SIMPPLLE modeling for Forest Plan Revision

June 2017
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Part 1: Natural Range of Variation

Introduction

The SIMPPLLE model

The SIMPPLLE model (SIMulating Patterns and Processes at Landscape level scaLEs) is used in Region 1 Forest Plan revision for two purposes: to calculate Natural Range of Variation (NRV) and to project the landscape conditions of the Alternatives for analysis in the Environmental Impact Statement. This document discusses the use of SIMPPLLE to analyze NRV. The introduction describes the nature and utility of SIMPPLLE. This is followed by a discussion of data sources, calibration, and finally a discussion of results specific to the Flathead National Forest.

The SIMPPLLE model is a stochastic vegetation simulation model used to model vegetation conditions for the National Forests. It takes a landscape condition at the beginning of a simulation (including past disturbances and treatments) and uses logic to grow the landscape through time, while simulating processes (growth, fire, insects, etc.) that might occur on that landscape during the simulation, accounting for the effects of those processes. Process occurrence in a timestep is dependent on many factors, including the vegetation's conditions at that timestep, the occurrence of past processes at a site, and proximity to other areas experiencing the outbreak of a particular process. Simulation timesteps are typically ten years, and simulations often are made for multiple timesteps. The logic assumptions in the model are set by the analyst, and come from a variety of sources, including expert opinion, empirical data, and modeled data from other forestry computer applications such as the Forest Vegetation Simulator.

One of the main utilities of the model is its stochastic nature. Managers cannot know with precision the specific types, locations, and extents of natural disturbances that will occur on the landscape. Therefore, the SIMPPLLE model will randomly assign fire, insect, and disease processes on the landscape in a manner consistent with what is known about the nature of these disturbances (e.g., insect-prone stands have a higher hazard and probability of getting an infestation, especially in a dry climate cycle). The model is typically run for multiple iterations to allow the manager to see a variety of possible projections, look for patterns, and adjust management response accordingly.

The other main utility of the SIMPPLLE model its spatially interactive nature. A process occurring on one site is dependent, to an extent, on the processes that are occurring on adjacent sites. Consider a fire event. SIMPPLLE simulates fire by assigning fire *starts* with a probability consistent with what historic records indicate for the area and climate. Each start is then given the opportunity to grow. The size the fire grows to is dependent on the surrounding vegetation as well as the historic probability that it will end with a weather event (or, if simulating fire suppression, whether or not there are enough resources,

etc. to put the fire out). The *type* of fire that spreads (lethal, semi-lethal, and non-lethal) is dependent on the vegetation conditions of the site (including past disturbance or treatment), the climate assumption for the timestep, its elevational position relative to the burning fire (uphill, downhill, etc.) and whether it is downwind or not. Again, the fire process will stop according to the probability of a weather ending event, successful fire suppression, or perhaps it runs up against a natural barrier such as the treeline or a lake. SIMPPLLE will then determine the *effect* of the fire by considering whether there are trees present capable of re-seeding/re-sprouting the site (in the case of a lethal fire), whether the stand's fuel conditions have been reduced (for semi- or non-lethal fires), and if there has been a change in size and/or species on the site.

Natural Range of Variation

The 2012 Planning Rule directives (FSH 1909.12 Chapter 20) describe using the Natural Range of Variation (NRV) as a basis from which to understand ecosystem integrity and establish desired future conditions that enhance the resiliency of the landscape. In the Zero Code of these directives is the definition of NRV, generally: "the variation of ecological characteristics and processes over scales of time and space that are appropriate for a given management application". The definition goes on to suggest that, "the pre-European influenced reference period considered should be sufficiently long, often several centuries…" and should "…include short-term variation and cycles in climate."

For the Flathead plan revision, we chose to model vegetation conditions from AD 960 through 2000. This reference period allowed us to simulate the conditions associated with much of the time period known as the Medieval Climate Anomaly (MCA) as well as the other end of the climate spectrum known as the Little Ice Age. The inclusion of the MCA in the simulation is potentially valuable in that it might indicate conditions and processes that could occur in the modern climate regime (Calder, Parker, Stopka, Jimenez-Moreno, & Shuman, 2015).

Data Sources

Vegetation Conditions

The Region 1 VMAP product for the Flathead National Forest was used to populate the landscape with Dominance Type, Size and Density information needed by the SIMPPLLE model. VMAP is a vegetation map derived mainly from remote sensed (satellite) data calibrated with on-the-ground sample data. The Dominance Type was supplemented with secondary species data using a combination of "looks like" data provided with the VMAP product and quantities of species presence indicated by Forest Inventory and Analysis (FIA) data. The "looks like" data is a similarity percentage to other polygons that are typed with a particular dominance type. For instance, a Douglas Fir VMAP polygon may have a "looks like" value for Ponderosa Pine of 20%. This indicates the polygon has a similar appearance to other polygons known to have Ponderosa Pine, but only a 20% similarity. If FIA indicates there is more Ponderosa Pine on the landscape than the VMAP has as dominance type, we searched for the most likely sites to add Ponderosa Pine as a secondary component by searching for the appropriate "looks like" threshold for each species. For instance, a "looks like" threshold for Ponderosa Pine of 15% would mean the site in question would be classified as a DF and PP mix. Ultimately the data from this process is used to

populate the grid of 150 m squares used in the SIMPPLLE simulation. See APPENDIX 1 for a detailed description of how this data was generated.

That said, we realize that pinning down an exact starting condition is not of much value for NRV (it is valuable for doing futuring and analyzing the Plan Alternatives, but that is another discussion). For one, it is a fallacy to assume that the conditions on the ground today are representative of vegetation conditions in the year 960. Secondly, the starting conditions for NRV are arguably not critical to the simulation. Other NRV studies, such as those conducted by LANDFIRE, use random starting conditions (reference). Therefore, to begin each simulation in the year 960, the current vegetation conditions derived from VMAP/FIA are simulated with the climate data from the past 15 decades, mainly to "wash" out the influences of modern vegetation management and fire suppression. Ultimately, the vegetation conditions resulting from this initial 150 year projection were used to approximate the landscape at year 960. A similar "washing" method was used by (McGarigal & Romme, 2012), who modeled current conditions for 100 years before summarizing results.

Initial Logic Assumptions in SIMPPLLE

The initial SIMPPLLE model logic used for the Flathead revision came from a long history of expert opinion, trial-and-error, and research that has been maintained and documented in logic files that are passed from forest to forest. These assumptions are documented in the model itself, through the Assumption Documentation screens. Before the Flathead, the Nez Perce Clearwater revised their logic in 2012 for an NRV run, and these assumptions were used in part as a basis for the Flathead analysis. However, there were several key points of logic updates made specific to the Flathead that occurred in two phases. First, the SIMPPLLE model developer (Jimmie Chew) was hired as a consultant to visit and update the Nez Perce Clearwater assumptions for the Flathead. These updates are documented in (Chew, 2014). Secondly, the assumptions were fine-tuned in a calibration exercised described here.

Historic Climate

In consultation with the RMRS in Missoula Montana, we determined that the appropriate indicator of past climate was the Palmer Drought Severity Index (Cook, Woodhouse, Eakin, Meko, & Stahle, 2004). PDSI has also served as an indicator for historic climate in other historical vegetation reconstructions (McGarigal & Romme, 2012). Data for the Index is typically reconstructed for localized points, and the data point nearest the Flathead was used to evaluate the climate for the area. Data is presented as a yearly indicator and therefore had to be generalized to a decadal average for simulations in the SIMPPLLE model. The data was smoothed using a 30 year third order "spline" function, which means that a curve was fitted for each year using a localized set of 30 data points using a third order polynomial equation (Figure 1). A random starting year within the first decade was then chosen to represent that decade, and points every 10 years from then were used to represent the full set of decadal index values. Finally, the points were categorized into 3 climate scenarios – wetter, dryer and normal – based on their quartile. The driest quartile indicated the dry decades of the simulation, the middle two were considered "normal" and the wettest represented the wet decades. Specifics of the data sources and analysis methods used to determine the historic climate for the Flathead National forest are found in APPENDIX 2.

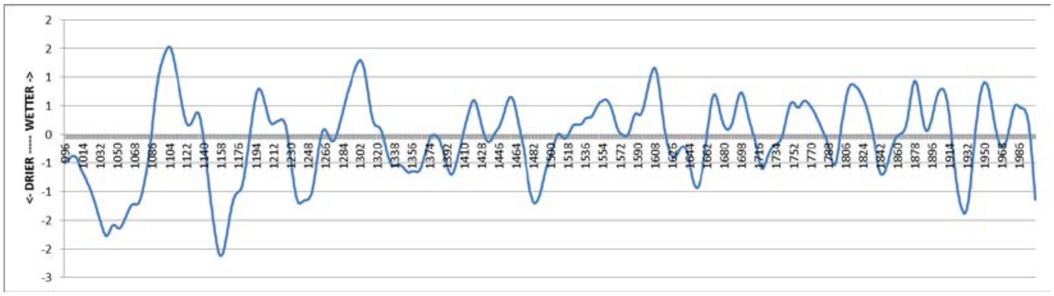


Figure 1 Smoothed Palmer Drought Severity Index values to represent historic climate

Default SIMPPLLE assumptions

Generally the default assumptions for the SIMPPLLE model (Westside Region 1 and Eastside Region 1 zones) are the result of many discussions with experts and researchers over the past 20+ years. Typically with every new application of the SIMPPLLE model, new science, thinking, and information is incorporated that improves the function and performance of the model beyond the previous application. These assumptions are then maintained and archived for future use by the next SIMPPLLE application. Again, the initial assumptions for the Flathead were based on those from the Nez Perce Clearwater NRV analysis and revised by (Chew, 2014) for the Flathead plan revision. Some of the nuances of resolving data conflicts and assigning existing processes to the starting landscape (such as root disease and recent fire) is documented in (Scott, 2014) (appendix F).

Pathways

Pathways describe decade-to-decade vegetation changes that result from the various disturbance and successional processes to which the vegetation might be subjected. They do not, however, define the likelihood/probability of those processes occurring. Processes probability and occurrence is logic defined elsewhere in the SIMPPLLE model, and described below. Figure 2 is a depiction of the SUCCESSION pathway for the DF-LP-ES-AF type on the D3B Ecological Group. The green arrows indicate the trajectory for vegetation condition if the SUCCESSION process is applied. Generally, vegetation becomes older, larger, and denser with this process. A set of pathways is defined for each of the potential processes that may be defined for this type, such as DF-BEETLE, STAND-REPLACING-FIRE, LIGHT-LP-MPB, etc. In total, the Flathead worked with about 175,000 pathways in the model (each arrow being a single pathway).

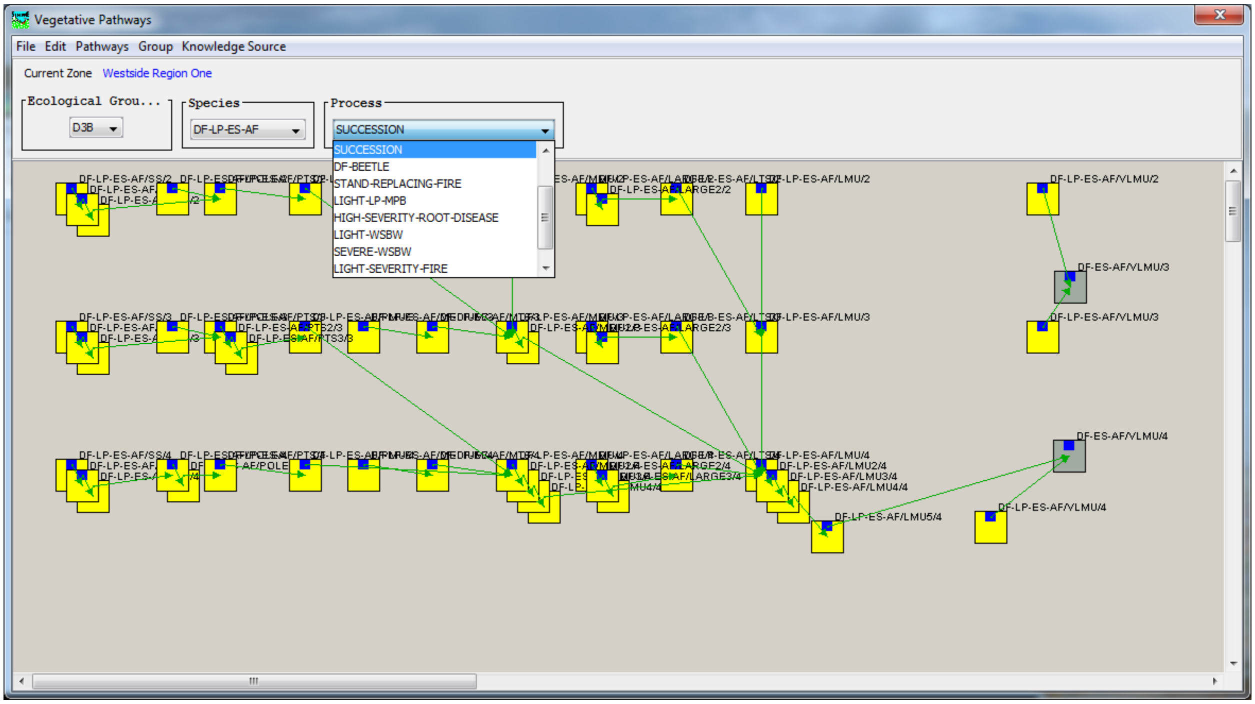


Figure 2: Succession pathway diagram for DF-LP-ES-AF vegetation type on Ecological Group D3B

Fire

Fire Process assumptions in SIMPPLLE are the most complex. Again, the default assumptions used to seed the Flathead NRV model had been developed over the years with a combination of research and expert opinion.

The key fire assumptions used in NRV are:

1. The probability of a fire starting in a pixel
2. Type of fire that starts in particular vegetation conditions
3. The fire spread type for particular vegetation conditions, climate, slope, and weather
4. The probability of a weather ending event stopping the fire at a particular size class.

The first assumption, probability of a fire starting in a pixel, was derived from the Region's fire start/history database. Since 1985, the forest has collected location data on where fires start on the forest. See Figure 3 for a depiction of where these fire starts have occurred. The data was analyzed to determine the decade when the most fire starts occurred on the forest. This decade was then used to represent the most extreme conditions in the model. The probability of fire occurring in a single pixel is simply the number of fire starts in this decade divided by the total acreage in the area being modeled. However, there are a few nuances to this method that should be considered.

1. The database (by inspection in Figure 3) appears incomplete. That is, there are conspicuous areas where there are no recorded fire starts. Analysis shows that these are largely non-Forest Service lands where data records are incomplete. To accommodate this phenomenon, only fire

starts on Forest Service lands were counted and the total area of Forest Service ownership was used to derive the probability of fire starts.

2. Since we used the most extreme decade as a base assumption for probability of fire starts, we added a probability to the SIMPPLLE model that some of these fires would extinguish immediately in climate periods that were not WARM-DRY. The probabilities were initially determined by comparing the decade with the most recorded fire starts to that with the least fire starts and using the ratio as a basis for the probability in the COOL-MOIST decades of the simulation. The NORMAL decades had a probability between the two. This analysis is supported by comparing the PDSI with the number of fire starts in the database (Figure 4). By inspection, one can infer that dry years are associated with more fire starts and wet years have fewer fire starts.
3. We attempted to account for the phenomenon of anthropogenic ignitions. This was accomplished in consultation with the Forest Archaeologist who was able to find records of historic campsites/occupation as well as travel routes. The natural lightning ignitions in these areas were assumed to be complemented by human caused ignitions. These areas were explicitly mapped as in the blue outlined areas of Figure 5. The Swan Valley was further analyzed with LandFire data to include Fire Regime Class of 35 years or less as part of the area with increased fire start probability. The exact magnitude of the increased probability is impossible to determine. Therefore, we used it as a variable calibration metric (meaning that if we saw model results inconsistent with our understanding of the ecology of the area, we could adjust this probability appropritately) and set the probability at 50% higher than the base fire probability of the rest of the area.

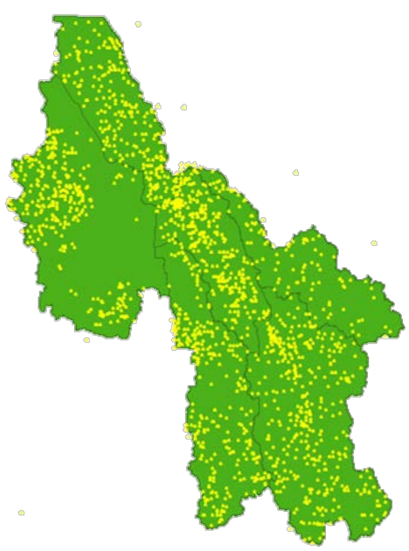


Figure 3: Fire Start data available for Flathead National Forest

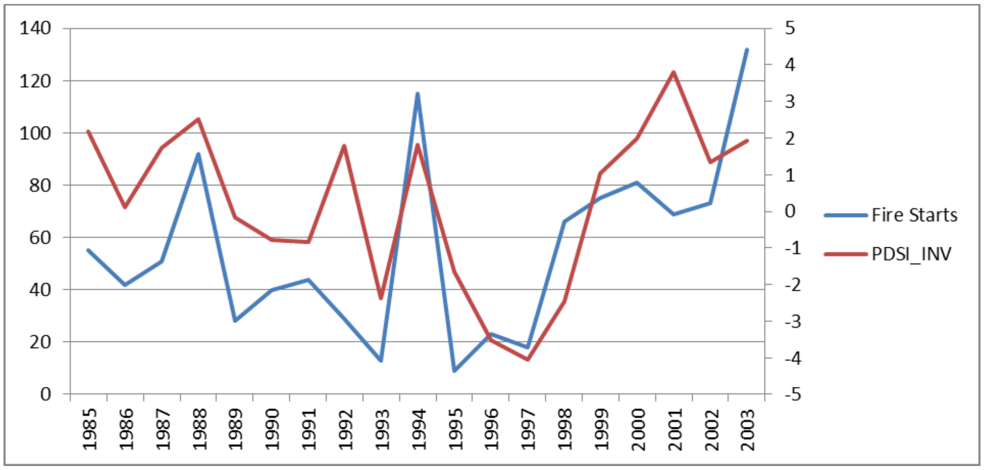


Figure 4: PDSI index^{-1} vs. number of fire starts

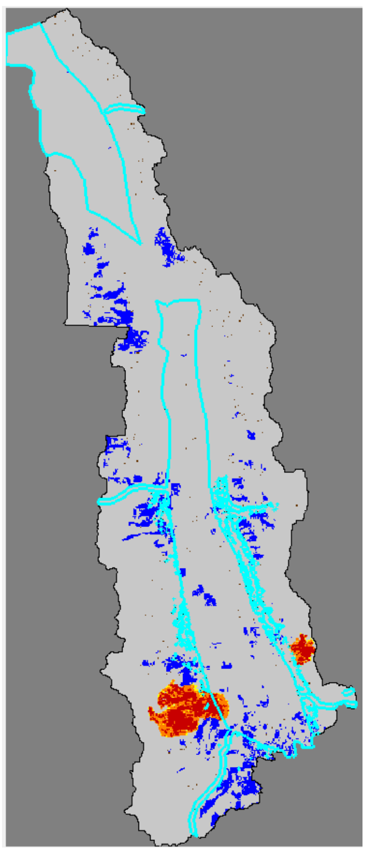


Figure 5: Areas with assumed higher fire start occurrences from historic anthropogenic burning

The second assumption (type of fire that occurs in a particular vegetation condition) has minor implications, as it only describes the severity of the fire in the pixel in which the fire event originates. So, not much time is spent revisiting the assumptions that are the model defaults.

The third and fourth assumptions (fire spread and probability of a weather ending event) are sensitive model parameters that require the most attention during the calibration process for NRV. Typically, fire spread assumptions are revisited and revised with each new application to reflect the site-specificity of these events relative to the application area. For instance, on the Flathead, work was done to generally increase the fire severity assumption based on the good growing conditions of the forest that tend to produce fully stocked, dense stand conditions that have low fire resistance when the dry out and are susceptible to fire.

See APPENDIX 3 for discussion on how we determine the default weather ending events and APPENDIX 4 for how weather-ending assumptions for the smallest size class are sensitive parameters that affect the magnitude of fire activity across all decades and the amplitude of fire activity between decades. In general, we use real data from the fire history database to get an idea of the fire size distribution that should be modeled in the driest, most extreme fire conditions.

Other Processes

Other disturbance processes in the model (outside of fire and succession) include insects and disease factors that influence vegetation change and condition. For the Flathead NRV study, the ROOT-DISEASE assumption received the most attention to calibrate it to reflect levels that are more consistent with what is known about its historic and present occurrence.

Present-day root disease occurrence was calibrated reflect FIA data. We considered percentage of FIA plots that had High Occurrence within areas of High Hazard (a spreadsheet from developed by Blakey Lockman, State and Private Forestry). Areas of High Hazard were developed using a combination of Ecoregion/PVT/VMAP Dom40 grouping. The correct percentage from the spreadsheet was assigned to each unique Ecoregion/PVT/Dom40 combination. This percentage was then used to randomly assign cell of each combination High Occurrence. There were 2015 polygons in the dataset that had high RD occurrence. This was modified to reflect recent fires, which override Root Disease and reduced root disease polygons to 1931. This was further modified to remove HTGs and Size Classes that did not have an RD logic built into SIMPPLLE, and reduced the final number of polygons with root disease to 1603.

Determining the spread rate of root disease was an iterative process to view the results, assess its accuracy, and adjust the probability of susceptible vegetation contracting root disease in any given decade. In the end, the probabilities on a decadal basis were revised to 1 or 2 percent.

Other processes such as DF-BEETLE, SPRUCE-BEETLE, WSBW, and MPB used the default percentages associated with the base SIMPPLLE model developed through time, and initially updated for the Flathead plan revision as described in (Chew, 2014).

Regeneration

Regeneration activity in SIMPPLLE is controlled by two main logic screens. First, the tree size and climatic conditions that must occur for the stand to serve as a) source for self-regeneration, b) source for adjacent regeneration, and c) source for “in-landscape” regeneration (long-distance seed dispersal). Generally, for the Flathead the Lodgepole Pine regeneration assumptions were revisited and revised to reflect the ability of a smaller size class stand to serve as an in-place seed source.

The second logic screen describes how those seed sources act. For instance, if a DF-LP stand is capable of producing seed, and a stand-replacing fire comes through to trigger a regeneration event, what conditions do those seeds produce? Perhaps, in a Wetter climate, they would produce a DF-LP Seed/Sap Density 4 stand, but in a Warmer/drier climate they would produce a LP Density 2 stand. One significant update to regeneration logic was to indicate that if a stand had a LP-MPB outbreak in the previous few decades, it was still a viable seed source for LP and would result in an LP component in that stand when a fire came through, even if LP was not a significant enough component to be recognized in the stand's species mix.

Calibration

Calibration is a series of tests to ensure the model is displaying good behavior. It involves doing a trial run, comparing the outputs with known conditions and sleuthing the source of the disparity. In a model with thousands of assumptions about vegetation growth, disturbance occurrence and response, and regeneration, it is not uncommon to find default assumptions that do not fully reflect the ecology of the landscape being modeled. Calibration is by far the most labor and time intensive step in the modeling process.

Generally, calibration is conducted in two main steps: fire and vegetation. More detail on these steps is found in APPENDIX 4, but we offer some general descriptions here. On the Flathead, and in other forests in Region 1, the most influential ecological process is fire. The first step, fire, runs the model for a full simulation, and compares the overall fire levels and size distribution to the historical occurrences known to have happened in the absence of fire suppression. This information can be in the form of fire maps, published studies on fire scars, other modeling efforts such as LANDFIRE, etc. Assuming you've done a good job about identifying the fire size distribution in the model, we generally adjust our least-confident assumptions to achieve the expected fire levels: number of fire starts and probability of a fire going out at a small size. Compared to large fires, small fires are difficult to detect and arguably do not make it into databases with the same accuracy as the larger fires. Therefore, we consider the number and persistence of small fires to be a calibration opportunity.

Once we calibrate the model to simulate an appropriate amount of fire, we evaluate the fire severity distribution. Again, we can review the available knowledge about historic fire severities to determine whether the outcomes are consistent with what we know. Fire severity is a direct user input (e.g., large, dense Douglas fir stands uphill from a spreading fire will experience a Stand-replacing fire). If the fire type distribution is inconsistent with our knowledge of fire activity, a detailed study must be done to find the key SIMPPLLE fire assumptions that are inconsistent with the ecology of the area.

The second main step in the calibration is the vegetation. To evaluate vegetation behavior, it is suggested to look at the persistence of each individual tree species through time. Dominance type can be used, too, but it may mask the modeled behavior of, say, Englemann Spruce, especially if spruce is seldom the dominant species of the stand. Individual species that end the simulation at levels with a high level of departure (positive or negative) from current condition should be questioned. For species that end with a much greater presence, we must ask whether that is reasonable to assume would occur in the absence of management and fire suppression. For species that end the simulation far below

current levels, we must ask why it is they persist on the landscape today, and whether it is reasonable to assume they did not in the past.

Once a problem with the default assumptions for vegetation is identified, there are several areas to visit and investigate the problem. Pathways can be evaluated for successional assumptions into (or out of) other pathways with or without the species indicated to be a problem. The insect and disease processes can be evaluated to see whether something is getting eliminated from the landscape due to over-aggressive infestation assumptions. Regeneration assumptions should be looked at to determine whether the latest knowledge about seed production maturity and nearby seed sources is consistent with the latest knowledge.

See APPENDIX 5 for detailed description of modifications and trials done for the Flathead NRV calibration.

Finally, the data source that was considered in the Calibration runs for the Flathead was the Hessburg (*date*) study that examined dominance types and size classes from photo-interpreted data from the 1930's. Figure 6 shows a comparison between the SIMPPLLE dominance type modeled through time and the Hessburg dominance type determined at a single point in time. The Hessburg dominance type average value NRV number was determined for the time period represented by the vertical bar on each graph (ca. 1930). There is a single point at that time to represent the distribution of dominance types. That point is then extended horizontally as a line to the beginning and the end of the simulation time period for comparison at all points in time. Notably, while the exact acreages do not match (SIMPPLLE and Hessburg), the relative abundance of each dominance type is similar. For example, both models show the spruce/fir dominance type as the most abundant, followed by Douglas Fir, etc. One caveat is that it is difficult to directly compare these two figures since the classification of dominance type is fundamentally different between the two models, as Hessburg used Photo Interpretation and the SIMPPLLE figures were aggregated from modeled species groups.

Runtime Assumptions

Simulation Starting Conditions

One question often raised about starting vegetation conditions is, "How do we know what conditions were like 1000 years ago to start the simulation?" Of course, we don't. We have done tests, however, that have shown that the model is rather insensitive to the starting condition. Consider Figure 7, which shows time 0 as the first point (SIMPPLLE input) for the randomly generated map (blue) and the current condition (standard = red). This is the total acreage at the beginning of the simulation that have Ponderosa Pine as a part of the stand component. After that first point, the flow stream shows periods 16-119, which appear identical, especially in the context of a stochastic model. Figure 8 shows a map of dominance types for a random start vs. current condition start (a and b) and the results at the end of the simulation (c and d). The appearance and quantities of dominance types at the end of the simulation is similar for the two different starting conditions. The insensitivity of initial conditions to NRV estimations is also a finding of (Keane, Parsons, & Hessburg, 2002). Therefore, since we need to create a map of the current condition anyway (for future modeling), we simply use the current condition to seed the simulation.

Simulation Timelines and Number of Runs

For each Geographic Area, we run 30 Monte Carlo simulations to arrive at a range of conditions that may have occurred in the past. Each simulation is first run through 15 decades with only natural processes, using a climate stream representative of 1850 to 2000. Fifteen decades is roughly the period of time over which we have been managing vegetation and suppressing fires. This arrives at a vegetation state indicative of conditions without modern management influences. Each run is then continued for another 104 decades to simulate vegetation conditions over the historic climate data available in the study.

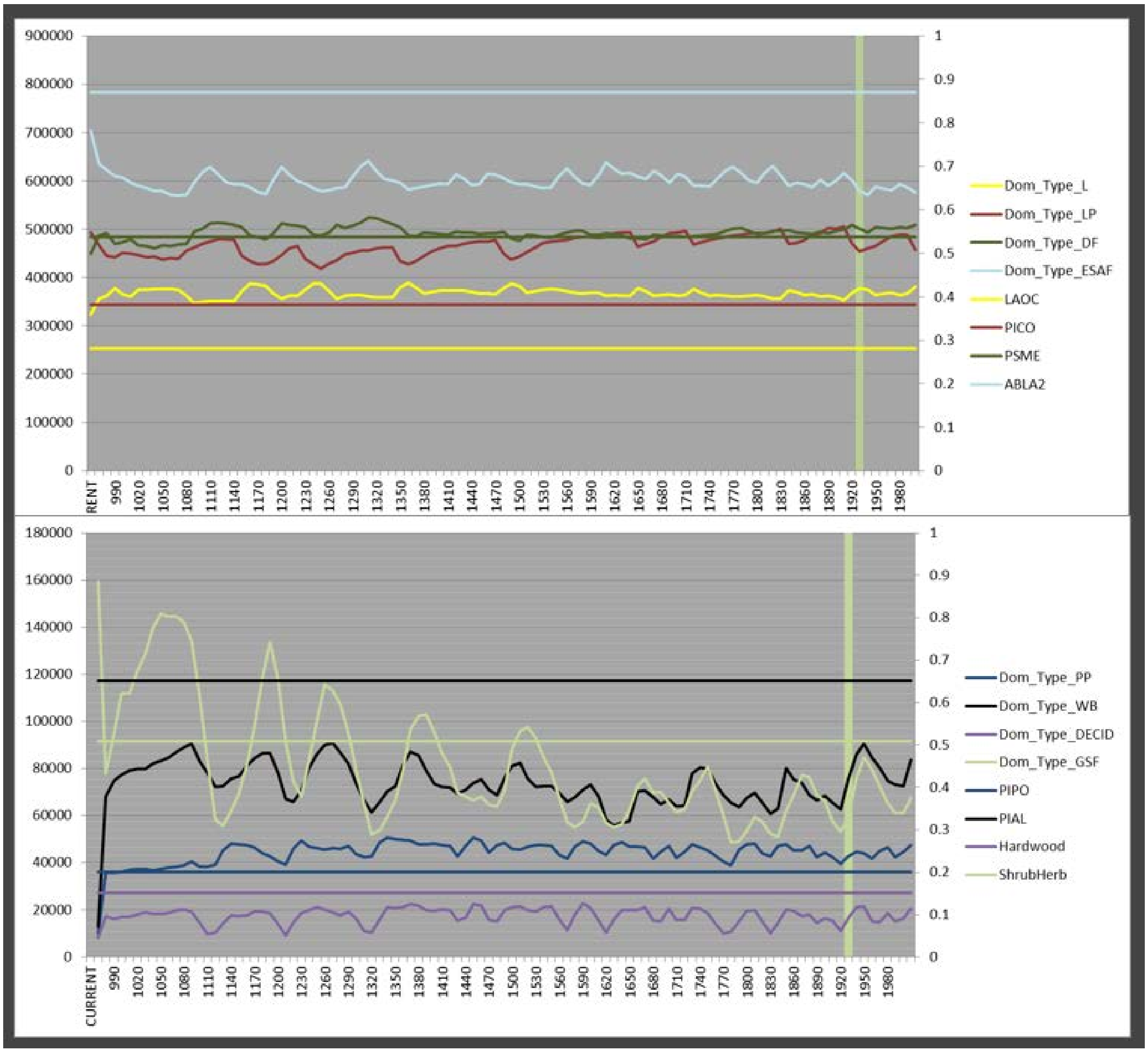


Figure 6: SIMPPLLE NRV for Dominance Type Compared with Hessburg NRV for Dominance Type

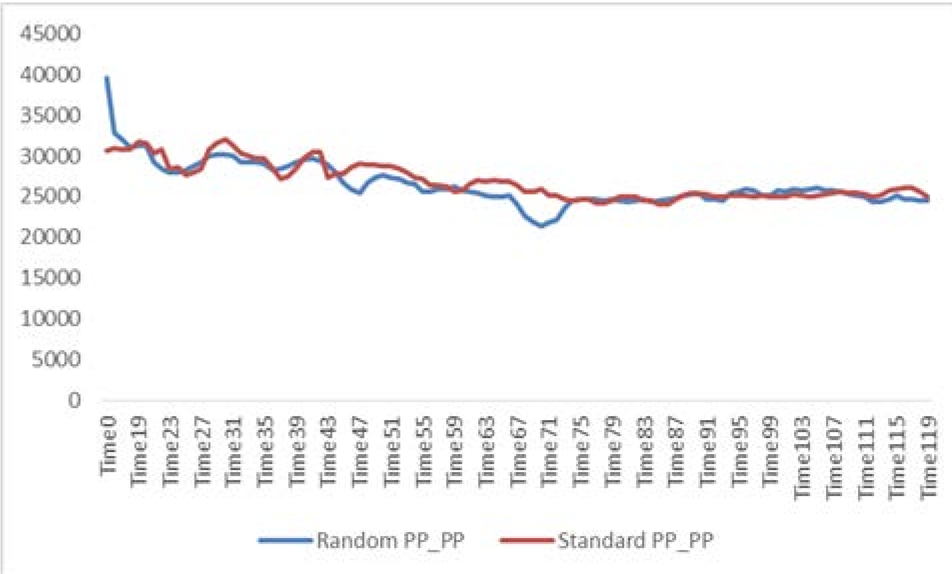


Figure 7: Acres of Ponderosa Pine in a random starting condition vs. using current conditions (Standard) to start the formulation.

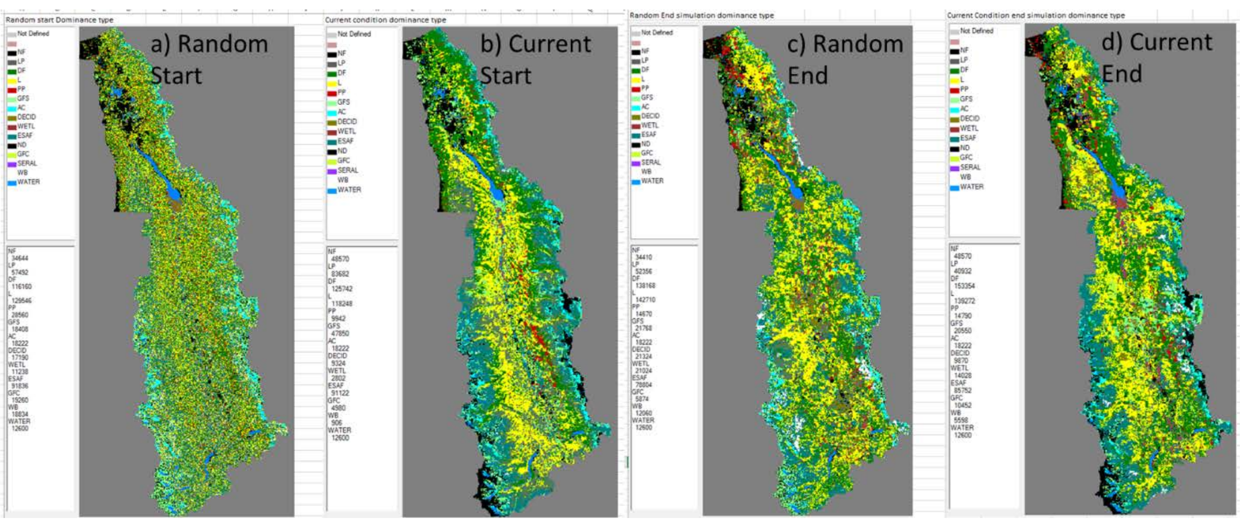


Figure 8: Starting with a Random condition or Current Condition (a and b) results in a similar ending condition after 1000 years of simulation (c and d)

APPENDIX 1: How to use VMAP to prepare a SIMPPLLE input file

The problem:

SIMPPLLE and VMAP describe vegetation differently. VMAP describes the current condition on the ground and SIMPPLLE is used to simulate growing that condition forward. Therefore, it is necessary to do a translation from the current condition VMAP to the SIMPPLLE vegetation categories.

Specifically:

VMAP describes dominance type (Dom6040) with categories that describe the dominant vegetation and the degree to which other species are mixed in. Examples are PIPO (>60% Ponderosa Pine) and PIPO-IMIX (40-60% Ponderosa pine, with intolerants making up the balance).

SIMPPLLE describes vegetation in terms of species groups and Habitat Type Group (HTG). SIMPPLLE has species groups that include PP (relatively pure Ponderosa Pine), DF-PP, DF-PP-LP, and so on. SIMPPLLE also defines a Habitat Type Group for each polygon on the landscape that describes the potential for the habitat to grow particular mixes of trees. So, one HTG may be able to grow DF-PP-LP, but another one may not be suitable for growing LP (lodgepole) and so DF-PP-LP is not defined for this HTG.

The solution:

We have invested considerable time in working developing a process to address this disconnect in vegetation classification systems. Specifically, the VMAP dataset includes information that describes the degree to which a polygon *looks like* a different tree species. We term these “minor species”. For any forest, there is a series of columns for each identified minor species and an associated percentage/probability that the polygon looks like it may contain presence of this species.

The following process has been developed to use available information to create the SIMPPLLE input file with species represented according to their abundance suggested by FIA.

1. Query the FIA database to determine the acres with a presence of the different species in each Habitat Type Group. For example, the G1 on the Flathead may have 20,000 acres that have a whitebark pine component.
2. Define the pathways present in the SIMPPLLE model (Pathways Needed). This is displayed in a matrix of Habitat Type Groups (columns) and species groups (rows). An “X” is used to indicate the presence of a pathway in the SIMPPLLE model. You can also use a “Y” to represent a pathway that is not there, but is planned for development.
3. Identify potential errors in VMAP for species that may be spectrally similar but occur in illogical places. For instance, Subalpine fir typically does not occur at low elevations, and may actually be Douglas Fir. So, in this case, it should be reclassified as DF. *Alternately, VMAP is arguably more believable than the Jones PVT layer (used to derive Habitat Type Group). It may be more*

appropriate to adjust the PVT/HTG label rather than the VMAP label. We currently do not have an automated process to do this, though.

4. Identify instances where you do not want to assign a particular minor species. For instance, Paper Birch may not be known to occur in the South Fork geographic area, and so we would not want to assign it to occur there.
5. Identify species that always occur together. For instance, FIA may suggest that a Subalpine Fir dominance type always has an Englemann Spruce component in the D3A Habitat Type Group.
6. Rules for the minimum percentage necessary for a minor species to be included in the species group. This can vary by Habitat Type Group, and is the key assumption to change once steps 1-5 are fairly final.

Once 1-6 have been identified, we use an iterative process to reasonably match the species amounts determined in Step 1. For instance, revisit the example in Step 1 (20,000 acres of whitebark pine in the G1 on the Flathead). We may use a 10% minimum as a starting point. If doing so results in 40,000, the minimum is too low, and next time around we might try 20%, which could results in 5,000 acres. In this case, the minimum is too high, so it adjusts to 15% and tries again. The process is repeated – by species, by habitat group – until the FIA estimates are reasonably matched. SOAP includes an automated process to read in the FIA estimates, compare them to the latest iteration, and make adjustments accordingly.

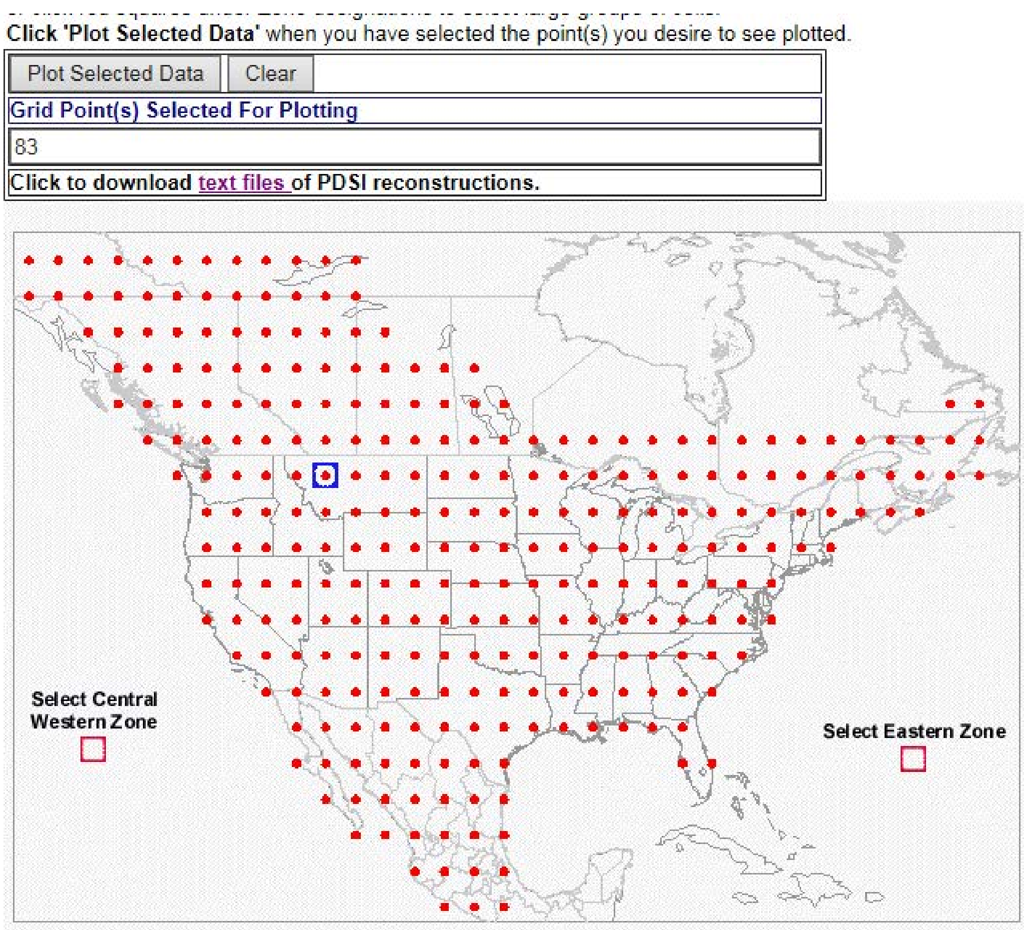
Once we are satisfied with reasonably matching the species abundances, we look at size class, density class, and structure estimates out of FIA to try to corroborate the VMAP assumptions.

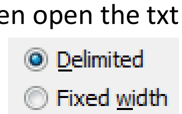
In the end, we should end up with a relatively clean input file for SIMPPLLE. If you assumed the presence of pathways that were not in the model, make sure you develop these before trying the import. SIMPPLLE will tell you if it encounters illogical combinations/non-present pathways.

APPENDIX 2: PDSI Data Source and Translation to SIMPPLLE Climate

Dowload Files

http://www.ncdc.noaa.gov/paleo/newpdsi.html



- Click on the gridpoint nearest to you location, remember the number that appears (83 in example), then click text files,
- On the next webpage click, Reconstructed PDSI data files for each gridpoint.
- Scroll down to the number for your gridpoint (again 83 in the example) and right click and "save link as" or "save target as" depending on your web browser. This will download your text file.
- Convert the text file to an excel spreadsheet by
    - Open Excel, then open the txt file
    - Click Delimited 

, then Next, then check 

, click Finish.
    - Delete the first row in the spreadsheet and save as an Excel Workbook.

Using a Cubic Spline In R to Soften PDSI Values

Preparation

1. Download PDSI text file
2. Convert it into an Excel spreadsheet (you don't have to, but this tutorial assumes data is in Excel)
3. Make sure you have R, R Commander, a dlpR library installed

In R

Packages – Load Package, select RCmdr

In R Commander go to Tools -> Load Packages and load dlpR

Go to Data -> Import Data, choose Excel, find your Excel spreadsheet and select the Sheet that has your PDSI values

Leave the Data set name at the default Dataset

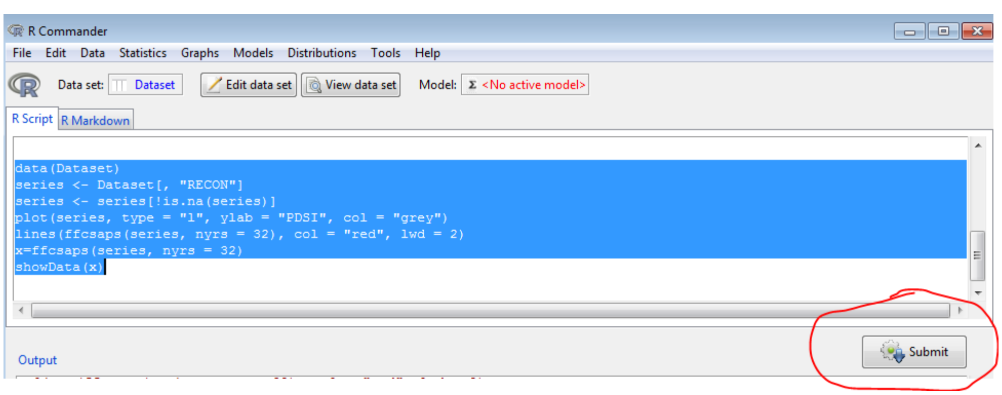
Click the "View data set" button

Paste in this code

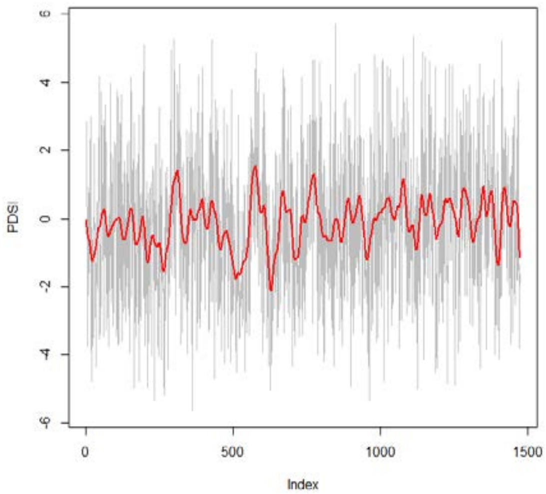
```
data(Dataset)
series <- Dataset[, "RECON"]
series <- series[!is.na(series)]
plot(series, type = "l", ylab = "PDSI", col = "grey")
lines(ffcsaps(series, nyrs = 32), col = "red", lwd = 2)
x=ffcsaps(series, nyrs = 32)
showData(x)
```

Note: this code will create a 32 year cubic spline.

Be sure to select the whole code and click the Submit Button



Now you should see a Plot of your PDSI values w/ cubic spline



And a table of values for the Spline. This is the table for ‘x’ in the code.

	dataframe
1	-3.184470e-02
2	-1.316944e-01
3	-2.297201e-01
4	-3.225781e-01
5	-4.041286e-01
6	-4.700881e-01
7	-5.204994e-01
8	-5.587329e-01
9	-5.901373e-01
10	-6.203978e-01
11	-6.535007e-01
12	-6.920817e-01
13	-7.391728e-01
14	-7.969047e-01
15	-8.657851e-01
16	-9.427098e-01
17	-1.020390e+00
18	-1.092290e+00
19	-1.154755e+00
20	-1.203905e+00
21	-1.235692e+00
22	-1.249750e+00
23	-1.247930e+00
24	-1.231909e+00
25	-1.204019e+00
26	-1.168895e+00
27	-1.131420e+00
28	-1.095085e+00
29	-1.061725e+00
30	-1.029887e+00

Copy and paste all the table values back into your original Excel spreadsheet

Converting Values from Annual to Decadal & Identifying Warm, Normal and Dry Decades

Converting Values from Annual to Decadal

- Now you have your 'smoothed' annual PDSI Values in the spreadsheet

	A	B	C
1	YEAR	RECON	Spline Values
2	750	-0.073	-0.655261426
3	751	-2.125	-0.620456798
4	752	-4.347	-0.585159441
5	753	0.738	-0.551299368
6	754	1.339	-0.524587497

- To get these values to Decadal Values, it is best to pick a random number between 0 and 9 and then pull the Spline value for the year ending in that value
- Excel can help you pick a ranodm number using the Random function
- You can also use the Right funtion to extract the ones place out of the year, and then use a Filter to pull out the years ending in the random number. The Spline value for this year will represent the decade.
- Copy and paste your decadal values into a new workbook

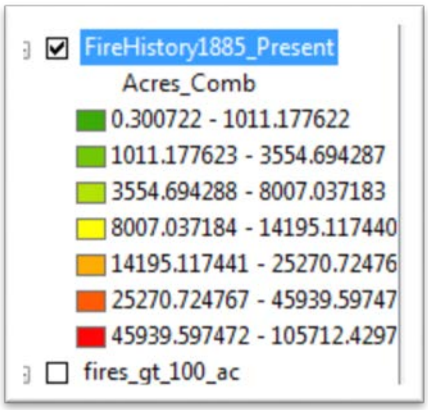
Identifying Warm, Normal and Dry Decades

- Use the Quartile Function to separate the lower and upper quartile.
- Use an IF fuction to identify values <= to the value in the lower quartile to represent Warm-Dry, and values >= the upper quartile to represent Cool-Wet, with everything else being Normal.
- With this method 25% of the timesteps will be Warm-Dry, 25% will be Cool-Wet, and 50% will be Normal.

APPENDIX 3: Using Fire History Database to Calibrate Weather-ending Logic in SIMPPLLE

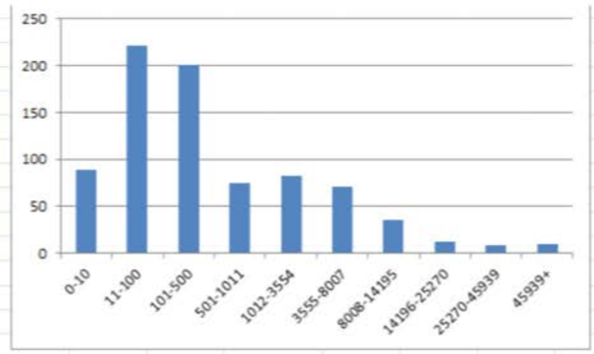
New Weather Ending Event Logic by GA

- Take the entire fire history polygon GIS layer and make sure the year and acres are accurate each fire polygon.
- Calculate Fire Class Size breaks ArcMap with a 'natural breaks' classification using the entire fire history layer for fires > 1011. NOTE: you may need to do this many times to determine a number of classes that seems suitable for the SIMPPLLE Model



- Using these new classes, run a Frequency calculation in Excel to generate the number of fires that occur in each of the classes
- Weather ending probabilities are calculated by using the fire history data for the entire forest and will not change from GA to GA, (except for the largest size class which is will vary by GA).
- The probabilities are calculated by taking the number of fires in the smallest size class and dividing by the total number of fires. Then, to calculate the probabilities for the next classes, take the number of fires in the next size class and divide by the remaining fires. The remaining fires are the fires in the current class and all larger classes. Step through each of the larger class sizes using only the remaining fires.

NaturalBreakBins	Bin	Frequency			
10	10	88	0-10	88	0.109046
100	100	222	11-100	222	0.308762
500	500	201	101-500	201	0.404427
1011	1011	75	501-1011	75	0.253378
3554	3554	82	1012-3554	82	0.371041
8007	8007	71	3555-8007	71	0.510791
14195	14195	36	8008-14195	36	0.529412
25270	25270	13	14196-25270	13	0.40625
45939	45939	9	25270-45939	9	0.473684
	More	10	45939+	10	



- Probabilities for the final size class (fires over 45,939 acres in the example) are determined for each GA using a spreadsheet model which is dependent on the Potential Fire Starts per Century for each GA.

- Maximum fire size probabilities will be changed based upon the number of starts that occurred historically and most acres burn in any given year in the Fire History GIS layer. Note that some GA's did not exceed 45,940 acres so the size class above 45,940 acres will have a value of 100 in the Weather Ending Events logic

  Note: The spreadsheet model could also calculate a probability for GA's that had a largest fire less than 45,940.

Size Class	Weather Ending Probability
0.25-10	0.3
11-100	0.31
101-500	0.4
501-1011	0.25
1012-3554	0.37
3555-8007	0.51
8008-14195	0.53
14196-25270	0.41
25271-45939	0.47
Final Size Class	0.212839795

Assumptions using Fire History Polygon Data

- Most fires mapped before 1985 were large area, high-severity, stand-replacing fires. Possibly because these type of fires would be the most documented and memorable type of fires
- Historical area burned for GA's that have vegetation with a low severity fire regime probably will be underestimated or even undocumented (Salish Mountains would be a prime example).

Geographic Area	GA Acres	Largest area burned in a single year	Max 10 Year Burn Acres
Hungry Horse	331,885.00	31,223	56,797.81
Middle Fork	375,275.00	146,077	184,060.70
North Fork	389,697.00	58,945	83,290.60
Salish Mountains	836,761.00	57,776	94,985.38
South Fork	790,742.00	176,419	237,985.55
Swan Valley	531,718.00	32,401	48,741.32

- The largest area burned by one fire for each GA will be the maximum size that any individual fire can burn in the model
- We wanted to have the maximum total amount of acres burned to rarely exceed the maximum sum total of acreage burned in any 10 year period in the Fire History for each GA.
- We noticed that changing the smallest fire class probability was very sensitive to the number of acres burned in each timestep and would affect the sum total area burned in each timestep. This probability would have to be changed for some GA's.

APPENDIX 4: Recommendations for Calibrating the SIMPPLLE Model

July 30, 2015

Purpose

This document is intended to capture some of the lessons learned from using the SIMPPLLE model to reconstruct Natural Range of Variation used in Forest Plan revisions for Region 1. It contains a recommended calibration process as well as tips and hints for fixing common issues that arise during the calibration phase.

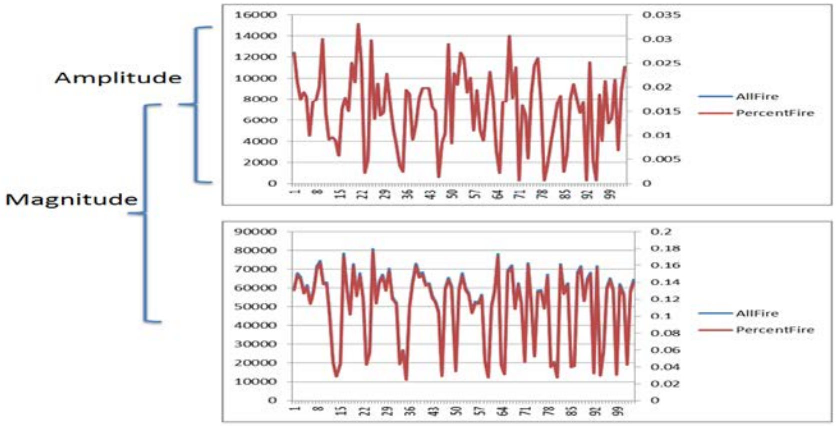
Background Information

Ideally, before starting on calibration runs, one would have as much of the following information as possible:

- Historic fire size distributions, including the size of the largest fire that is likely to burn in the geographic area. Ultimately, this needs to be translated into a list of the probability that a fire will naturally extinguish (presumably due to weather) at these different sizes.
- Fire severity distribution – relative mix of light/mixed/stand replacing fire
- Climate stream for the period of reference. We have been using Palmer Drought Severity Index (PDSI) to look back approximately 1000 years. This is classified into a predominant climate for each decade. Climate classes are Warm, Normal, and Cold. The distribution of climates over this period is 25% Warm, 50% Normal, and 25% Cold.
- This assumes that Pathways, input files, fire severities, regeneration logic, insect & disease, etc. are at a point reasonable for beginning the calibration runs.

Calibration Steps

1. Calibrate for fire amounts to emulate known historic patterns and quantities. Fire quantities, when graphed as a line, can be thought of like a wave pattern, with amplitude (difference between the peaks and valleys) and magnitude (y-intercept of the horizontal median line)
    a. Controlling magnitude – median fire amount across all decades – is done by adjusting the probability that a fire will go out at smaller sizes (Weather Ending – fires > .25 acres). The model is VERY sensitive to this parameter value
    b. Controlling amplitude – difference in fire amounts between warm and cold periods – is controlled by the probability of going out at < .25 acres (Weather Ending – Fires < .25 acres). The fire starts entered in the FMZ/fire occurrence logic screen in should correspond to the maximum number of fire starts anticipated during a dry period. The appropriate number of those fires should then end due to weather for both Normal and Dry periods.



2. Calibrate the fire type you know should happen on the landscape. This is through the Fire Event Logic. The Spread tab is perhaps the most important, as if you get something wrong in the TYPE tab, it may only affect the origin pixel. The Spread logic probably has a much greater influence on the model's behavior.
3. Assess the behavior of the presence and persistence of different species. Is the overall level trending up or down at an unreasonable level? If so, ask the following questions:
    a. If a species is trending up, look into the seed producing logic (perhaps adjust the probabilities of it producing seed), order of regeneration (in the Regeneration menu), never-ending pathways, bug susceptibility (make sure it is defined to get bugs and if so, what is the probability it will?)
    b. If a species is trending down, look for events that cause the species to either regenerate or encroach. Does it produce seed, and can it regenerate from itself or an adjacent stand? If not, can it encroach an undisturbed stand and therefore will grow into the understory of purer stands over time (this is a pathway edit)?

Helpful Tips

- While final and perhaps very early calibration runs should encompass the full time period to be simulated for NRV, intermediate runs can be much shorter to check for the effect of intermediate effects to the system logic. For instance, if the full simulation is to be 100 time periods, perhaps there are many problems that can be detected and corrected by looking at only 40 timesteps. This will save you time.

APPENDIX 5: Detailed Calibration Assumption Changes for Flathead Revision

82214:

- Weather ending changes to increase amplitude of fire activity (more fire when it burns, less when it's wetter)
- Modify C2 pathways to get GF encroachment
- Take out Adjacent preference to see what happens

Aug25_SV_A

- Added in GF adjacent seeding preferences for Larch (started with the old seeding preferences and augmented)
- Halved the root disease probabilities – much more was showing up than currently expressed

825_SV_B

- Turned off DF Succession Regeneration
- Reverted back to 822x adjacent seeding logic
- Changed L-DF-GF pathways to change succession to DF-GF in densest size class (C2, D1, D3A/B)
- Lowered the root disease to ¼ original assumption

826_SV_A

- In the D3A, L-DF SS and Pole -> L-LP with MSF
- In the D3A, L-LP MSF maintains L-LP – adds structure, but does not kill the LP – SS and Pole states
- In D3A, L-LP goes to L-LP-ES-AF instead of L-DF-LP with succession
- D3A Cottonwood – succession from CW SS to CW-ES-AF PTS
- D1 Mesic shrub succession -> L-WP-GF

826_SV_B

- D3A: CW-ES-AF LMU succession to ES-AF changed to perpetual CW-ES-AF
- D3A: L-DF VL Succession to L-DF-ES-AF instead of L-DF-ES (same with LSF)
- Added regen logic for L-ES-AF after LP-MPB to regenerate to L-LP-ES-AF
- Added regen logic for small DF-LP-ES-AF and small L-LP-ES-AF to regenerate as LP

826_SV_C

- Added WB in-landscape to F1 and D3B – 25%
- C2: Mesic shrub succession -> L-GF (changed from L-DF-GF)
- Added more regen logic after LP-MPB

826_SV_D

- Took out WB succession in F1 and D3B
- Changed D3B L-DF pathway to add LP after MSF
- ~~Added in LP-> LP-ES-AF to Succession Regeneration~~
- Lowered prob of LP-MPB in Normal decades

826_SV_E

- ~~Took out LP -> LP-ES-AF succession~~
- Lowered prob of LP-MPB in Normal (below 826_SV_D)

826_SV_F

- Lowered chance of Class A Fire weather-suppression in Normal/Cooler
- Lowered prob of LP-MPB in Normal (below 826_SV_E)
- Lowered prob of LIGHT-LP-MPB in Normal and Cooler
- Added no DF-BEETLE if DF-BEETLE last timestep

826_SV_G

- Added succession to BP pathways (D1-> BP-L-DF and D3A - >BP-ES-AF)
- ~~Added ES-AF succession to LP in D3B, D3A, and F1 pathways~~

827_SV_A

- Added succession to BP pathways (D1-> BP-L-DF and D3A - >BP-ES-AF)
- ~~Took out ES-AF succession in LP in D3B, D3A, and F1 pathways~~
    - LP persistence is much shorter in the LP-ES-AF as it rapidly changes to ES-AF. In the long run, this pathway with LP-ES-AF should be examined for validity. Why does LP persist so much longer when not encroached by ES-AF? In reality, we are seeing a lot of ES-AF encroachment in old LP stands. Perhaps for the Swan, this is appropriate.

828_SV_A

- Modified LP-ES-AF pathways in D3A, D3B, F1 to match LP growth for those pathways
- Added LP -> LP-ES-AF succession in D3A, D3B, F1 to new pathways

828_SV_B

- ~~Added in-place regeneration in D3A and D3B for L-DF as L-LP. L-DF is not a type currently, and there is a lot more L-LP type than what the simulations end up showing~~
- D1:
    - Added succession from L-DF -> L-DF-GF
    - Changed succession from L -> L-DF to L -> L-DF-GF
    - Added succession from L-ES and L-AF -> L-C-ES-AF
    - Added succession from LP -> DF-LP for small classes

- o Changed BP succession so it persists in mixed stands rather than transitioning to non-type
- D3A:
  - o Changed the CW transition to succeed from CW-ES-AF -> ES-AF after 200 years

828_SV_C

- The L-DF regeneration for HTG-Specific screwed up the preferred adjacent regeneration logic. Re-did 828_SV_B with new pathway logic and old regen logic for L-DF

828_SV_D

- ~~Tried to reinstate the D3A L-DF regen logic to L-LP.~~
- Modified CW logic on D1 and C2 to be like modified D3 – 200 years to succeed rather than no succession at all

829_SV_A

- Added WB in-place seed regeneration logic
- ~~Could not get HTG-specific regen logic to work for D3A LP. It gets rid of adjacent seeding preferences, so I got rid of it. In fact, don't even try to look at other HTGs or it seems to clear things out.~~
- Changed regeneration to LP component to up to 50 years after last MPB epidemic. Thought is that LP persists at very low levels after an outbreak, but reseeds very well after a fire. LP that survives an outbreak was probably rather small/young at the time.
- D3B:
  - o Edited WB pathways to show succession to climax WB-DF-ES-AF and WB-LP-ES-AF species. Added decades worth of persistence to the end of the pathways
- F1:
  - o Edited WB pathways to show succession to climax WB-DF-ES-AF and WB-LP-ES-AF species. Added decades worth of persistence to the end of the pathways
- D1:
  - o Took out birch persistence, but extended lifespan to 120 years
  - o Added L-DF-C-GF pathway, updated veg attributes, fire spread, and regen logic. Added succession pathways.
  - o Updated succession pathways to reflect more Cedar. This is a cedar type and it should persist.

829_SV_B

- Fixed adjacent regeneration for L-DF-ES-AF types with past MPB
- ~~Tried new build of SIMPPLLE to specify L-DF regen to L-LP on D3A~~

902_SV_A

- ~~Ran 829_SV_B with old regen logic (no L-DF specific on D3A with old SIMPPLLE. New version did not work)~~

908_SV_A

- D3A, D3B, F1
  - Changed MSF pathways for L-LP types to regenerate as L-LP 2 story after MSF
  - Added fire spread logic to burn MSF these types

908_SV_B

- D3A
  - Fixed L-LP succession to L-DF-LP succession pathway in Large (changed to succ to L-LP-ES-AF)
  - Default shrub succession to L-LP-ES-AF rather than L-DF-ES-AF
  - Changed LP-AF succession (large) to LP-ES-AF rather than AF
  - DF-LP MSF changed to retain DF-LP

908_SV_C

- C2
  - Changed pathway: pure LP LP-MPB results in either L-GF SS or L-LP-GF PTS
  - PP-DF gets GF succession/encroachment
- D3A
  - DF Succession to DF-WP-ES-AF
  - DF-WP Succession to DF-WP-ES-AF

909_MF_B

- D3A
  - Added L-DF-AF -> L-DF-ES-AF Succession
  - Change pathway for pure LP to LP-DF after SEVERE-LP-MPB (now, it goes to LP SS)
  - Add succession for BP to BP-ES-AF. Extend succession from BP to ES-AF
- F1
  - SEVERE-LP-MPB in LP converts to DF-LP rather than LP-SS
  - Succession in DF-LP changed to DF-LP-ES-AF rather than DF-LP-AF
- Other
  - Changed fire regen logic after LP-MPB in WB-ES-AF to result in WB-LP-ES-AF stand. It would probably be just a WB-LP stand, but we don’t have that pathway.
  - In-place seed for WB results in WB after fire regeneration (wasn’t in there before)

909_MF_C

- F1
  - Change WB successional pathways to keep it instead of succession to ES-AF

    - Changed succession for LP-AF to LP-ES-AF rather than ES-AF
    - LP is a sink – add succession to DF-LP-ES-AF (this loses all its acres)
- D3A
    - AF is a sink – after MSF, get DF-ES-AF
    - AF also gets succession to DF-ES-AF

909_MF_D

- F1
    - Young LP succession to DF-LP-ES-AF in Density 2 and 3 stands
- D3B
    - Young LP succession to DF-LP-ES-AF in Density 2 and 3 stands
- G2
    - Succession from WB to WB-ES-AF
    - LP SEVERE-LP-MPB turns to WB-ES-AF
    - Added succession from WB to WB-ES-AF

909_MF_E

- Changed Wetter fire weather ending to 57% consistent with data
- Changed prob of going out at 46,000 acres to 80% rather than 100%. Largest fire in this landscape was 146,000 acres
- Added WB in-place seed capability of Medium Stands (10-15" – these are probably some of the larger WB trees that occur). Set the probability at 50%

909_SF_B

- Increased Weather Ending <.25 prob to 57% in cool/wet relative to real data
- Increased .25-10 Weather ending from .3 to .5 because too much of the area was burning (up to 50%, whereas data shows only 30% burns max)

910_SF_A

- Increased Weather End < .25 prob to 75% in cool/wet, 33% for Normal
- Increased .25-10 Weather ending to 65%
- THIS RUN RESULTED IN TOO LITTLE FIRE

910_SF_B

- Reverted back to 909_SF_B fire assumptions
- Used changed regen and seed producing logic for L-LP types (see OTHER, below)

910_SF_C

- Updated D3A pathways – MSF in DF-LP types results in L-LP

- Scaled back Cooler and Normal fires- to <.25 acre weather prob at 75% and 33%

909_NF_B (aka 910_NF_A)

- Toned down the fire activity; increased weather-ending in <.25 to 75% cool, 33% normal. .25-10 increased to 50%. This was due to up to 3X max fire activity resulting in the run (and LP increased, L decreased)

910_NF_B

- Changed fire for .25-10 weather ending to 65% (up from 50%)

911_SM_D

- The only difference between C and D is that D was run with a weather-ending of .25-10 of 88%, instead of 85%

OTHER CHANGES:

- Changed DF-LP succession on F1 from DF-LP-AF to DF-LP-ES-AF
- Changed L-LP types regen logic for warm/dry from regenerating LP to regenerating L-LP with in-place seed
- Changed Medium sized WB pine in-place seed prob. From 50% to 75%
- Added in-landscape to BP for D1 and D3A
- Added regeneration priority to BP types for adjacent stands
- Added last 150 years of climate to the beginning of the stream to wash out effects of fire suppression for NRV runs (Regional Climate Variable)
- Changed root disease logic in PP types on A2, B2, B1 to retain size; moves to lower density multi-story stands. [Otherwise, was moving everything to Pole size stands that could not regenerate with SRF. Should be some big trees retained if they were there to begin with]
- Added regen logic to PP-DF and L-DF-PP types. If have root disease, in-place regenerates without the DF
- Extended BP duration on D1 (BP-L-DF) and D3A (BP-ES-AF)

BIN

- Change SEVERE-LP-MPB in pole sized stands to retain some LP; they are resilient and there will likely be remnant trees left

Part 2: Modeling the Future for the Final EIS of the Flathead Forest Plan Revision

4/21/2017
Eric Henderson, Region 1 analyst

Introduction

SIMPPLLE was one of two projection models used to evaluate the future and determine the effects on vegetation associated with the different Alternatives. The first model, Spectrum, was used to determine a set of treatments that would move the forest to the vegetation desired conditions. Spectrum was run separately for each Alternative to account for differences in allowable treatments on differing land management allocations. These treatments were then used as inputs to the SIMPPLLE model. SIMPPLLE is better suited to look at more nuanced vegetation processes, including the uncertainty of climate and disturbance levels and timing (such as fire). The vegetation effects for each Alternative were analyzed based on the outcomes of the SIMPPLLE model, including movement towards desired conditions and effects on future disturbance levels.

Generally, the baseline assumptions used for future projections are the same as those used for modeling Natural Range of Variation. Some key assumptions that remained the same were the growth rates and regeneration rules, fire intensity assigned to vegetation types, and effects of fire and other pathogens to the vegetation they affect. However, there were some updates in the SIMPPLLE model.

This document describes the key assumptions that were updated for future projections with the SIMPPLLE model. Specifically, it will discuss the uncertain future climate, updates to insect and disease assumptions, and how fire suppression was determined and modeled. It also contains Alternative-specific information about treatment levels and the ability of SIMPPLLE to implement those treatments in the context of uncertainty in the fire and disturbance levels in the future. This discussion pertains to the analysis process used in the modeling projections conducted for the Final Environmental Impact Statement of 2017 associated with the Flathead Forest Plan.

Time Horizon and Future Uncertainty

Time Horizon for Projections

Future projections with the SIMPPLLE model were done for fifty years into the future, modeled in five decadal timesteps. Fifty years roughly corresponds with the time horizon for which future climate models generally agree, after which they become more divergent (Halofsky, et al., 2017). It also projects out sufficiently beyond the anticipated life of the Forest Plan, which was anticipated by NFMA to be 10-15 years, and in practice has been more than 30 years (the Flathead National Forest Plan was adopted in 1986).

Future Climate Assumption

Projections in SIMPPLLE associated with the DEIS runs assumed two decades of "Normal" climate followed by three decades of "Warmer and Drier" climate. Upon reviewing these results in consultation with the Rocky Mountain Research Station, we determined it was more representative to use a "Warmer and Drier" climate for all five decades of the future projection. This is in part responsive to the actual climate trend that has been experienced in the area (Halofsky, et al., 2017) as well as to adequately represent expected fire levels in the context of recent fire activity (Figure 9).

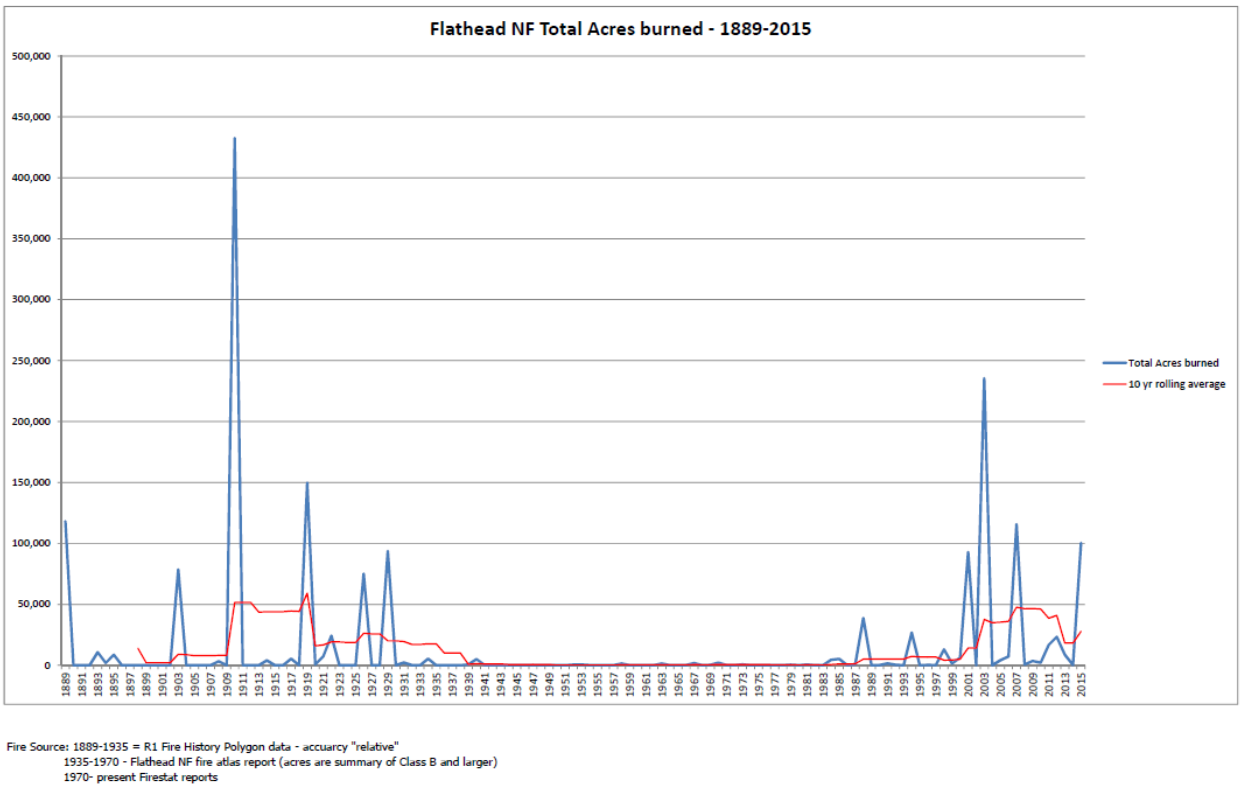


Figure 9: Flathead National Forest annual fire acres and 10-year rolling average. Fire levels have averaged roughly 20,000-25,000 acres per year from 2006-2015.

Future Uncertainty in Fire Activity

The effects of future climate on fire activity is one of the uncertainties we attempted to address with the SIMPPLLE model. Presently, it is unclear whether we will see a continuation in the current trend, an increase, or even a potential decrease as the future forest may not sustain the requisite fuel loads to continue burning at current levels. Therefore, the forest evaluated a "Future Range of Variation", or FRV, that included runs with the current trend, as well as increased and decreased fire activity. Technically, this was accomplished by varying the probability of a fire being extinguished by a weather event when it reached one-quarter acre in size. Higher probabilities of ending at this size result in lower fire activity on the landscape, and vice-versa. Table 1 below shows the ¼ acre weather-ending fire assumptions for the FRV runs of the Alternatives. Figure 10 below shows the range of fire levels resulting from these assumptions for the Alternative B of the FEIS. Only stand-replacing fire is shown, but it represents 99% of the fire activity in these decades.

Geographic Area	FRV Level	Probability
Hungry Horse	High	36
Hungry Horse	Low	85
Hungry Horse	Med	50
Middle Fork	High	20
Middle Fork	Low	60
Middle Fork	Med	30
North Fork	High	35
North Fork	Low	70
North Fork	Med	50
Salish Mountains	High	70
Salish Mountains	Low	92
Salish Mountains	Med	86
South Fork	High	30
South Fork	Low	65
South Fork	Med	47
Swan Valley	High	60
Swan Valley	Low	85
Swan Valley	Med	75

Table 1: Weather-ending probabilities for Class A fires by GA used to represent FRV for the FEIS Alternatives.

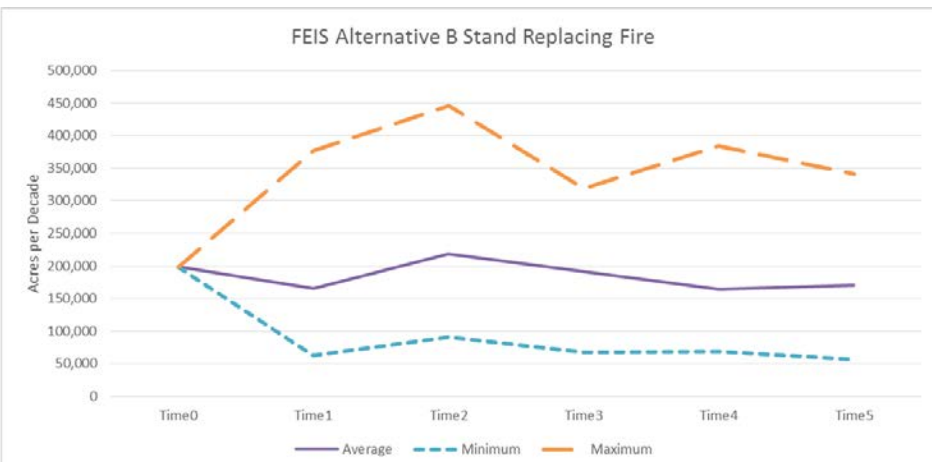


Figure 10: Future fire level range of variability used for Alternative B FEIS analysis. The solid line in the center is the average fire activity level across all runs. This is bracketed by the other two lines which show the minimum and maximum fire activity for any run in each time period. Note that none of these lines represents all data from a single run; it is likely, for instance, that five separate runs were used to represent the maximum fire line – a different run for each period, etc.

Process Updates

Fire Suppression Assumptions

Fire suppression assumptions were thoroughly revisited and tested for future projections. See Appendix A for complete documentation and results. Briefly, there were three key assumptions that were

adjusted and used in the calibration: probability of applying suppression activity to a fire, probability of success in suppressing the fire at the Class A (<.25 acre) level, and the response time required before suppression activity can begin.

The probability of applying suppression activity is defined in the "Fire Suppression Event Probability" logic screen. For the final analysis, the probability varied by whether or not the fire occurred in WUI (a 100% chance fires will be suppressed here), Wilderness (only a 51% chance) or non-WUI and non-Wilderness (100% chance).

Fire suppression success at the Class A level is defined in the "Fire Suppression for Class A Fires Logic" screen. For the final analysis, fires in the Wilderness or Cool-Moist Habitat Type groups had a 0% chance of getting suppression (from active fire suppression) at the Class A level. Note that this is in addition to Class A fires that are put out by weather, and so there is still a chance for fires in these areas to be extinguished at this size. For all other fires – outside Wilderness and outside Cool-Moist – we assumed a 30% chance of suppression activities being successful at the Class A level.

Response times varied by both Geographic Area as well as by areas identified as having "pre-historic burning" (phb) starts associated with Native American fire management. The phb areas were used as a proxy for those areas that are today closest to roads and towns and are accessible in a timely manner. Final response time numbers are shown in Appendix A and range from 2 hours for those areas relatively close to suppression forces, to 50 hours for remote wilderness areas that are typically far removed from both detection and suppression forces.

One note about these assumptions: fire suppression logic in SIMPPLLE is one of the most complex areas of the model. In addition to the assumptions discussed here, there are definitions about conditions under which fires are suppressed (e.g., not when there is a severe fire), the fire spread rate associated with different vegetation conditions, and the assumed rate of suppression by vegetation type and fire size, that could vary with the assumed number of suppression crews actively engaged in the event. These assumptions were not modified for the Flathead, but they were revisited and developed during the Kootenai and Idaho Panhandle revisions. The adjustments to the logic presented in the document here reflect both Flathead-specific situational management assumptions and calibration adjustments that resulted in a reasonable fire activity outcome. One might argue the specifics of the number (e.g., is it really 25 hours for this response time, or a 51% chance of suppression?), as to whether it's as realistic as possible. However, in this instance, the inputs result in *outcomes* that were deemed consistent with known and expected fire activity levels, and therefore we are confident using these assumptions to project a reasonable future fire scenario.

Insect and Disease Assumptions

In reviewing the Insect and Disease outcomes from the projections (using the NRV assumptions), it was apparent that DF-BEETLE and SPRUCE-BEETLE not adequately portray the future. Modeled levels into the future were far higher for both of these types to an unreasonable degree. We therefore consulted with the Forest Entomologists (Forest Health Projection) to develop more reasonable assumptions (Sturdevant & Reeves, 2016).

The specific updates that were made to the logic included:

DF-BEETLE

- After an infestation, the stand would not see a re-emergence for at least 50 years
- DF-BEETLE could only originate in stands having a fire or western spruce budworm outbreak within the past decade
- DF-BEETLE could spread to non-fire affected areas only if those areas were adjacent to a stand with an outbreak

SPRUCE-BEETLE

- After an infestation, the stand would not see a re-emergence for at least 50 years.
- SPRUCE-BEETLE was initiated in stands that had experienced light- or mixed-severity fires in the recent past
- SPRUCE-BEETLE had an increased probability of spreading to immediately-adjacent stands

The results of these changes are shown in Figure 11. For the FEIS runs, DF-BEETLE levels are maintained in the near-term (20 years) and then show a decline, whereas the SPRUCE-BEETLE mainly does not occur.

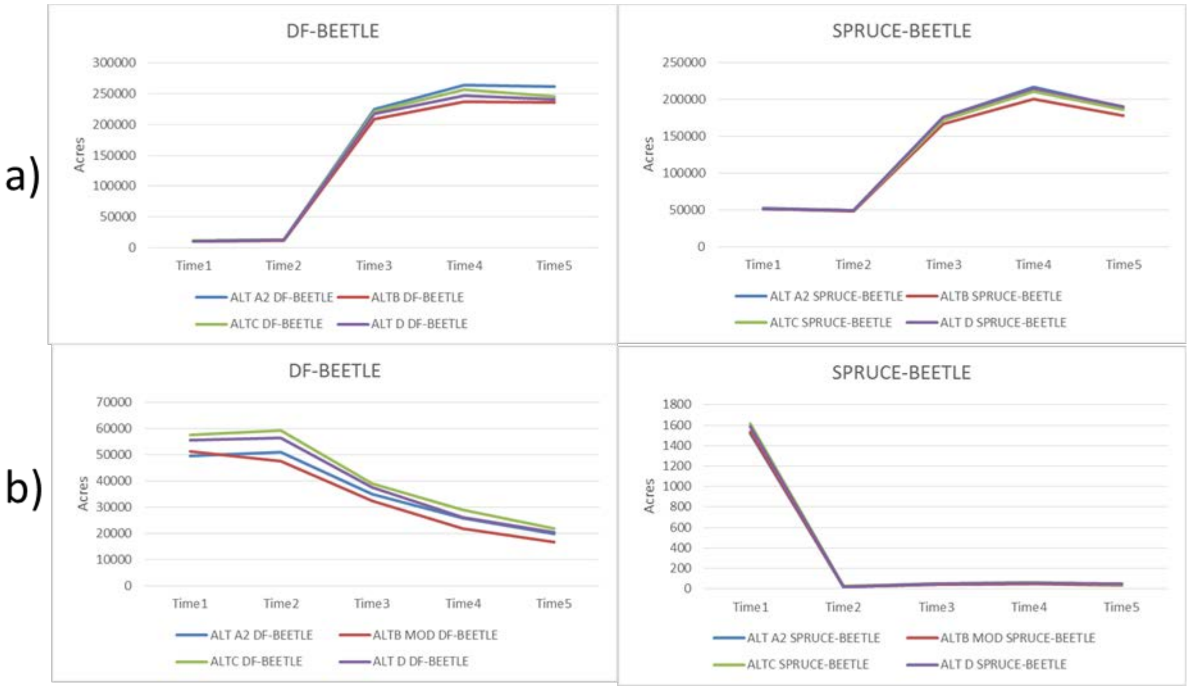


Figure 11: Pre- (a) and post- (b) insect and disease logic effects for DF-BEETLE and SPRUCE-BEETLE. The assumptions in row (b) were used for the FEIS analysis.

Starting Condition Assumptions

Agriculture and Urban

Agricultural and Urban lands were added to the landscapes in the Action Alternatives to reflect changes in land use relative to the NRV runs. The process to incorporate this data into the SIMPPLLE model is described in Appendix B.

Presence of Large Trees

The Region 1 Classification System (Barber, Bush, & Berglund, 2011) describes how stand diameter is calculated using the Basal Area Weighted Average Diameter (BAWAD) method. In general, this produces a figure that indicates the presence of larger trees (15"+ diameter) better than other methods such as Quadratic Mean Diameter (QMD). The authors are correct that "management questions typically are concerned with the larger, dominant and co-dominant trees in a setting."

However, the calculation can also result in a diameter that does not recognize any trees in the stand. Consider Example 3 from the paper in Table 2:

Example 3:	DBH	BA	BA * DBH	TPA* DBH^2	QMD	BAWAD
TPA 0	1	0.0	0.0	0.0		
500	5	68.2	340.9	12500.0		
0	10	0.0	0.0	0.0		
0	15	0.0	0.0	0.0		
0	20	0.0	0.0	0.0		
20	25	68.2	1704.4	12500.0		
520		136.4	2045.3	25000.0	6.9	15.0

Table 2: Example 3 from (Barber, Bush, & Berglund, 2011) showing that BAWAD results in a size classification (15”) that does not describe any of the trees on the site (500 5” trees and 20 25” trees).

In this stand there are 500 trees (per acre) that are 5 inches in diameter and 20 trees that are 25 inches in diameter. The R1 Classification System calculates a 15” stand (BAWAD column), even though there aren’t any trees in this stand that are in the 15” class. Furthermore, the presence of 25” trees is a strong indicator of quality wildlife habitat for some species, and their existence is masked by the 15” classification. Finally, the SIMPPLLE model is currently calibrated to recognize the presence of the 20 very large trees in its successional pathways, and would classify the stand as 20”+ diameter with two stories (as it actually is). The 15” classification from BAWAD (while not incorrect) does not adequately represent the largest cohort of 25” trees. Thus, the forest developed a method to distinguish stands with the presence of large (15”+) and very-large (20”+) trees, which is described in Appendix C. Briefly, a stand with 10 or more trees per acre of at least 15” in diameter was classified as “large”, and if it had 10 or more trees per acre of 20” or more in diameter, it was classified as “very large”. Each FIA plot was evaluated according to these criteria to get an estimate of the total acres forest-wide. Then, the VMAP stands were evaluated with the process described in Appendix C, and developed by (Northern Region Geospatial Group, 2015) to identify the polygons with the approximate total acreage (Table 3 and Table 4) to indicate the spatial distribution of stands containing these trees.

PVT	Treesize	MinVal	MaxVal	Only on FS Ownership	Applied to Broad VMAP
CMMD	4400	119000	123000	120431	152728
COLD	4400	3500	5500	5399	7103
WARM_DRY	4400	12000	15000	12284	20948
WARM_MOIST	4400	2000	4000	3972	14623

Table 3: Acres of large trees allocated to Broad PVT. MinVal and MaxVal define the algorithm’s boundaries, FS Ownership shows how many acres are identified on FS lands, and Broad VMAP shows the total acres applied to the VMAP used for SIMPPLLE modeling.

DOM_MID_40	MinVal	MaxVal	Only on FS Ownership	Applied to Broad VMAP
8405	5000	6500	1625	2048
8065	24000	26000	26650	32775
8045	12500	14500	15490	23142
8055	0	2000	57	94
8075	52000	55000	55253	73103
8015	0	1500	21	1451
8025	39000	42000	42424	62399
8095	0	2000	2	23
8505	1000	4000	657	737

Table 4: Large tree distribution by Dominance Type. These goals (MinVal and MaxVal) are not in addition to Table 3 but identify the distribution across the Dominance Types. MinVal and MaxVal are goals; the assignment algorithm was run to a point where most of them were met (FS Ownership). The Broad VMAP shows the acreage distribution applied to the landscape used in the SIMPPLLE model.

Modeling Vegetation Treatments by Alternative

The Spectrum model (USDA Forest Service, 1995) was used to determine, for each Alternative, a management strategy for moving the forest to the vegetation type and structure desired conditions in the forest plan. Inputs included a description of the current land base, a list of treatment options, the desired conditions, and the management limitations associated with each Alternative, including assumptions about how much of the forested land base would be affected by fire. [Note: determining the fire levels in the Spectrum model was an early application of SIMPPLLE in the analysis process and is described in Appendix G, below.] Outputs included acres of treatment by Management Area and vegetation class, as well as a measurement of wood volume and movement toward desired conditions. The SIMPPLLE model used the treatments scheduled by Spectrum to spatially model the Alternatives while accounting for stochastic events such as fire, beetle outbreaks, etc.

Translating from Spectrum outputs to SIMPPLLE inputs requires a bit of calculation. The Spectrum model runs the whole forest at once, but does not keep track of explicit spatial locations of the aggregated landscape units, called Analysis Areas, or Analysis Units. SIMPPLLE maintains much more detail about the spatial arrangement of the landscape (to a 150m pixel) and requires more computing power to run. Therefore the forest was split into six areas for analysis, called “Geographic Areas”. These included the North Fork, Middle Fork, South Fork [all referring to the Flathead River], Salish Mountain, Hungry Horse and Swan Valley geographic areas. Therefore, the treatments scheduled by Spectrum at the forest level need to be split and appropriately allocated to each of these six GAs.

To do this, we recognized three static identifier classes that could be used to proportionally allocate the treatments between the GAs; the Management Area Group (MAG), initial vegetation type, and initial size/structure class. Spectrum would report the acres of each treatment type by each unique combination of these three identifiers. These acres were then allocated to the GAs according to their proportion of the forest-wide acres of the unique type. Consider Table 5 that shows how prescribed

burns are allocated between the GAs. Across the forest, there are 95,959 acres of Species IMXSW Size Medium in Management Area MAG1. These acres are distributed as shown in the column "GA Acres of Type". For example, Hungry Horse has 5806 of these acres, or about 6%. In the first decade, Spectrum prescribed 30,438 acres of Prescribed burn in this type (TotTrt1 On Forest). Because Hungry Horse has 6% of this type, it is assigned 6% of the Spectrum solution, or 1843 acres (Treat1 column). This logic continues for the rest of the GAs, for the remainder of the time periods, and occurs across all initial Types and prescriptions assigned by Spectrum.

The last step in the Spectrum to SIMPPLLE translation is to convert the Spectrum vegetation dominance type to the SIMPPLLE species types. In Spectrum, the vegetation types are aggregated into many fewer categories than what SIMPPLLE recognizes. Therefore, a Spectrum dominance type can represent many different SIMPPLLE species, and all of these must be listed in the SIMPPLLE input file. A list of the SIMPPLLE species and their associated dominance type is included in Appendix E.

Table 6 displays the total treatment acres by decade for each Alternative. This is the total acreage modeled in SIMPPLLE across all GAs, Vegetation Types and Management Areas.

Species	Size	Treatment	Mgmt Area	GA	GA Acres Of Type	Total Acres Of Type	Treat1	TotTrt1 On Forest	Treat2	TotTrt2 On Forest	Treat3	TotTrt3 On Forest
IMXSW	Medium	RxB-In	MAG1	Hungry Horse	5806	95959	1843	30458	680	11240	686	11332
IMXSW	Medium	RxB-In	MAG1	Middle Fork	21318	95959	6767	30458	2497	11240	2518	11332
IMXSW	Medium	RxB-In	MAG1	North Fork	12056	95959	3827	30458	1412	11240	1424	11332
IMXSW	Medium	RxB-In	MAG1	Salish Mountains	3154	95959	1001	30458	369	11240	372	11332
IMXSW	Medium	RxB-In	MAG1	South Fork	45082	95959	14309	30458	5281	11240	5324	11332
IMXSW	Medium	RxB-In	MAG1	Swan Valley	8540	95959	2710	30458	1000	11240	1008	11332

Table 5: Example of how the Spectrum solution for prescribed burn is allocated to the Flathead Geographic Areas for SIMPPLLE model. There are 95,959 acres of IMXSW size Medium in MAG1 distributed across the 6 GAs. The Spectrum solution (e.g., 30,458 acres in period 1) is allocated proportionally across these GAs.

Alternative A						
Prescription	Decade 1	Decade 2	Decade 3	Decade 4	Decade 5	Totals
Light RxB	0	0	0	0	0	**0**
High RxB	0	0	0	0	0	**0**
Even-aged	11992	10808	13910	13240	17530	**67480**
Thin	0	0	0	0	0	**0**
Group Sel	4999	4998	5000	4999	5110	**25106**
Grand Total	**16991**	**15806**	**18910**	**18239**	**22640**	**92586**

Alternative B						
Prescription	Decade 1	Decade 2	Decade 3	Decade 4	Decade 5	Totals
Light RxB	0	32904	0	0	41277	**74181**
High RxB	36531	17031	25692	74989	33717	**187960**
Even-aged	21379	20447	19734	3057	9351	**73968**
Thin	10000	10000	9999	80869	46582	**157450**
Group Sel	0	0	0	0	0	**0**
Grand Total	**67910**	**80382**	**55425**	**158915**	**130927**	**493559**

Alternative C						
Prescription	Decade 1	Decade 2	Decade 3	Decade 4	Decade 5	Totals
Light RxB	6224	7246	23259	6224	7246	**50199**
High RxB	0	0	51734	68769	67746	**188249**
Even-aged	769	4108	14392	0	6750	**26019**
Thin	14998	14997	14996	56186	25584	**126761**
Group Sel	9998	9998	0	9998	9998	**39992**
Grand Total	**31989**	**36349**	**104381**	**141177**	**117324**	**431220**

Alternative D						
Prescription	Decade 1	Decade 2	Decade 3	Decade 4	Decade 5	Totals
Light RxB	12148	0	20074	12148	0	**44370**
High RxB	0	0	32176	60427	72456	**165059**
Even-aged	18066	8955	12901	20973	7000	**67895**
Thin	0	9946	983	17845	39603	**68377**
Group Sel	0	4922	4931	0	4922	**14775**
Grand Total	**30214**	**23823**	**71065**	**111393**	**123981**	**360476**

Table 6: Spectrum prescriptions by Alternative. These are aggregated across Vegetation type, size and Management Area Group (MAG)

Discussion

This document describes SIMPPLLE model assumptions used in the Flathead Forest Plan Revision that were updated for the plan's Environmental Impact Statement. These updates were made to incorporate the latest science, data, and knowledge that were available at the time of the revision. They represent, to the scientists' knowledge, the best information available at the time of the projections. Assumptions were tested and validated with the methods described in the main body of this document and the Appendices. The effects projected with the SIMPPLLE model almost certainly contain inaccuracies (as is the case with all models). However, by updating these assumptions for projections of all Alternatives provides a basis for comparison of effects between them; they have a level playing field. Finally, the information and knowledge gained here by the Flathead revision effort can and will be used to strengthen the assumptions used in other modeling efforts in Region 1.

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APPENDIX A: Fire Suppression Assumptions in the SIMPPLLE Model

Flathead National Forest DEIS Analysis

11/18/2015

Background:

The Alternatives were run initially using the fire suppression logic derived on the Kootenai and Panhandle forest plan revisions. This logic defined very effective suppression, and resulted in roughly 7500 acres of fire *per decade* for the first two planning periods. In Figure 1, Decade 0 represents actual fire on the Flathead National forest in the past decade (~350,000 acres). Decades 1-5 portray the minimum, average, and maximum fire levels from 30 replicates (model runs) of the Flathead National Forest. The average (blue) drops to 7500 acres/decade for Decades 1 and 2 before jumping to about 30,000 acres in Decades 3-5. The maximum amount of fire modeled in any single simulation was 66,000 acres in Decade 4 (green line). This was flagged as "probably not realistic" to go forth with DEIS analysis and more work was done to revisit the fire suppression strategy on the Flathead.

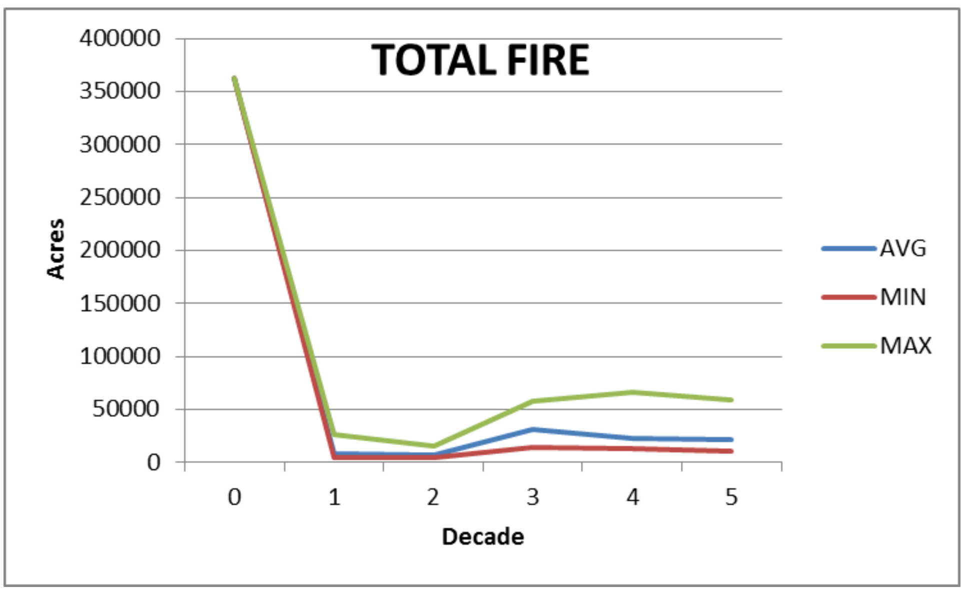


Figure 1: Initial Alternative B fire levels using Kootenai/Panhandle suppression logic

Key Assumptions:

Here are some of the key assumptions used in the modeling done for this analysis:

- The same Alternative B treatments scheduled by Spectrum were applied to all of these test runs (benchmark, Options)
- The climate for all of these test runs was assumed to be [Normal-Normal-Dry-Dry-Dry] for Decades 1-2-3-4-5
- Fire suppression logic has several different components, but the main three tested and reported on in this paper are 1) the probability that a fire will be suppressed at all (Fire Suppression Event Probability), 2)the effectiveness of suppressing a fire at the Class A level (Fire Suppression for Class A Fires) and 3) the response time/delay before suppression forces arrive at a fire.

- In the Background run shown above, Fire Suppression Event Probability for all fires was 100% and the Fire Suppression for Class A Fires was 51% for Wilderness in a dry climate, 60% for wilderness in a Normal or Wetter climate, 60% for non-wilderness in a dry climate, 75% for non-wilderness in a normal climate and 97% for non-wilderness in a Wetter climate. Suppression forces arrived ½ hour after a fire began.
- Fire spread rates, suppression rates, and types of fire that had suppression applied assumptions were not changed.
- Fires could also go out with rain events ("weather ending"). The likelihood of going out at Class A due to weather was higher in a Normal climate than in a drier climate. Weather ending probabilities at different size classes for larger-than-Class-A fires were consistent with the analysis done for the NRV runs.

Benchmark:

One of the first tests we conducted was to run a Benchmark run to assess the overall effectiveness of the fire suppression that resulted in Figure 1. In other words, is it fire suppression that causes the drop in fire levels, or are there other assumptions such as weather, fire starts, vegetation conditions, climate, effective management, etc. that cause the drop. The Benchmark was run *with* the scheduled treatments from Spectrum for Alternative B, but without any sort of fire suppression activity. The Benchmark was only run for 10 replicates, however, to save time in the overall testing phase. The results of the Benchmark are shown in Figure 2.

Again, Figure 2 shows the past Decade of fire activity in Decade 0 at about 350,000 acres. Without suppression, the average *wild*fire levels remain at about 350,000 before jumping 50,000 acres/decade in the final 3 decades. The maximum fire simulated in any iteration is 560,000 acres in Decade 3. With additional simulations, we should expect that maximum would likely increase, but the average should be about the same.

Note that this graph (or any graph in this document) does NOT display the scheduled prescribed fire. Alternative B schedules approximately 40,000 acres of prescribed fire for Decades 1 and 2, 25,000 acres for Decade 3 and 65,000 acres in Decades 4 and 5.

Results indicate that the fire suppression assumptions in the model have a marked, measurable impact on the amount of fire expressed on the landscape.

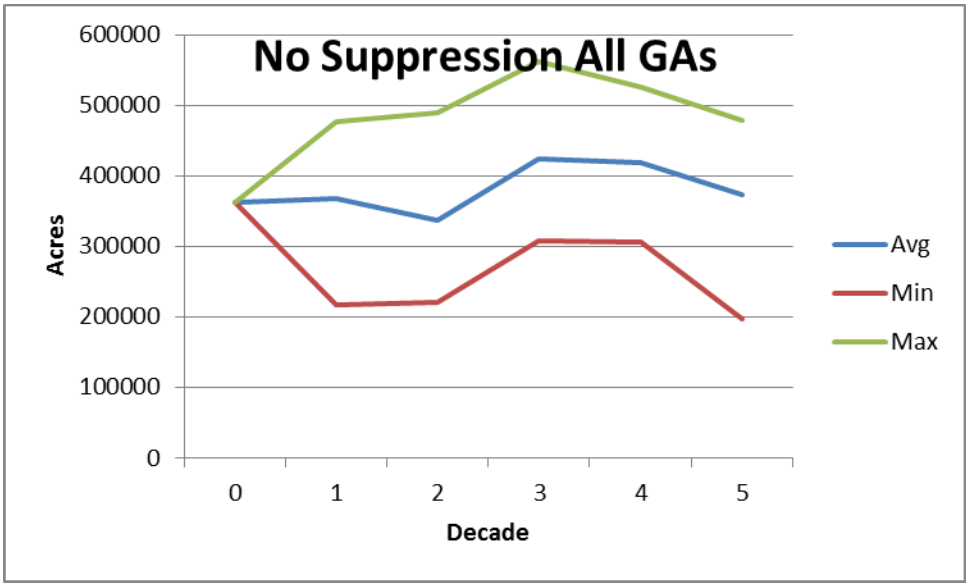


Figure 2: Benchmark Option with Alternative B vegetation & prescribed fire treatments, but no fire suppression activity.

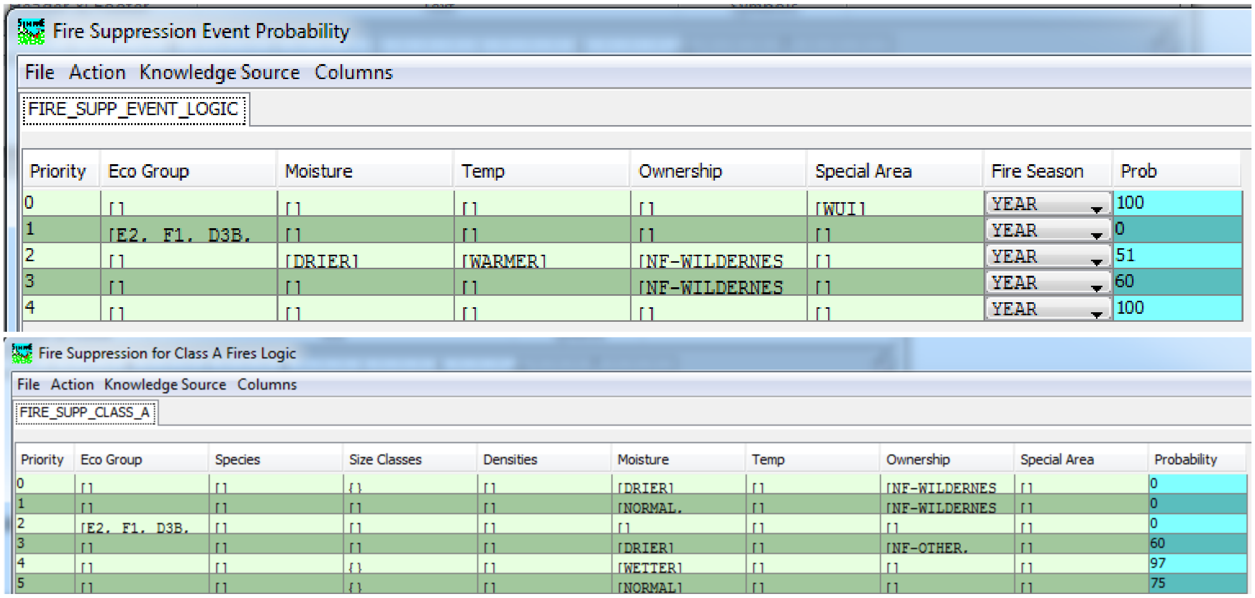
Options:

A total of six Options were explored for varying the fire suppression logic to more realistically portray fire activity and suppression effectiveness on the Flathead. Four of these options are discussed in detail.

Option 3:

Option 3 explores the ineffectiveness of fire suppression in wilderness and the Cool Moist habitat type group (E2, F1, D3A, D3B). All WUI fires are suppressed, however, the assumptions were that if a fire originated in Cool Moist outside of WUI, conditions were such that suppression would be ineffective and therefore no suppression was applied. In the wilderness, 51% of the fire events had suppression applied (application does not equate to effectiveness) in a Warm/Dry climate, and 60% of events were suppressed in the Normal Climate. There was a 0% chance that a fire could be suppressed at the Class A level in the Wilderness or in the Cool Moist HTG. The SIMPPLLE input screens for these assumptions are shown in Figure 3. This option was run for 5 replications.

Figure 4 shows wildfire resulting from these fire suppression assumptions. It is noticeably higher than the initial fire described in the Background. There was concern about the drop-off of fire in Decade 5, however, it is difficult to say whether this is because of a model anomaly, or whether this is because of a "limited sample size" of only 5 replicates. Overall fire levels in all decades are projected to be roughly 50% of the past 10 years.


Fire Suppression Event Probability

File Action Knowledge Source Columns

FIRE_SUPP_EVENT_LOGIC

Priority	Eco Group	Moisture	Temp	Ownership	Special Area	Fire Season	Prob
0	[]	[]	[]	[]	[WUI]	YEAR	100
1	[E2, F1, D3B,	[]	[]	[]	[]	YEAR	0
2	[]	[DRIER]	[WARMER]	[NF-WILDERNES	[]	YEAR	51
3	[]	[]	[]	[NF-WILDERNES	[]	YEAR	60
4	[]	[]	[]	[]	[]	YEAR	100

Fire Suppression for Class A Fires Logic

File Action Knowledge Source Columns

FIRE_SUPP_CLASS_A

Priority	Eco Group	Species	Size Classes	Densities	Moisture	Temp	Ownership	Special Area	Probability
0	[]	[]	{}	[]	[DRIER]	[]	[NF-WILDERNES	[]	0
1	[]	[]	[]	[]	[NORMAL,	[]	[NF-WILDERNES	[]	0
2	[E2, F1, D3B,	[]	[]	[]	[]	[]	[]	[]	0
3	[]	[]	[]	[]	[DRIER]	[]	[NF-OTHER,	[]	60
4	[]	[]	{}	[]	[WETTER]	[]	[]	[]	97
5	[]	[]	{}	[]	[NORMAL]	[]	[]	[]	75

Figure 3: Fire suppression assumptions for Option 3

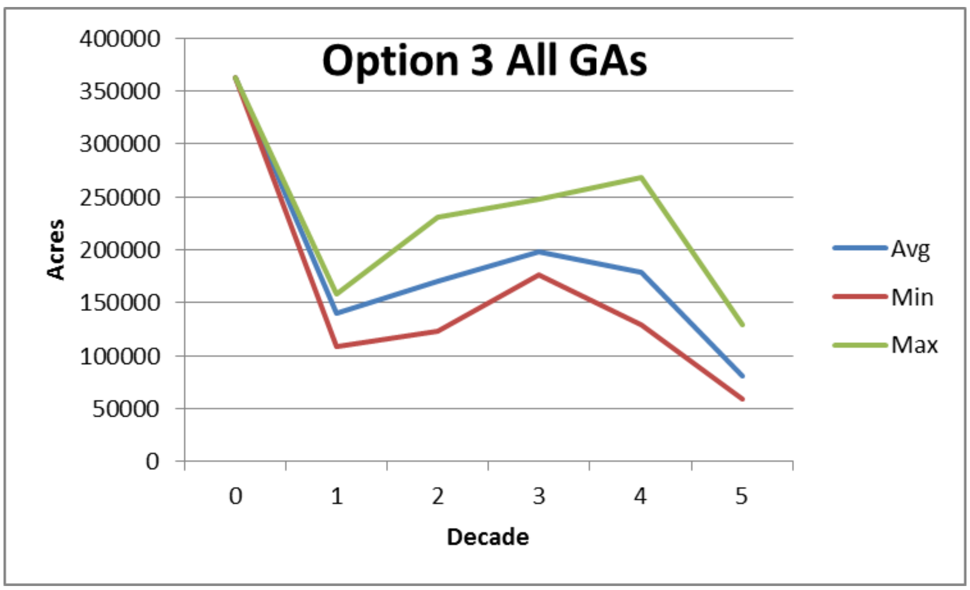


Figure 4: Total wildfire activity for Option 3. Summary is provided for 5 runs.

Option 4:

Option 4 allows that some fires will be suppressed in the Cool Moist HTG, but reduces the suppression activity in Wilderness. Again, all WUI fires are suppressed, but no Wilderness fires are suppressed in the Warm/Dry climate, 25% of wilderness fires are suppressed in Normal climate (relative to Option 3 60%), and 25% of non-wilderness Cool Moist fires outside of WUI are suppressed. No fires are caught at the Class A level in Wilderness or Cool Moist HTG. Class A suppression effectiveness outside of Wilderness is dropped to 50% (from 60%) in a Dry climate and 60% (from 75%) in a Normal climate. Figure 5 shows the SIMPPLLE input screens for these assumptions. Option 4 was run for 5 replicates and the results are shown in Figure 6. Option 4 fire activity is higher than Option 3, mainly due to the reduced fire suppression activity in the Wilderness, which is a significant portion of the Flathead. Still none of the replicates shows fire activity as high as what has occurred from 2005-2014 (Decade 0).

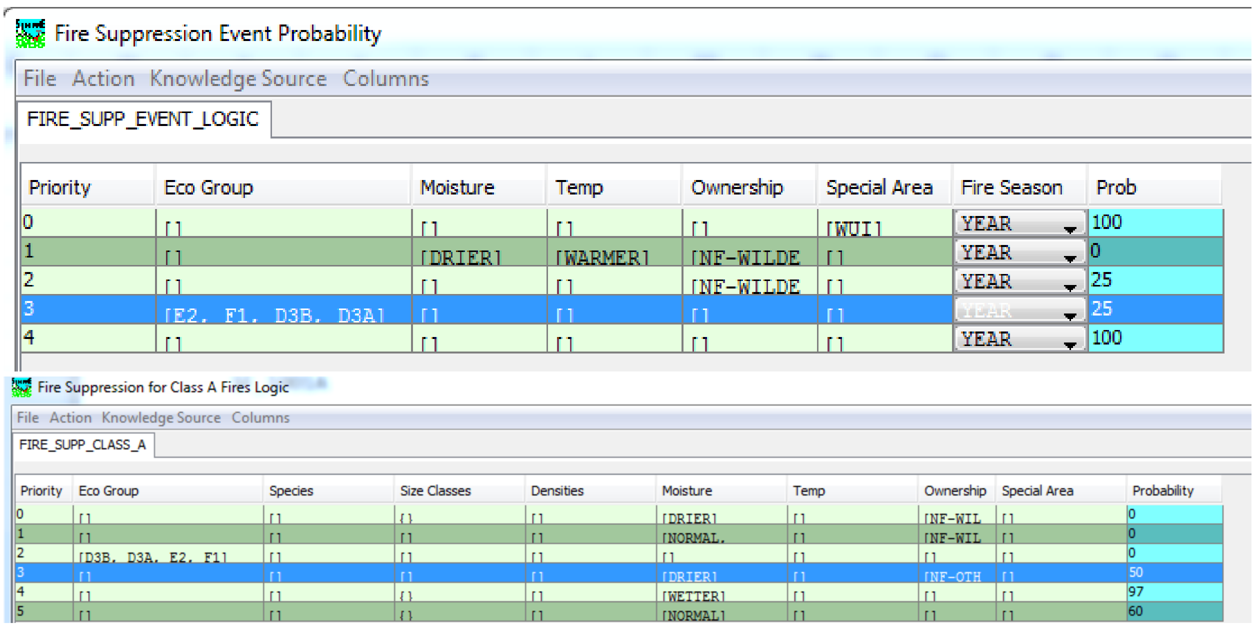


Figure 5: SIMPPLLE assumptions for Option 4.

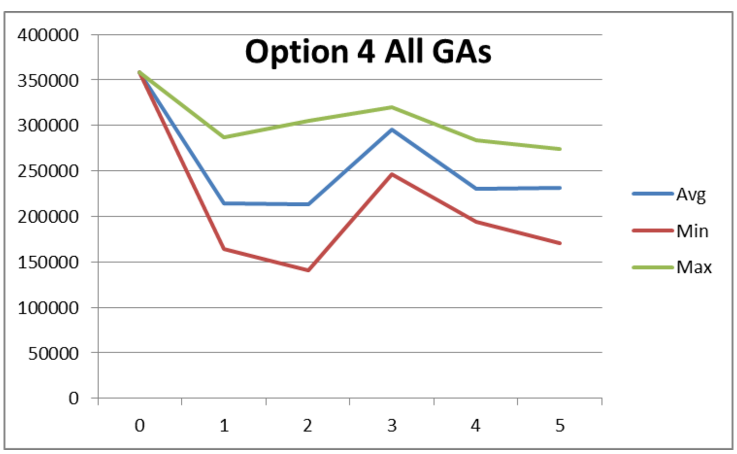
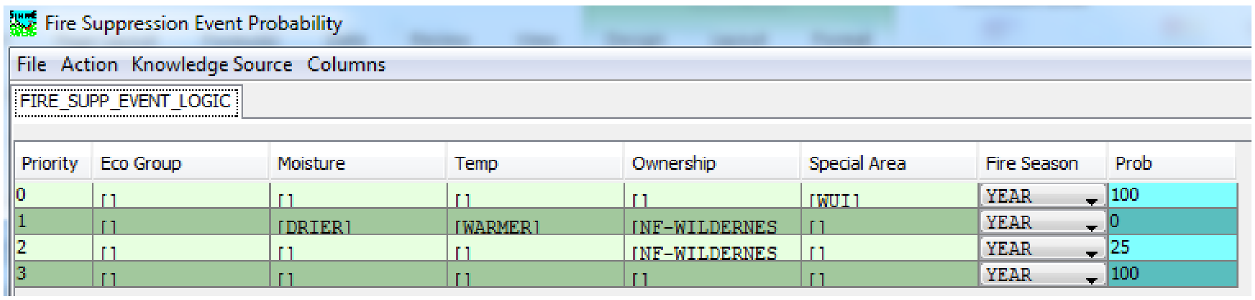


Figure 6: Fire activity levels associated with Option 4 results

Option 5:

Option 5 adds back fire suppression over Option 4. Specifically, Cool Moist is not a consideration for whether fire suppression is applied. The same probabilities or suppression in Wilderness are applied (0% in Warm/Dry and 25% in Normal). Of those suppressed in Wilderness, 25% are put out at Class A in Normal climates. Effectiveness at Class A is 25% for Cool Moist, and the outside-Wilderness effectiveness at Class A is restored to 60% Drier and 75% Normal (Figure 7). Option 5 was run for 5 replicates.

Results from Option 5 are shown in Figure 8. Not surprisingly, fire levels are lower than Option 4 to the tune of 100,000 acres/decade. A single replicate showed fire levels in Decade 2 similar to the past 10 years.

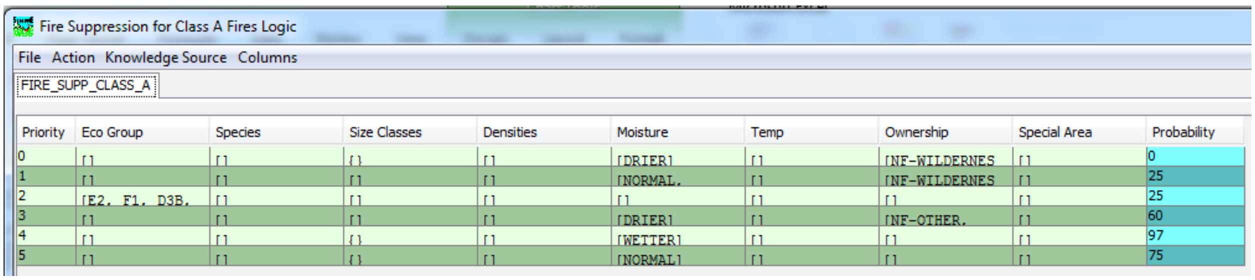


Fire Suppression Event Probability

File Action Knowledge Source Columns

FIRE_SUPP_EVENT_LOGIC

Priority	Eco Group	Moisture	Temp	Ownership	Special Area	Fire Season	Prob
0	[]	[]	[]	[]	[WUI]	YEAR	100
1	[]	[DRIER]	[WARMER]	[NF-WILDERNES	[]	YEAR	0
2	[]	[]	[]	[NF-WILDERNES	[]	YEAR	25
3	[]	[]	[]	[]	[]	YEAR	100



Fire Suppression for Class A Fires Logic

File Action Knowledge Source Columns

FIRE_SUPP_CLASS_A

Priority	Eco Group	Species	Size Classes	Densities	Moisture	Temp	Ownership	Special Area	Probability
0	[]	[]	{}	[]	[DRIER]	[]	[NF-WILDERNES	[]	0
1	[]	[]	[]	[]	[NORMAL,	[]	[NF-WILDERNES	[]	25
2	[E2, F1, D3B,	[]	[]	[]	[]	[]	[]	[]	25
3	[]	[]	[]	[]	[DRIER]	[]	[NF-OTHER,	[]	60
4	[]	[]	{}	[]	[WETTER]	[]	[]	[]	97
5	[]	[]	{}	[]	[NORMAL]	[]	[]	[]	75

Figure 7: SIMPPLLE Fire Suppression assumptions for Option 5

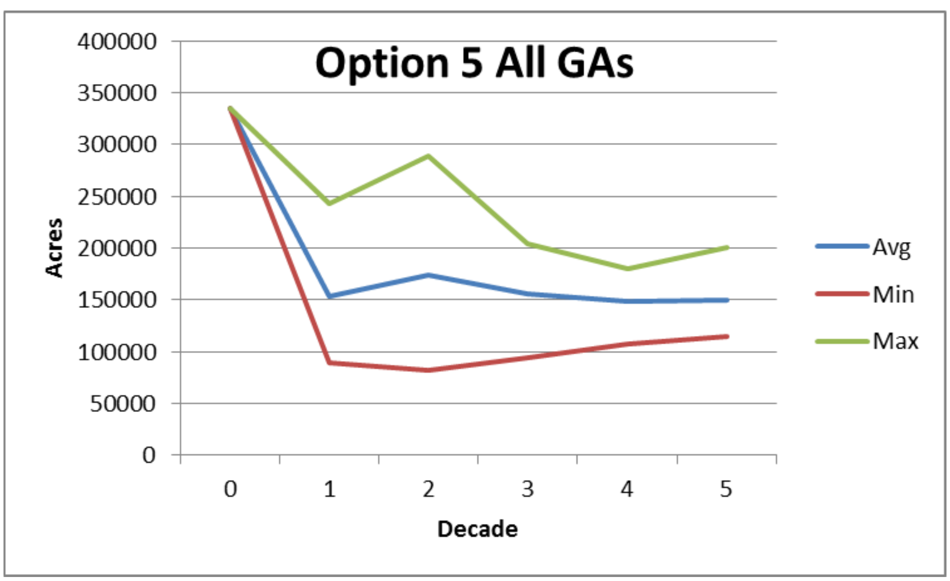


Figure 8: Fire levels resulting from Option 5 Fire Suppression strategy

Option 6 (Final – sent to ERG for modeling):

Option 6 is the logic used for the simulations written up in the Draft EIS released for review 11/16/2015. In general, fire suppression is applied more often, but with less success at the Class A level. Additionally, and most importantly, we changed the suppression response time from a default of ½ hour to up to 2 days for remote portions of the forest. Figure 9 shows these assumptions. Fires in Wilderness were suppressed about half the time for both climate situations, but Class A was assumed not caught for Wilderness or Cool Moist fires. Class A fires in non-wilderness non-Cool Moist were caught at a rate half of the initial assumption (30% in Warm, 37% in Normal). Response times varied from 2 hours for accessible, near-to-town fires and up to 2 days for the farthest, least accessible corners of the forest.

Results (Figure 10) show that *on average*, fire activity for Decades 1 and 2 was roughly 1/3 that of the past decade. However, in the set of 30 replicates, the maximum run achieved about 2/3 of the recent level in Decades 1 and 2, and in Decade 3, 1 replicate exceeded the current fire level.

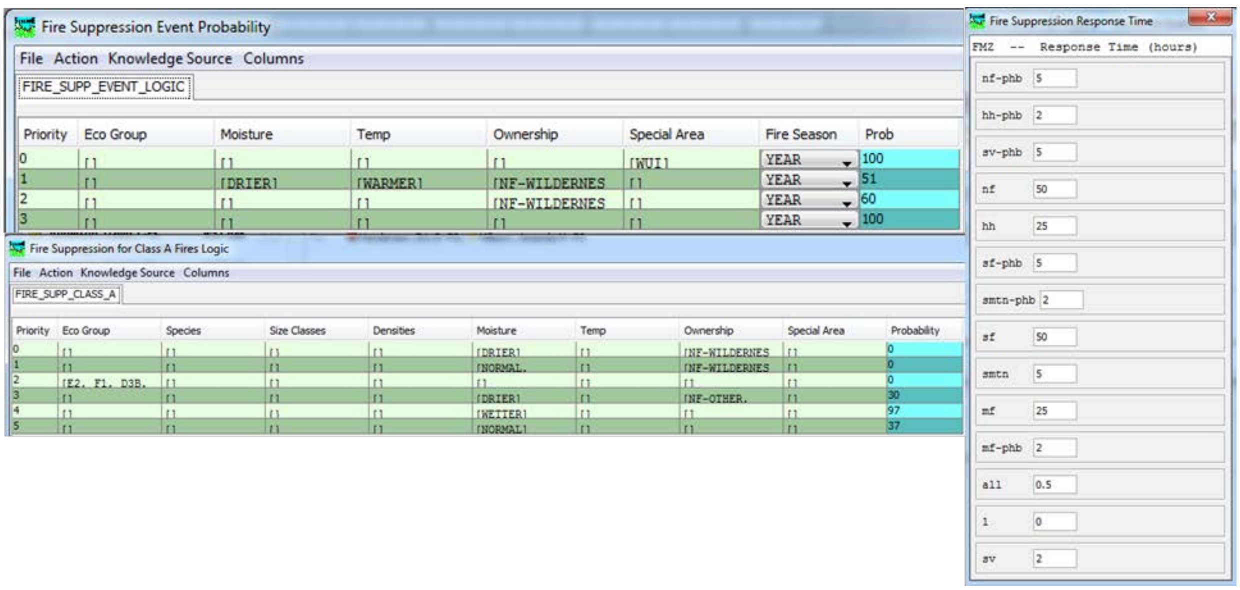


Figure 9: Fire suppression logic for Option 6.

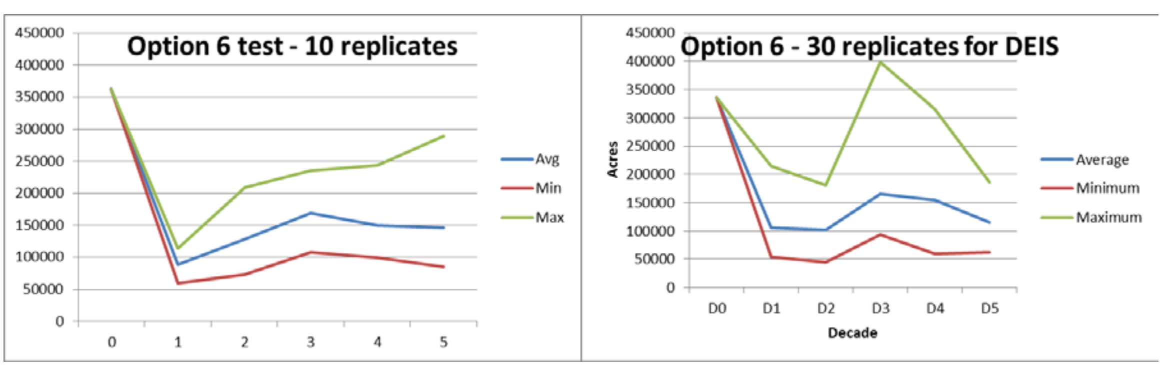


Figure 10: (a) Results from the 10 replicates evaluated in making the decision and (b) results from the 30 replicates used to quantify DFC and habitat results (supplied by ERG).

Option 6 with Climate Change:

Subsequent to the Option 6 sent to ERG (above), we developed an Option to test what happens if we assume climate change to warm/dry effective immediately. All Options to this point assumed a [Normal-Normal-Dry-Dry-Dry] climate scenario for the 5 decades of the simulation. This Option used a [Dry-Dry-Dry-Dry-Dry] climate assumption. Fire suppression tactics were the same as Option 6 above. The simulation was run for 10 replicates.

Figure 11 shows the result of this simulation. Relative to Option 6 (above) the average fire level jumps to 150,000 acres in the first decade rather than in the 3rd.

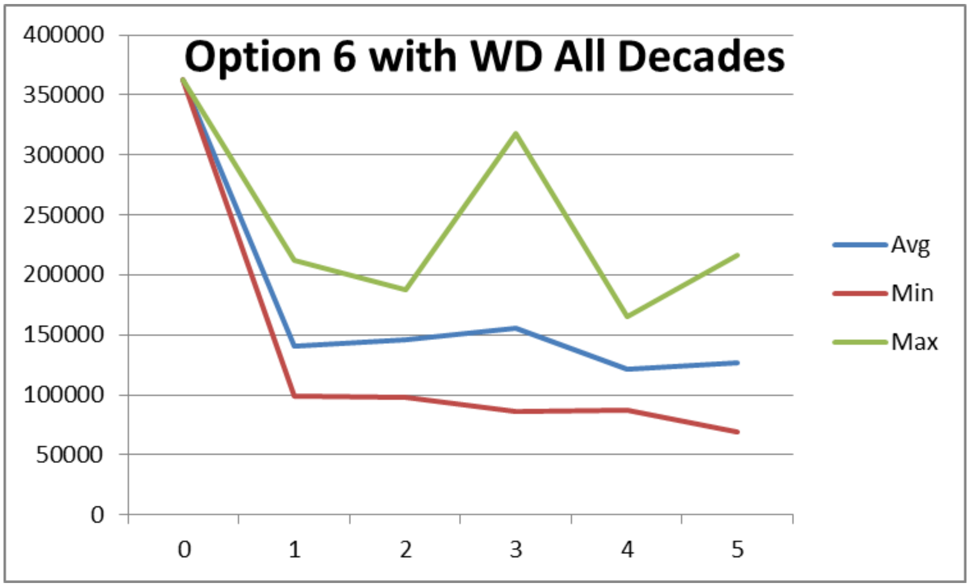


Figure 11: All fire resulting from Option 6 with Climate Change. Results show spread from 10 replicates.

APPENDIX B: Calculating Ag and Urban Areas for the Flathead

April 9, 2015
Eric Henderson

Operations performed first on the VMAP dataset "VmapGAwProb_FSown" with 566,xxx records.

Data source: \Landcover_10.1.gdb\Landcover_2013 (raster)

Urban Value Query (based on table from metadata below):

(ESLF_CODE >=21 AND ESLF_CODE <=31) OR (ESLF_CODE >=311 AND ESLF_CODE <=314) OR ESLF_CODE =410

- ➔ Species = "NF", Size = "NF" and HTG = "XX3", Density = 1

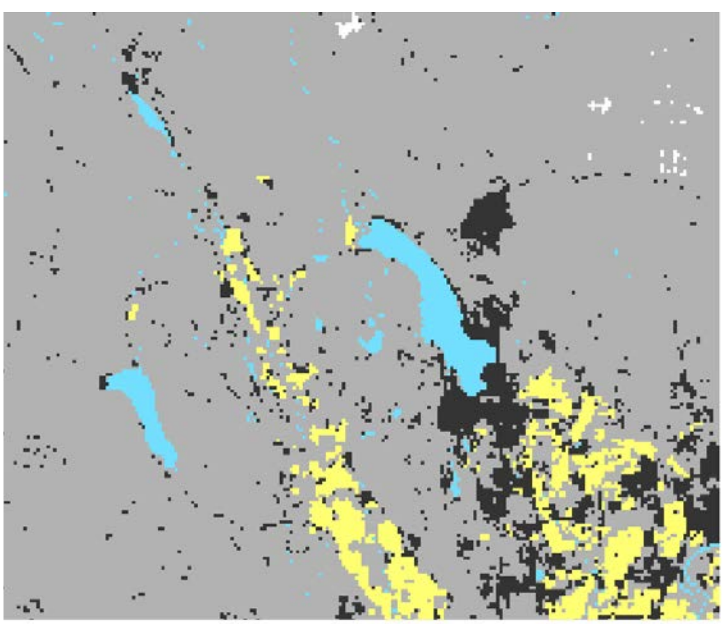
Agriculture Value Query:

(ESLF_CODE = 81) OR (ESLF_CODE =82)

- ➔ Species = "AGR", Size = "AGR" and HTG = "XX1" , Density = 1

After this, the irregular VMAP polygon features were exported as a 30 m pixel dataset, based on their OBJECTID. The square polygons of the SIMPPLLE input file were then used as zones to run a "Zonal Statistics as Table" function to determine the VMAP polygon ID that was mostly in each SIMPPLLE square. The VMAP polygon that most represented each SIMPPLLE square was then used to populate the attributes of each SIMPPLLE square.

Example of results: Whitefish lake with black as urban and yellow as agriculture:



Unfortunately, the species and size classes I used were out of the VMAP to SIMPPLLE analysis that was done in January, 2014, which did not include Avalanche Chute information or the debugging that occurred with the SIMPPLLE import errors. So I had to go back and populate the "AGURB_SPECIES" fields, etc. with the NRV calls in all areas but the AG and URBAN areas identified in this analysis.

Table of codes to represent urban (blue highlight) and agriculture (yellow highlight) areas

Attribute Value	Definition of Attribute Value
0	Background
11	Open Water
21	Developed, Open Space
22	Developed, Low Intensity
23	Developed, Medium Intensity
31	Quarries, Strip Mines and Gravel Pits
311	Coal bed methane
312	Gas and Gas Storage
313	Injection
314	Oil and Oil and Gas
410	Wind turbine
81	Pasture/Hay
82	Cultivated Crops

APPENDIX C: Texture Analysis Process

Eric Henderson

April 28, 2015

Data Sources:

- Rob Ahl's texture table, including original VMAP ObjectID and a MEANTXTMI value.
- VmapGAwProb_FSown that includes the field "FID_VMapBasePVT2013Sept12"

Process:

1. **Prepare the Data**

- Create a new field in the VMAP polygon dataset to store texture
- Join the VMAP polygon dataset to the table using the FID_VmapBasePVT2013Sept12 field and the OBJECTID field of the table
- Fill the polygon dataset with the texture information
- Create a PVT to Broad PVT look-up table. Create a field in the VMAP dataset, join the table, and populate the field.
- Create fields for large tree information – 2 columns (I chose integer) one for each size (15-20 and 20+)

2. **Query the FIA**

- Use the same look-up table for PVT to broad PVT to link to the plot-level data on MT_ID_PVT_1004
- Query for summarizing the TPA for each plot in each broad PVT/ size class category (NTG). Include the Broad PVT and R1 Classified size per plot
    - o Control for burned plots – take these acres out. Burned blot information can be found in the Spatial Dataset (SD) tables
    - o Summarize acres that meet both the 15-20" criteria and the 20"+ criteria
- Also, query by Geographic Area. Summarize the 15-20" acres and the 20"+ acres

3. **Summarize Results**

- Figure the FIA calculated acres of each BroadPVT/R1 Size Class that have the appropriate TPA in each size category (15-20" or 20"+).
- Compare the FIA calculated BroadPVT/R1 Size Class acreage to the mapped number of acres in the same category. Typically, I found that the larger size classes were measured more abundantly than mapped. Use this information to figure and adjust the appropriate number of acres to map in each category. However, removing the burned plots greatly improved the compatibility/consistency of the two datasets.

4. **Map the results**

Simple Procedure:

1. Select the polygons of FS ownership that have the BroadPVT/R1 Size Class combination with 15-20” and 20”+ large trees
2. Narrow the selection with the texture information (texture >=x) until the selected number of acres approximates the number of calculated acres that should be mapped from step 3.
3. Fill in the 15-20” and 20” columns with a value indicating these polygons have the appropriate number of trees to meet the criteria.
4. Use the threshold criteria determined in Step 2 to apply to the rest of the non-FS VMAP polygons

Complicated Procedure:

1. Export the dataset to text file table
2. Construct an input file with as many goals as you like. The goals can be overlapping, such PVT/size and GA. Specify a min/max acre value as well as an output value to assign the appropriate acres. Overlapping goals with the same output value will be balanced. Here is an example:

```
Continuous Value Column: Values in this column will be evaluated for above/below the thresholds for inclusion in the total
Texture_Value
Area Column: Column with values per polygon that are used to meet the goals
ACRES
PolyID Column: Stores information about the polygon unique identifier to use as a spatial join later on
OBJECTID
NCols,Col1_etc,Colval1_etc,MinVal,MaxVal,OutputVal,InitialThreshhold
2,Broad_PVT,TREESIZE,CMMD,4200,24000,26000,1,50
2,Broad_PVT,TREESIZE,CMMD,4300,380000,390000,1,50
2,Broad_PVT,TREESIZE,CMMD,4300,112000,125000,2,50
2,Broad_PVT,TREESIZE,CMMD,4400,210200,210240,1,50
2,Broad_PVT,TREESIZE,CMMD,4400,158000,162000,2,50
2,Broad_PVT,TREESIZE,COLD,4300,53000,57000,1,50
2,Broad_PVT,TREESIZE,COLD,4300,12000,14000,2,50
2,Broad_PVT,TREESIZE,COLD,4400,19790,20000,1,50
2,Broad_PVT,TREESIZE,COLD,4400,10000,12000,2,50
2,Broad_PVT,TREESIZE,WARM_DRY,4300,58000,61000,1,50
2,Broad_PVT,TREESIZE,WARM_DRY,4300,6000,6500,2,50
2,Broad_PVT,TREESIZE,WARM_DRY,4400,15310,15330,1,50
2,Broad_PVT,TREESIZE,WARM_DRY,4400,6000,6500,2,50
2,Broad_PVT,TREESIZE,WARM_MOIST,4300,36980,37010,1,50
2,Broad_PVT,TREESIZE,WARM_MOIST,4300,9000,9500,2,50
2,Broad_PVT,TREESIZE,WARM_MOIST,4400,16780,16800,1,50
2,Broad_PVT,TREESIZE,WARM_MOIST,4400,4000,4500,2,50
1,TREESIZE,3100,0,0,1,200
1,TREESIZE,3300,0,0,1,200
1,TREESIZE,8600,0,0,1,200
1,TREESIZE,8900,0,0,1,200
```

   Note that in this case, if you have a 15-20” class and a 20”+ class, and use a minimum texture value to delineate each, the acreage goal for the 15-20” class must be the sum of the 15-20” goal and the 20”+ goal. Then, the appropriate number of 20”+ polygons overwrite those 15-20” polygons with the highest texture values.

3. Iterate with the SOAP routine to attempt to get within the min/max acre range for each goal. Outputs include a text file with each polygon coded for whether it meets the output value criteria. A column for each potential output value is created. A file of weights/texture values found to meet the criteria is crated. A file of iteration results is created that you can manually inspect to determine if it meets the goals or not. Notes:

a. Polygons that have overlapping goals (part of this GA goal and also part of a PVT/size goal both to get an output value of 1 [15-20" class]) must meet the sum threshold value of those two goals to be assigned.
b. Tests indicated that the search algorithm has an easier time if you can eliminate some classes off the bat – so, the goal for size 3100, etc. is 0.

4. Run step 3 on just he FS lands. Save the output weights per goal. Run again on the full forest for a single iteration that uses those same weights in order to assign large trees to the rest of the non-FS VMAP polygons.

APPENDIX D: 15- and 20-inch tree query definitions

TABLE 2 WESTERN MONTANA ZONE OLD GROWTH TYPE CHARACTERISTICS *(02/05 errata edit)*

DESCRIPTION		MINIMUM CRITERIA			ASSOCIATED CHARACTERISTICS						
OLD GROWTH TYPE	HABITAT TYPE GROUP	MINIMUM AGE OF LARGE TREES	MINIMUM NUMBER TPA/DBH	MINIMUM BASAL AREA (FT^2/AC)	DBH VARIA-TION 2/	PERCENT DEAD/ BROKEN TOP 1/	PROB-ABILITY OF DOWN WOODY 2/	PER-CENT DECAY 1/	NUMBER CANOPY LAYERS 3/	SNAG S ≥9" DBH 1/	NUMBER OF SAMPLES
1 - PP, DF, L, GF,LP	A,B	170	8 ≥ 21"	60	M	12 3 - 23	L - M	5 0-11	SNGL	6 0 - 22	4,847
2 - DF,L, PP,SAF,GF	C	170	8 ≥ 21"	80	H	11 0 -21	M	5 2-12	SNGL/MLT	7 2 - 37	2,505
3 - LP	C,D, E,F,G,H	140	10 ≥ 13"	60 /70/ 80 (4)	L	11 5 - 22	H	6 2-15	SNGL	19 0-92	2,648
4 -SAF,DF,GF,C, L,MAF,PP,WP,WH , WSL	D E,F	180	10 ≥ 21"	80	H	9 0-19	H	9 1-31	SNGL/MLT	15 2 - 43	13,867
5 - SAF,DF,GF,L, MAF,PP,WP,WSL	G,H	180	10 ≥ 17"	70/80(5)	M	9, 1 - 18	H	6 0-12	MLT	12 3 - 36	4,053
6 - SAF,WSL,DF,L	I	180	10 ≥ 13"	60	M	11 2 - 31	M	10 2-17	MLT	25 5 - 38	255
7 - LP	I	140	30 ≥ 9"	70	L	8 3 - 14	H	5 0-11	SINGLE	17 9 - 22	95
8 - SAF,WSL	J	180	20 ≥ 13"	80	M	12 10 - 14	M	5 0-8	SNGL/MLT	37 33- 40	14

1/ These values are not minimum criteria. They are the range of means for trees ≥9" DBH across plots within forests, forest types, or habitat type groups.

2/ These are not minimum criteria. They are Low, Moderate, and High probabilities of abundant large down woody material or variation in diameters based on stand condition expected to occur most frequently.

3/ Not a minimum criteria. Number of canopy layers can vary within an old growth type with age, relative abundance of different species and successional stage.

4/ In Old Growth Type 3, 60 ft^2 applies to habitat type group E for LP, 70 ft^2 of basal area applies to habitat type group C for LP and habitat type group H for ES,AF,WBP, 80 ft^2 of basal area applies to all other habitat type and cover type combinations in Old Growth Type 3 .

5/ In Old Growth Type 5, 70 ft^2 applies to habitat type group H for SAF, 80 ft^2 of basal area applies to all other habitat type and cover type combinations in Old Growth Type 5 .

Similar groups:

Warm/Dry – base on OG Types 1,2

8 TPA >= 20" -> VL

10 TPA >= 15" -> L

Warm/Moist & Cool Moist – Moderately Dry – based on OG Types 4,5

10 TPA >= 20" -> VL

10 TPA >= 15" -> L

Cold – based on OG Types 6,8

10 TPA >= 15" -> L

APPENDIX E: Crosswalk between SIMPPLLE and Spectrum Types

SIMPPLLE	Dom Type
AF	AF/S
AF-ES-MH	AF/S
AF-MH	AF/S
AL	WBP
AL-AF	WBP
AL-ES-AF	WBP
AL-WB-AF	WBP
BP	HRDWD
BP-GF	HRDWD
BP-ES-AF	HRDWD
BP-L-DF	HRDWD
C	GF/C
CW	HRDWD
CW-ES-AF	HRDWD
DF	DF
DF-AF	DF
DF-C	DF
DF-C-ES-AF	DF
DF-ES	DF
DF-ES-AF	DF
DF-GF	DF
DF-LP	DF
DF-LP-AF	DF
DF-LP-ES	DF
DF-LP-ES-AF	DF
DF-LP-GF	DF
DF-PP-GF	DF
DF-PP-LP	DF
DF-WP	DF
DF-WP-GF	DF
DF-WP	DF
DF-WP-GF	DF
DF-WP-AF	DF
DF-WP-ES	DF
DF-WP-ES-AF	DF
ES	AF/S
ES-AF	AF/S
GF	GF/C
L	WL
L-C	WL
L-C-ES-AF	WL
L-DF	WL
L-DF-AF	WL
L-DF-C	WL
L-DF-ES	WL
L-DF-ES-AF	WL
L-DF-GF	WL
L-DF-LP	WL
L-DF-PP	WL
L-DF-RRWP	WL
L-DF-WP	WL

SIMPPLLE	Dom Type
L-ES	WL
L-ES-AF	WL
L-GF	WL
L-GF-ES-AF	WL
L-LP	WL
L-LP-ES	WL
L-LP-AF	WL
L-LP-ES-AF	WL
L-LP-GF	WL
L-PP	WL
L-PP-LP	WL
L-WP	WL
L-WP-GF	WL
L-WP	WL
L-WP-GF	WL
L-WP-C	WL
LP	LP
LP-AF	LP
LP-ES	LP
LP-ES-AF	LP
LP-GF	LP
MH	WBP
PF	WBP
PP	PP
PP-DF	PP
QA	HRDWD
QA-LP	HRDWD
RRWP	WP
WP	WP
WP-ES-AF	WP
WB	WBP
WB-AF	WBP
WB-DF-AF	WBP
WB-DF-ES-AF	WBP
WB-LP-ES-AF	WBP
WB-ES-AF	WBP
WH	GF/C
WH-C	GF/C
WH-C-GF	GF/C
WP	WP

APPENDIX F: Flathead Grid Documentation (Scott, Jared., 2014)

Flathead Grid Documentation

May 9, 2014

Note: “Grid” = the square polygons in the Flathead Geodatabase

- Avalanche Pathways
  - Grid gets AC when 50% or > of pixel has an avalanche pathway
  - Removed anything large only left open and closed ‘herb’ and ‘ss’
- Riparian
  - Used 40% or > area
  - Riparian overrides AC, only 4 pixels actually overlap so probably insignificant
- Populated the AC and Riparian in HT_GRP field of the TOTALFLATHEAD grid, then joined each GA grid table with the TOTALFLATHEAD table to replace values of the GA HT_GRP field with those of the TOTALFLATHEAD HT_GRP field. Joined tables using the STAND_ID field. Tried using SLINK field to do the join, however it seems that the SLINK fields are not identical so values in other fields did not seem to match

Found many Pathways errors when importing into SIMPPLLE

Changed NH4’s by joining table of original feature class and copied values out of original HT_GRP

- Alpine Grasses and Upland Grasses to Riparian Grasses
- Water back to XX5
- Xeric Shrub to Mesic Shrubs
- Queried (veg_polys.HT_GRP = 'NF4' AND veg_polys.SPECIES LIKE '%LP%') to select DF-LP, DF-LP-AF, DF-LP-ES, DF-LP-ES-AF, DF-PP-LP, L-DF-LP, L-LP, L-LP-AF, L-LP-ES, L-LP-ES-AF, L-LP-GF, LP, LP-AF, LP-ES, LP-ES-AF, L-PP-LP, WB-LP-ES-AF
  - This query also selected QA-LP, but I removed from selection for now since pathways exist.
  - Changed these back to original HT_GRP, 562 records changed
- Then Queried veg_polys.HT_GRP = 'NF4' AND veg_polys.SPECIES LIKE '%DF%' to select BP-L-DF, DF, DF-AF, DF-C-ES-AF, DF-ES-AF, DF-GF, DF-PP-GF, DF-WP, DF-WP-ES-AF, L-DF, L-DF-AF, L-DF-C, L-DF-ES, L-DF-ES-AF, L-DF-GF, L-DF-PP, L-DF-WP, PP-DF
  - Removed the BP-L-DF because Eric created pathway for BP using this query veg_polys.SPECIES LIKE '%BP%'
  - Changed these back to original HT_GRP, 386 records changed

- Then Queried veg_polys.HT_GRP = 'NF4' AND veg_polys.SPECIES LIKE '%L-%' to get BP-L-DF, L-C-ES-AF, L-ES, L-ES-AF, L-GF, L-PP, L-WP, L-WP-C
    - Removed the BP-L-DF because Eric created pathway for BP using this query veg_polys.SPECIES LIKE '%BP%'
    - Added Species = L
    - Changed these back to original HT_GRP, 120 records changed
- Then Queried
-
    - (veg_polys.HT_GRP = 'NF4' AND veg_polys.SPECIES = 'AF') OR (veg_polys.HT_GRP = 'NF4' AND veg_polys.SPECIES = 'ES') OR (veg_polys.HT_GRP = 'NF4' AND veg_polys.SPECIES = 'ES-AF') OR (veg_polys.HT_GRP = 'NF4' AND veg_polys.SPECIES = 'WB-AF') OR (veg_polys.HT_GRP = 'NF4' AND veg_polys.SPECIES = 'WB-ES-AF') OR (veg_polys.HT_GRP = 'NF4' AND veg_polys.SPECIES = 'WP-ES-AF') to get final changes
    - Changed these back to original HT_GRP, 54 records changed

AC Errors

- We decided to change any densities that were 4's to 3, except for AL-ES-AF and everything else back to Original HT_GRP because we believe pathways exist for these densities
- Changed all AC errors back to Origional HT_GRP using the following query:

(veg_polys.HT_GRP = 'AC' AND veg_polys.SPECIES = 'AL-ES-AF') OR

(veg_polys.HT_GRP = 'AC' AND veg_polys.SPECIES = 'BP-ES-AF') OR

(veg_polys.HT_GRP = 'AC' AND veg_polys.SPECIES = 'BP-L-DF') OR

(veg_polys.HT_GRP = 'AC' AND veg_polys.SPECIES = 'ES') OR

(veg_polys.HT_GRP = 'AC' AND veg_polys.SPECIES = 'L-DF-GF') OR

(veg_polys.HT_GRP = 'AC' AND veg_polys.SPECIES = 'PP-DF')

- Then changed densities from 4 to 3 for using this query

(veg_polys.HT_GRP = 'AC' AND veg_polys.SPECIES = 'CW-ES-AF') OR

(veg_polys.HT_GRP = 'AC' AND veg_polys.SPECIES = 'DF-ES-AF') OR

(veg_polys.HT_GRP = 'AC' AND veg_polys.SPECIES = 'DF-PP-LP') OR

(veg_polys.HT_GRP = 'AC' AND veg_polys.SPECIES = 'L-DF-LP') OR

(veg_polys.HT_GRP = 'AC' AND veg_polys.SPECIES = 'L-ES-AF') OR

(veg_polys.HT_GRP = 'AC' AND veg_polys.SPECIES = 'WB-DF-AF') OR

(veg_polys.HT_GRP = 'AC' AND veg_polys.SPECIES = 'WB-ES-AF')

6/11/14

Root Disease

Removed Closed-Herb, Open-low, NF, and SS Sizes and A2, C2, E1, E2, G1, G2, NF1, NF2, and NF4 (regardless of size class) that also had Root Disease. Changed 45196 records in Process field from "Root Disease to " ".

Used this query to select:

(("PROCESS" = 'ROOT-DISEASE' AND "SIZE_CLASS" = 'CLOSED-HERB') OR

("PROCESS" = 'ROOT-DISEASE' AND "SIZE_CLASS" = 'NF') OR

("PROCESS" = 'ROOT-DISEASE' AND "SIZE_CLASS" = 'OPEN-LOW-SHRUB') OR

("PROCESS" = 'ROOT-DISEASE' AND "SIZE_CLASS" = 'SS'))

OR

(("PROCESS" = 'ROOT-DISEASE' AND "HT_GRP" = 'A2') OR

("PROCESS" = 'ROOT-DISEASE' AND "HT_GRP" = 'C2') OR

("PROCESS" = 'ROOT-DISEASE' AND "HT_GRP" = 'E1') OR

("PROCESS" = 'ROOT-DISEASE' AND "HT_GRP" = 'E2') OR

("PROCESS" = 'ROOT-DISEASE' AND "HT_GRP" = 'G1') OR

("PROCESS" = 'ROOT-DISEASE' AND "HT_GRP" = 'G2') OR

("PROCESS" = 'ROOT-DISEASE' AND "HT_GRP" = 'NF1') OR

("PROCESS" = 'ROOT-DISEASE' AND "HT_GRP" = 'NF2') OR

("PROCESS" = 'ROOT-DISEASE' AND "HT_GRP" = 'NF4'))

6/24/14

Copied the TOTALFLATHEAD_2014_0609_ChangeRootD.gdb and changed name to TOTALFLATHEAD_2014_0624

TOTALFLATHEAD_2014_0609_ChangeRootD.gdb will need to add New Root Disease Hazard

Now start HRV with TOTALFLATHEAD_2014_0624_HRV

To do list for HRV GDB

1. Change NF to Upland grass
2. Add FMZ's showing Native American Burning
3. Need to add new Root Disease Hazard/Severity by randomly assigning areas of High Hazard with % of High Severity…Not sure if we need to look at HTGRP category or just assume that all areas of High Hazard have a % probability of High Severity.

7/17/2014

Changing all NF values

Heidi recommended that NF should be changed to Upland grass except in the Flathead Valley, where I used the prehistoric burning layer to intersect all NF in the Flathead Valley. I changed the HT_GRP to B2, Species to PP-DF, SS, and Density 2. All other NF's will be changed to HT_GRP – A2, Upland Grass

Changing Root Disease Occurrence

Root disease occurrence was changed in the Grid to reflect occurrence within FIA data. I used Blakey Lockmans spreadsheet that gave a percentage of FIA plots that had High Occurrence within areas of High Hazard. Areas of High Hazard were developed using a combination of Ecoregion/PVT/VMAP Dom40 grouping. Dom40 grouping had to be extracted from the Dom6040 field in SIMPPLLE Grid. I was able to create an Ecoregion/PVT/Dom40 combination within the Grid so that I could assign the correct percentage from the spreadsheet to each unique Ecoregion/PVT/Dom40 combination. Once this was done, I used this percentage to randomly assign cell of each combination High Occurance. The random assignment was done by creating a new field called 'Random' with a Float type. I used a python code to generate a random decimal number from 0 to 1. Then I was able to query records that had a Random number <= to the percentage.

There were 2015 polygons in the grid that have high RD occurance, however, we decided that all Fire processes override Root Disease, so I ended up with 1931 polygons with RD. Then, I reran the query done on RD from 6/11/14 (see above) to remove HTG's and Size Classes that did not have an RD logic built into SIMPPLLE. I changed this selection values from Root-Disease to " ". The final RD total of polygons are now – 1603.

Prehistoric Burning

The fire staff gave me a GIS layers that showed areas of frequent prehistoric burning. One layer was a polygon based off expert opinion from the Forest Archeologist showing areas of frequent buring. Another layer was LandFire data for the Swan Valley region where I queried out the Fire Regime Class of < 35 years. The last layer was a line feature class of 'Travel Routes', where I changed Grid Cells that were within 200m of these lines.

The FMZ field was changed for these areas from the GA to GA-PHB.

8/5/2014

Did some runs, found out that changing “All other NF’s will be changed to HT_GRP – A2, Upland Grass” from 7/17/2014, created Large Pipo on top of Mission Mountains which would be inaccurate. So I joined the Grid with a backup copy before the said change was made, joined on StandID and selected where Grid HTG = A2 and Backup Grid HTG = NF1 or NF2. I changed the Species and Size Class back to backup values and HTG to backup NF1 or NF2.

8/8/2014

We noticed during a few calibration runs that Lodgepole Pine was being reduced by fire across many of the GA’s. We did not believe this to be true so we changed the regeneration logic to allow for lodgepole pine to regenerate 2 timesteps after Mountain Pine Beetle outbreaks. We also changed the regeneration logic to have more consistency and allow for more Lodgepole Pine regeneration both in-place and adjacent. These changes did allow for lodgepole to perpetuate after fire on the landscape.

8/14/2014

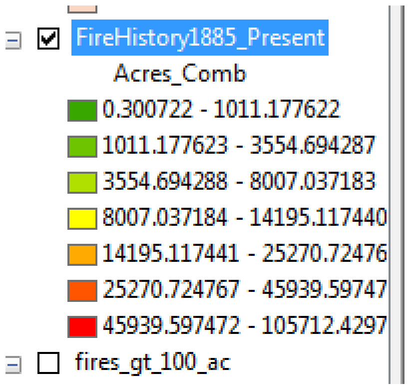
We created a new system knowledge file for Hungry Horse GA to ‘burn’ water. This allowed fires to start and also spread across the water so that fires would not be trapped on one side of Hungry Horse Reservoir. This allowed for the islands in the reservoir to have fire.

8/20/2014

New Weather Ending Event Logic by GA

Fire Class Size breaks were updated using a ArcMap with a ‘natural breaks’ classification using the entire fire history layer for the flathead for fires > 1011 acres (Arcmap screenshot of Natural Breaks on Left, New Fire Ending Event classes on Right) Note, Final size class probabilities are determined using a spreadsheet model which is dependent on the Potential Fire Starts per Century for each GA.

Note: We noticed that changing the smallest fire class probability was very sensitive to the number of acres burned in each timestep. See **Calibrating Burn Acreage in Timesteps** below.



Size Class	Weather Ending Probability
0.25-10	0.3
11-100	0.31
101-500	0.4
501-1011	0.25
1012-3554	0.37
3555-8007	0.51
8008-14195	0.53
14196-25270	0.41
25271-45939	0.47
Final Size Class	0.212839795

Maximum fire size will be changed based upon the most acres burn in any given year in the Fire History GIS layer. Note that some GA's did not exceed 45,940 acres so the size class above 45,940 acres will have a value of 100 in the Weather Ending Events logic Note: The spreadsheet model that could also calculate a probability for GA's that had a largest fire less than 45,940 but more calibration runs need to be determines.

Calibrating Burn Acreage in Timesteps

Premliminary calibration runs found that changing the probability of the smallest fire size class will impact the amount of acreage burned in any given timestep. So far trial and error runs changing that probability have been used so that the maximum amount of area burn would be similar to the Max 10 Year Burn Acres. More calibration runs need to be done to finalize that probability for each GA.

Geographic Area	GA Acres	Largest area burned in a single year	Max 10 Year Burn Acres
Hungry Horse	331,885.00	31,223	56,797.81
Middle Fork	375,275.00	146,077	184,060.70
North Fork	389,697.00	58,945	83,290.60
Salish Mountains	836,761.00	57,776	94,985.38
South Fork	790,742.00	176,419	237,985.55
Swan Valley	531,718.00	32,401	48,741.32

New Prehistoric Burn (FMZ) logic

Increased the FMZ fire start value the following FMZ's-- SF-PHB (South Fork Prehistoric Burning), Smtn-phb (salish mountains), sv-phb (Swan Valley)

FMZ	Original Value	50% Increase Value
sf-phb	139	209
smtn-phb	144	216
sv-phb	105	158

APPENDIX G: Using SIMPPLLE to determine fire levels in Spectrum

The Spectrum harvest scheduling model is used in forest plan revision to calculate treatments needed to move towards vegetation desired conditions. When scheduling these treatments it is necessary to consider the role of disturbance processes, as they may either supplement or oppose movement towards desired conditions. The SIMPPLLE model was applied at an early stage of the analysis process (November, 2014) to determine the natural disturbances levels considered in the Spectrum model. Fire suppression assumptions (fire spread and fire line building rates) from previous planning efforts were applied to the Flathead. The fire suppression strategy (how/where to apply suppression forces) was modeled with assumptions specific to the Flathead. Here is a brief synopsis of the assumptions and outcomes of this analysis.

The Flathead Spectrum model was initially developed for the ca. 2006 forest planning effort. In that model was an assumption of 7500 acres per decade of stand-replacing fire. In the years since that initial planning effort, the forest has experienced stand-replacing fire at levels well above 7500 acre per decade. To address this disconnect, the Flathead adopted assumptions developed by the Kootenai and Idaho Panhandle National Forests (KIPZ) when their plans were revised in 2015. In the KIPZ revision, time was spent with forest Fire Management Officers to refine the fire suppression assumptions in SIMPPLLE. Specifically, the rate of spread of fire was revised to consider vegetation conditions, weather, and slope. To estimate suppression effectiveness, the rate of fire line creation was revised to account for vegetation conditions (e.g., it’s faster to create fire line through grass than through thick forest) and the size of the fire. Larger fires were assumed to have more fire crews assigned and therefore could build fire line at increased rates.

The fire spread and suppression rates developed for the KIPZ were directly used for the Flathead’s analysis of future fire spread. The Flathead fire start and size information from the NRV analysis was used as a basis for what types of fires would be seen in the future. Whether or not the fire was actively suppressed was based on where it started; 100% of non-wilderness fires were suppressed and 50% of wilderness fires were suppressed. The climate assumption moving into the future was NORMAL NORMAL WARM WARM WARM for the next 5 decades. The resulting fire activity levels – of Stand Replacing Fire – are shown in the following Table:

	Decade 1	Decade 2	Decade 3	Decade 4	Decade 5	Total
Fire_ESAF	11373	14110	21290	23418	22532	18545
Fire_GSF	3235	2291	2536	2777	1865	2541
Fire_DECID	30	38	110	197	161	107
Fire_DF	2516	4553	8921	9428	8757	6835
Fire_LP	11048	14194	16666	14372	11497	13555
Fire_L	1896	2810	4938	3836	3718	3440
Fire_PP	52	103	271	470	414	262
Fire_AC	0	0	3940	4326	4069	2467
Fire_WETL	7	27	228	247	230	148
Fire_GFC	6	10	9	30	31	17
Fire_WB	194	268	552	651	617	456
Total	30357	38404	59461	59752	53891	48373

	Decade 1	Decade 2	Decade 3	Decade 4	Decade 5	Total
SIZE_Fire_SS	6237	11411	17040	14971	14679	12868
SIZE_Fire_POLE	9524	5004	6707	10861	8840	8187
SIZE_Fire_MED	8861	15426	20997	15812	11422	14504
SIZE_Fire_LARGE	2499	4268	10247	13140	15034	9038
SIZE_Fire_VL	0	5	99	143	204	90
Total	27121	36114	55090	54927	50179	44687

Some notes on these figures:

- The covertype fire numbers include non-forested types (GSF) that are not in the Size Class table
- These figures represent ONLY stand-replacing fire, and do not include non-stand replacing fire activity (mixed- and light-severity). Therefore, they are lower than recent fire activity levels on the Flathead.
- These were not the final figures included in the Spectrum model depicted in Appendix 2 of the FEIS. Fire levels in Spectrum were adjusted slightly to accommodate infeasibilities resulting from limited yield tables/timing choices for stand-replacing fire (a modeling limitation).