activities to Protect, Restore, and Maintain Sagebrush-Steppe Ecosystems*, OWF Policy Memorandum 2016-07. Washington, DC. Office of the Secretary, US Dept. of the Interior. 4p.

McHugh, Charles. 2014. S-495 Unit 1: Introduction to Geospatial Fire Analysis, Interpretation and Application, Lesson 2: Theory, Assumptions, and Limitations of Fire Behavior Models. Unpublished course materials available in online learning at www.frames.gov. 37p.

Miller R. F., Chambers, J. C., Pellant, M. 2014. A field guide to selecting the most appropriate treatments in sagebrush and pinyon juniper ecosystems in the Great Basin: Evaluating resilience to disturbance and resistance to invasive annual grasses and predicting vegetation response. Gen. Tech. Rep. RMRS-GTR-322. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 72pp. http://www.fs.fed.us/rm/pubs/ rmrs_gtr322.html.

Nelson, K.J., Connot, J., Peterson, B., Martin, C. 2013. The LANDFIRE Refresh Strategy. Fire Ecology Volume 9, Issue 2. p. 80-101. http://fireecologyjournal.org/docs/Journal/pdf/Volume09/Issue02/080.pdf

Short, Karen C. 2013. Spatial wildfire occurrence data for the United States, 1992-2011 [FPA_FOD_20130422]. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. http://dx.doi.org/10.2737/RDS-2013-0009l.

U.S. Department of the Interior, 2015b, An integrated rangeland fire management strategy—Final report to the Secretary of the Interior: Rangeland Fire Task Force, 82 p., https://www.forestsandrangelands.gov/rangeland/documents/IntegratedRangelandFireManagementStrategy_FinalReportMay2015.pdf

Appendix A: NEPA-Identified Treatments

In addition to the fuel treatments created through the IFTDSS analysis process detailed in the body of this report, IFTDSS was used to demonstrate a process whereby NEPA-proposed treatments on the Virginia Range landscape could be tested for effectiveness and prioritized. These treatments are shapefile polygons acquired from the BLM, Carson City District and are shown in Figure 1. Some of these treatments are "fuel breaks," such as the one shown in purple, and others are "conifer removal" treatments, such as the one shown near the center in light green.

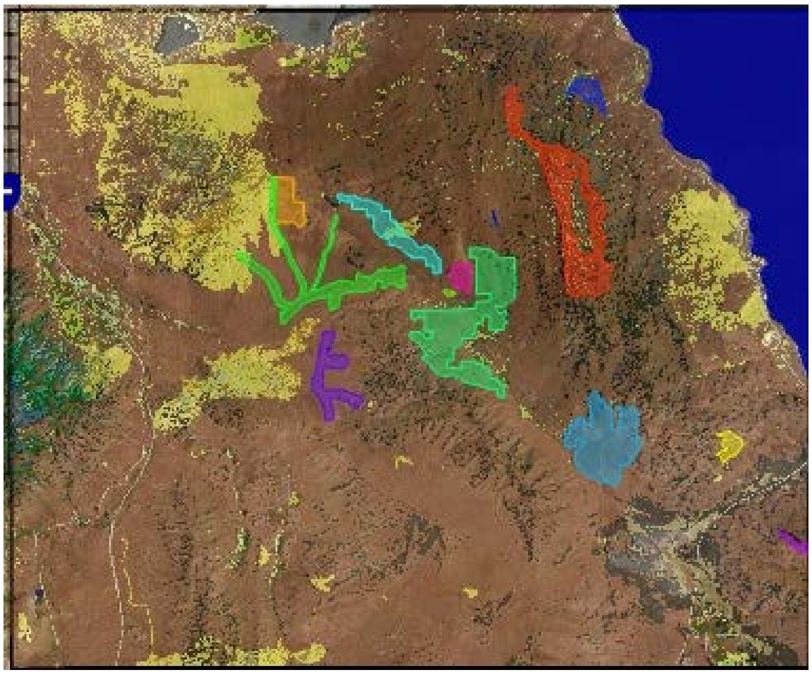


Figure 1. NEPA-proposed fuel treatments in the analysis area.

The Values at Risk (VAR) analysis results in Figure 2 depict all the NEPA-proposed fuel treatments on the landscape with 2500 random ignitions, a 6 hour burn period, and the same 90th percentile weather used in the analyses detailed in the body of this report. Because the 90th percentile winds are from the southwest, treatments (red arrows) located south of the core habitat area are most effective in impeding fire movement into the area of interest, defined by the red circle. The lowest losses, represented in greens, are in the core sage-grouse habitat area.

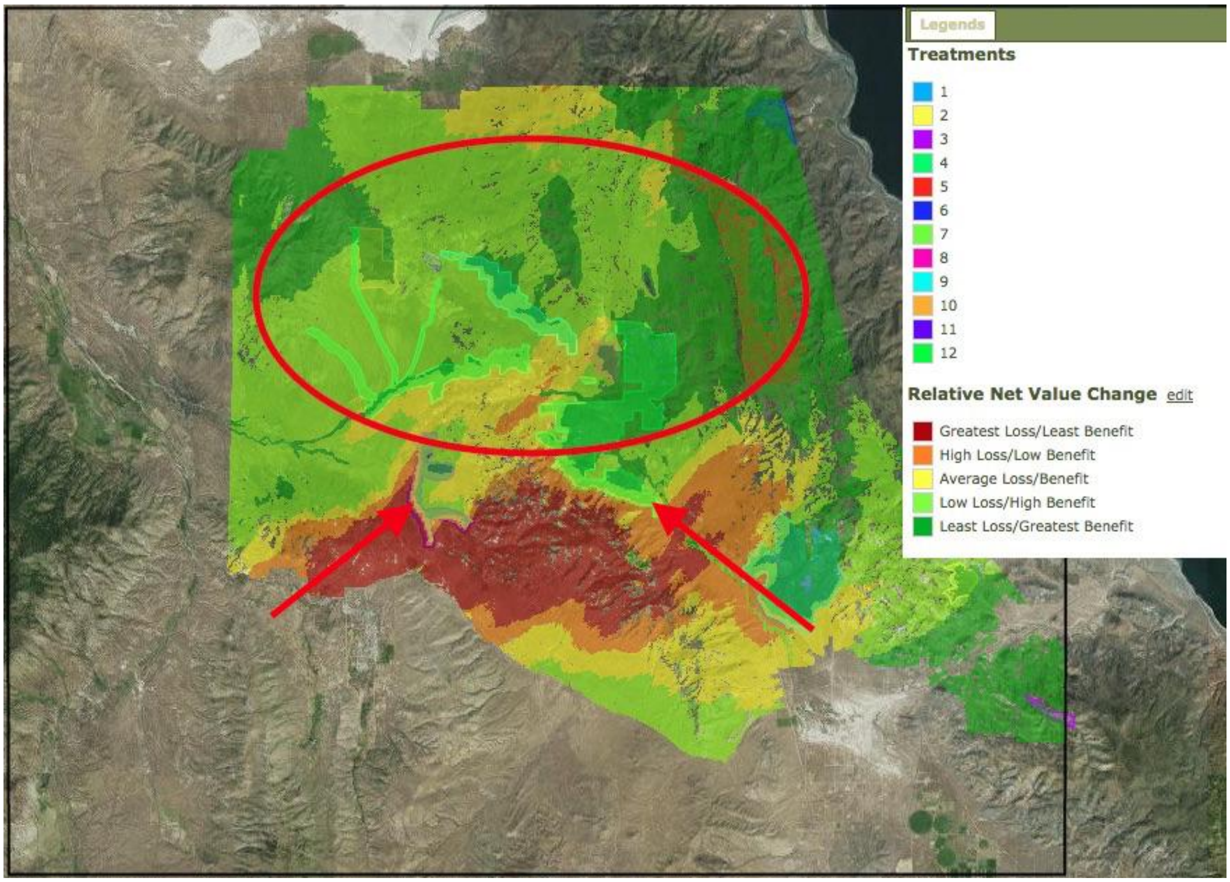


Figure 2. Values at Risk output when NEPA-proposed fuel treatments are used in the analysis. IFTDSS REF: (Values At Risk Iterations >> Risk Proposed Fuels Treatments I).

The analysis was repeated using the same weather conditions, but a different suite of fuel treatments. In this scenario, the proposed fuel breaks were included, but the conifer removal fuel treatments were excluded. This situation removes one of the two fuel treatments highlighted in Figure 1. Notice that, in Figure 3, the missing conifer fuel treatment (indicated by yellow arrow) no longer slows fires. These fires now spread into the primary sage-grouse habitat area unimpeded and the result, rather than a "Low Loss/High Benefit," is now a "High Loss/Low Benefit".

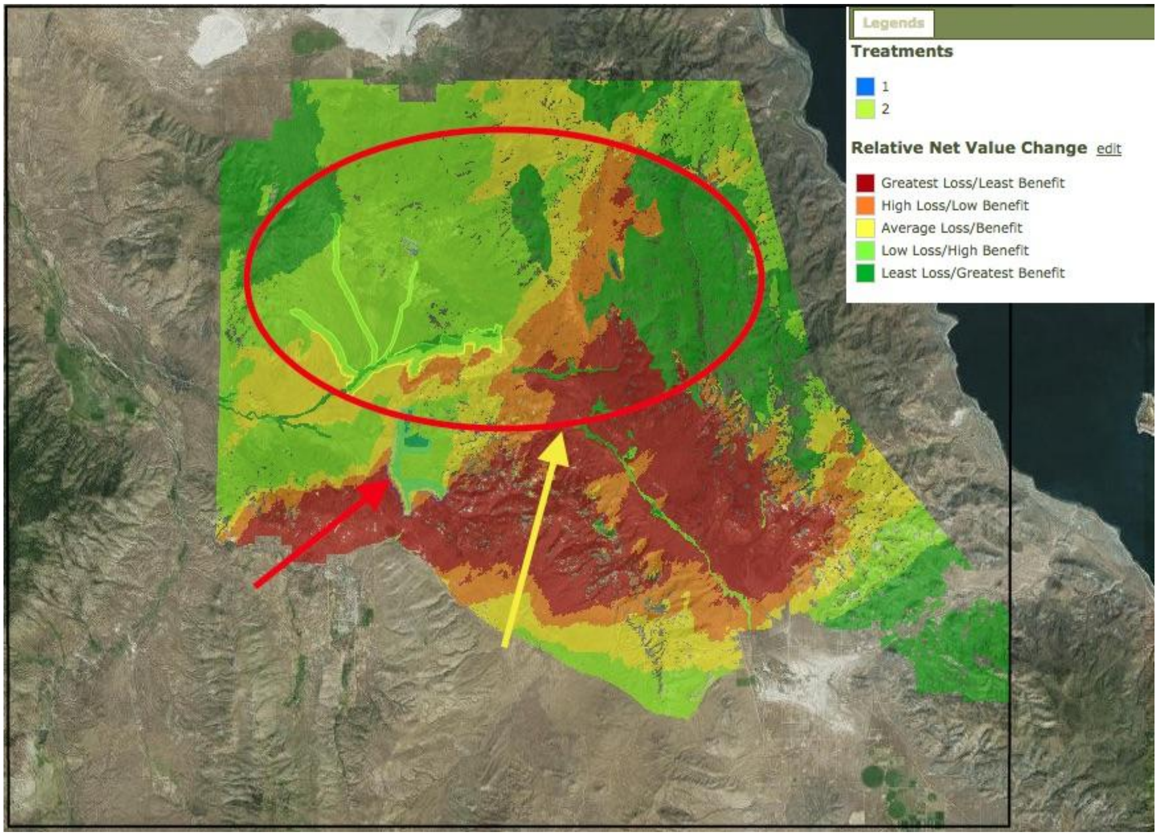


Figure 3. Values at Risk Analysis with NEPA-proposed fuel breaks, but without the NEPA-proposed conifer fuel treatments. IFTDSS REF: (Values At Risk Iterations >> Risk Proposed Fuel Breaks).

These two analyses illustrate that the two treatments located south of the habitat area are effective in modifying fire spread from prevailing southwest winds and reduce potential damage to the sage-grouse habitat area. These analyses demonstrate how IFTDSS helps inform treatment effectiveness and provides insight to prioritize implementation of fuel treatments. Further analysis can be performed to prioritize the other proposed fuel treatments and to assess potential human and lightning ignitions by continuing to test treatments in a sequential fashion. This is simply a demonstration of the process.

Appendix B: Unedited Landscape Analysis

LANDFIRE fuels layer data typically requires modifications for modeling applications. For this project, the LANDFIRE (v. 2010) data were modified to reflect local conditions, which was detailed in the body of this report. However, analyses were repeated on the unedited landscape for comparison purposes.

Figure 1 displays a human ignition scenario along Highway 395 under the same 90th percentile weather conditions as the analyses detailed in the body of this report, but with no LANDFIRE fuel modifications. With unaltered LANDFIRE fuel models, the average fire size after 6 hours of burning under 90th percentile weather conditions was 2,782 acres, which was smaller than expected. This was likely due to inadequate representation of shrub fuels. Many of the observed shrub fuels were depicted in unmodified LANDFIRE data as grass (e.g. showing as GS2/122 when it should be SH5/145).

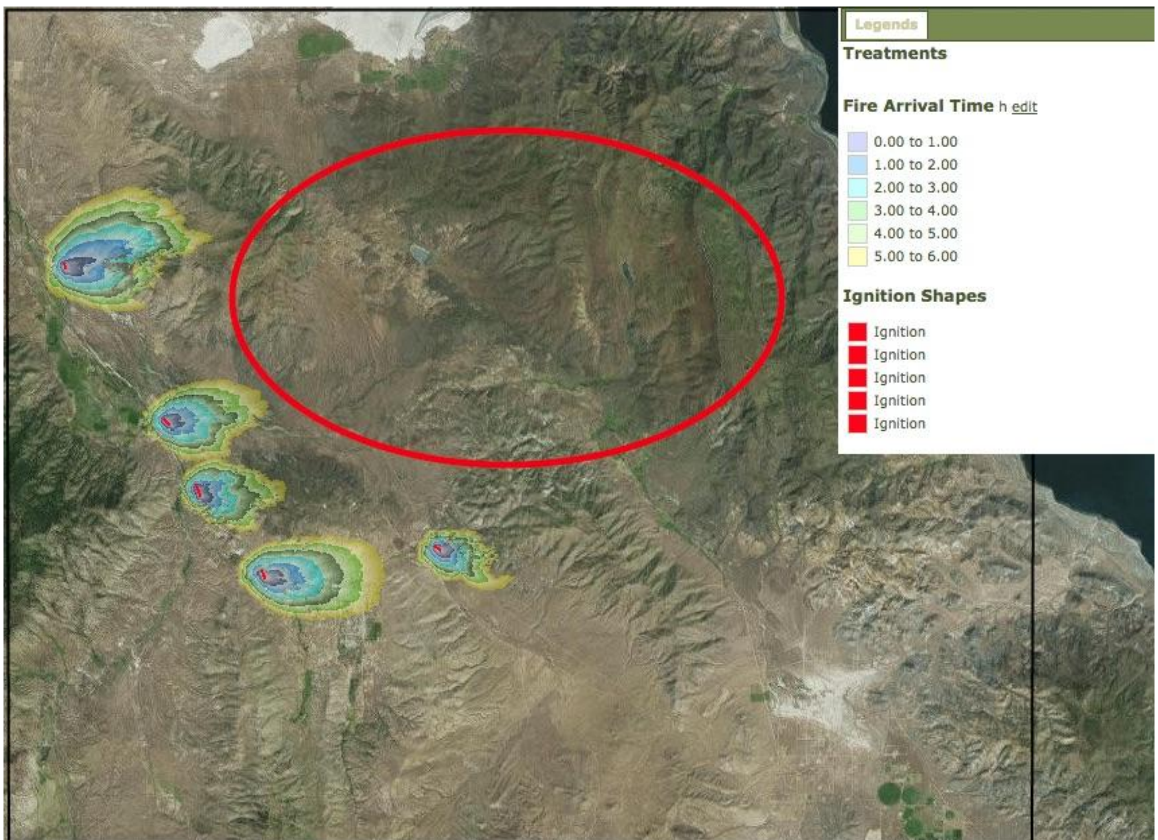


Figure 1. Minimum Travel Time, Highway 395 scenario, no treatment and unedited LANDFIRE data. IFTDSS REF: (UnEditedLandscape >> Human Starts MTT Unaltered).

Historic fires from 1999-2013 ranged from 1,349 to 36,000 acres with a mean acreage of 11,551 (n=7). However, fire sizes in areas where another fire had not previously occurred to limit new fire spread were 36,000 acres and 22,675 acres. These sizes are more indicative of the potential in the habitat area modeled here. Changes to the existing condition for the LANDFIRE fuel models subsequently produced modeled fires averaging 23,678 acres. Therefore, fuel model changes were deemed sufficient to represent the existing condition. By changing fuel model GS2-122 to SH5-145, fire sizes were modeled at acreages similar to actual wildfires burning under conditions that similar to what was modeled.

Figure 2 depicts a Minimum Travel Time run in the same lightning scenario as used in the main body of this report. The left image is the unedited landscape, and the right image is the edited landscape. The two images show the distinct differences in fire behavior between the edited and the unedited LANDFIRE fuels in the landscape file. The right image represents fire behavior more representative of expected fire behavior.

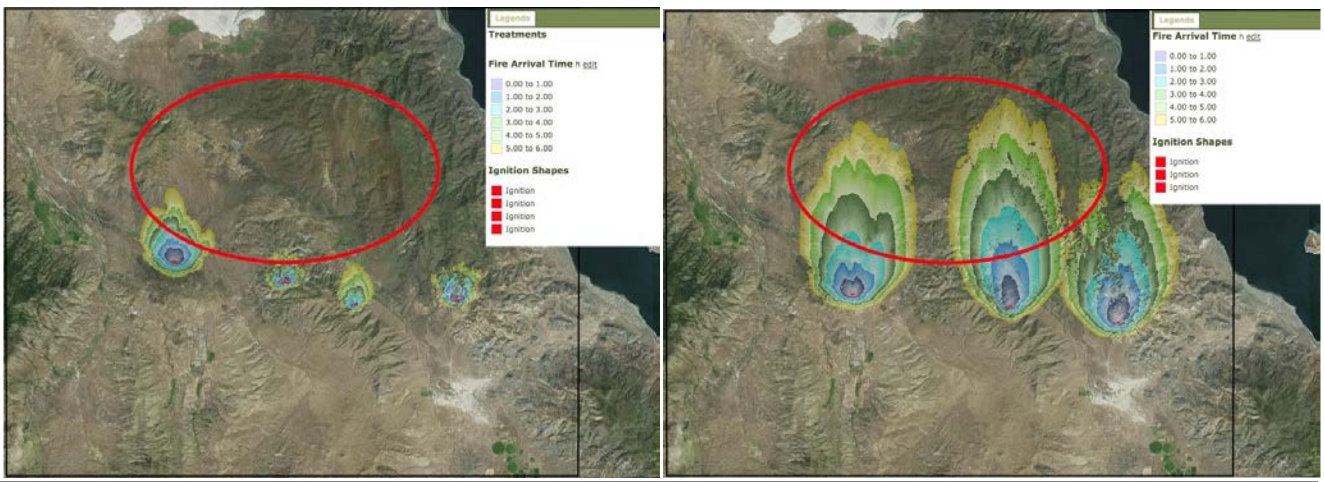


Figure 2. Minimum Travel Time, Lightning scenario, no treatment and unedited LANDFIRE data. IFTDSS REF: (UnEdited Landscape >> MTT Lightning Unaltered Landscape)/(Sage Grouse Set Up>> 90th Percentile 2 Lightning scenario Fuel Break edits) Pre Treatment.