CROWN FIRE ASSESSMENT IN THE URBAN INTERMIX: MODELING THE SPOKANE, WASHINGTON PONDEROSA PINE FORESTS

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ABSTRACT

To address the problem of crown fire hazard urban intermix problem in the Ponderosa pine forests around Spokane, WA., using field data we linked three models, CROWNS2, NEXUS, and FVS/SVS/SUPPOSE. By manipulating these models, we were able to obtain indications of expected outcomes given certain levels of risk. CROWNS2 and NEXUS were used to determine crown bulk density and expected fire behavior, FVS/SVS/SUPPOSE was used to obtain effective life of treatment and visual outputs. With the goal of eliminating crown fire hazard, four different thinning and pruning regimes were then modeled, giving expected current stand fire behavior, current treated stand fire behavior, and future expected stand fire behavior.

The models were useful in illustrating risks, hazards and the potential outcomes of different treatments. To become more widely used, the models will have to be combined with appropriate algorithms and standardized inventory data. Both accuracy and assumptions of models must be verified.

INTRODUCTION

Across the western United States, increasing crown fire hazard in the urban intermix threatens life, property, and resources. Silvicultural prescriptions focusing on reduction of crown bulk density to reduce crown fire hazard in the Spokane WA. urban intermix are necessary to mitigate this hazard. We utilized existing fuel, fire behavior, forest succession, and visual projection models to illustrate the consequences of no action compared to thinning and pruning in Ponderosa pine forests. Crown bulk density was reduced to threshold values reported in the literature that are expected to reduce the crown fire threat (0.1 and 0.05 kg/m^3)(Agee, 1996). We also imposed a pruning that effectively removed ladder fuels and raised the height to live crowns and thus reduce crown fire initiation. We projected expected fire behavior and tree mortality outcomes for current stand and treated stand conditions and determined the effective life of these treatments. We formatted the results in computer graphics so that the general public could easily understand the projected fire behavior, especially the crown fire potential.

METHODS

The major theme of this paper is the linking of models, not to provide a “how to” manual. Therefore, we have attempted to explain the general procedure we followed without listing too many technical steps.

The models we used were CROWNS2, NEXUS (Spring ’98 release), Forest Vegetation Simulator/Stand Visualization System/SUPPOSE 1.10 (FVS/SVS/SUPPOSE), and the Stand Visualization System 3.11 (SVS) stand-alone version. CROWNS2 (Reinhardt, 1998) is a spreadsheet that converts basic tree measurements into crown bulk density. NEXUS (Scott, 1999) is a spreadsheet that predicts fire behavior, including crown fire initiation, based on environmental and stand characteristics. The algorithms Nexus uses are based on Rothermal’s surface and crown fire spread models combined with Van Wagner’s crown fire initiation theory.

Based on stand data, SVS (McGaughey, 1996) generates an abstract computer image. Data can be manipulated within the simulator to customize the image based on management actions, etc. SVS has been bundled with the Forest Vegetation Simulator (FVS) and SUPPOSE. FVS (Wykoff, 1982) is a distance-independent tree growth and yield model. SUPPOSE is the graphical user interface for the FVS.

Field data was gathered at Riverside State Park, Spokane, WA. Four 1/20-acre plots were randomly selected. All trees of any size were measured for the following: species, diameter at breast height, height, crown ratio, crown radius, and height of lowest branch. In the various models, this data was expanded to represent 1-acre areas. The models supported X and Y coordinates for spatial mapping, but we did not utilize them.

The basic process for expected outcomes of a current stand condition follows. First, the stand data was entered into a Microsoft Excel 6.0 spreadsheet, then the relevant measurements imported into CROWNS2 to determine crown bulk density. Also from the Excel spreadsheet, the relevant measurements were entered into SVS, giving the view of the current 1-acre area. Using the crown bulk density from CROWNS2 and the canopy closure percentage generated by SVS combined with the environmental conditions we chose, Nexus was run. The default settings were used and crown fire was enabled. Using the fire type or scorch height generated, the effects to the 1-acre were manipulated in the SVS file editor using a custom tree file.

Following that methodology produced a visualization of the current stand, expected fire behavior, and a visualization of post-fire effects in the 1-acre area.

The next step involved manipulating the trees per acre and height of lowest branch in CROWNS2 using the current tree data from the previous CROWNS2 run. By selectively removing trees and altering the heights of lower branches and observing the changes in the graphic output, we were able to structure the crown bulk density of the stand to fit our prescriptions.

The same tree records were removed from the SVS stand file that were removed from the CROWNS2 run above resulted in visual output that matched the newly altered 1-acre area. Again, using crown bulk density, canopy closure, and environmental data, expected fire behavior outcomes were generated and visuals created.

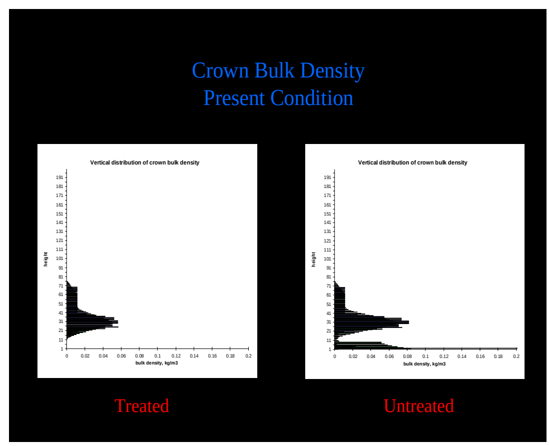
To make fire behavior predictions for future conditions, we first had to grow the 1-acre areas to the desired future date, in this case we chose 20 years. To accomplish this, we inputted the stand data into FVS via the editor. SUPPOSE was used to advance the 1-acre area to the future year. This gave us the future predicted condition. The FVS stand file was imported into an Excel spreadsheet where a pivot table using height and dbh as variables was created. Next we averaged the tree data for each dbh/height category. For example, if 5 trees with a dbh of 10 inches and a height of 35 feet had a crown radius of 6 feet and 5 other trees of the same dbh/height measurements had a crown radius of 8 feet, we input 10 trees with crown radius of 7 feet. Due to the vast amount of tree records generated by FVS, we were forced to this convention, otherwise it was not feasible given time limits and the data entry structure of the other programs.

At this point, we followed the same procedure as above, using CROWNS2, Nexus, and SVS to obtain the expected fire behavior outcome and visuals.

RESULTS

The example area was measured for species, tree height, diameter at breast height (DBH), crown ratio, and crown radius. Using an expansion factor of twenty to expand the plot to 1 acre in CROWNS2, the crown bulk density was determined to be 0.07 kg/m^3 (See Fig. 1.). Our treatment consisted of reducing the crown

Present



Future

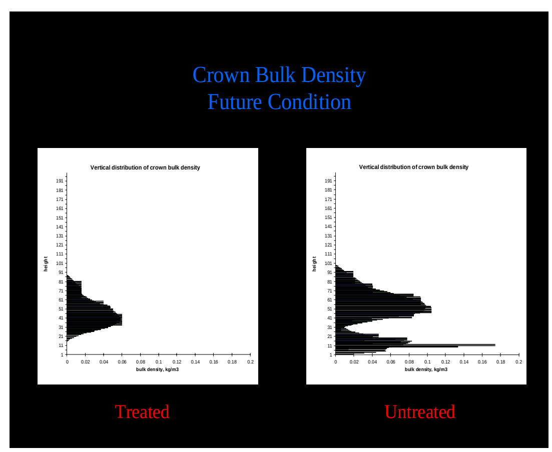
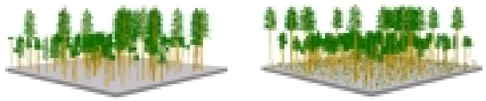


Figure 1. A comparison of crown bulk densities between the untreated and treated forested areas in the present condition and projected 20 years. The top row represents the present stand condition (treated left, untreated right). The bottom row represents future stand condition (treated left, untreated right).

Present Time, No Fire



Treated Untreated

Present Condition, Fire @ 0 mph

Treated Untreated

Present Condition, Fire @ 15 mph

Treated Untreated

Present Condition, Fire @ 30 mph

Treated Untreated

Figure 2. Images created to visualize potential crown fire hazard and scorch damage to a forested area at a specified windspeed. Untreated areas in the right hand column represent the area without any silvicultural modification. Treated areas in the left-hand column represent a reduction in crown bulk density from 0.7 kg/m^3 to 0.5 kg/m^3 via a pruning and small tree removal to a height of 17 feet. Slash assumed to be created in the treated areas was removed from the simulation.

Present Condition, Fire @ 60 mph

Treated Untreated

Figure 2. continued.

bulk density to 0.05 kg/m^3 and removing trees and lower branches to a height of 17 feet. The Nexus output projected that at 37 m.p.h., a crown fire would result. SVS, using the inventory data, produced visuals of untreated vs treated 1-acre areas (See Fig. 2). Using the Nexus data, the SVS visual was modified to reflect the effects of the crown fire.

Using the SVS\FVS\SUPPOSE model, the future expected stand condition in the year 2018 (20 years) was produced. Using the data from FVS and entering it into CROWNS2, the crown bulk density was determined to be 0.1 kg/m^3. Nexus projected a crown fire at 38 m.p.h. (See Fig 2.). The higher windspeed was required to compensate for the denser canopy.

Returning to the present time, by manipulating the stand data in CROWNS2, the crown bulk density was reduced to meet our prescription. The result of this process was two tree data tables, one containing the trees left on site and one containing all the trees removed. Removing the individual tree records and modifying the crown ratio in the SVS editor (See Fig 1.) created the visual. Assuming that slash from the thinning operation was removed from site, Nexus projected a crown fire to occur at a windspeed of 53 m.p.h.

Future Condition, No Fire

Treated Untreated

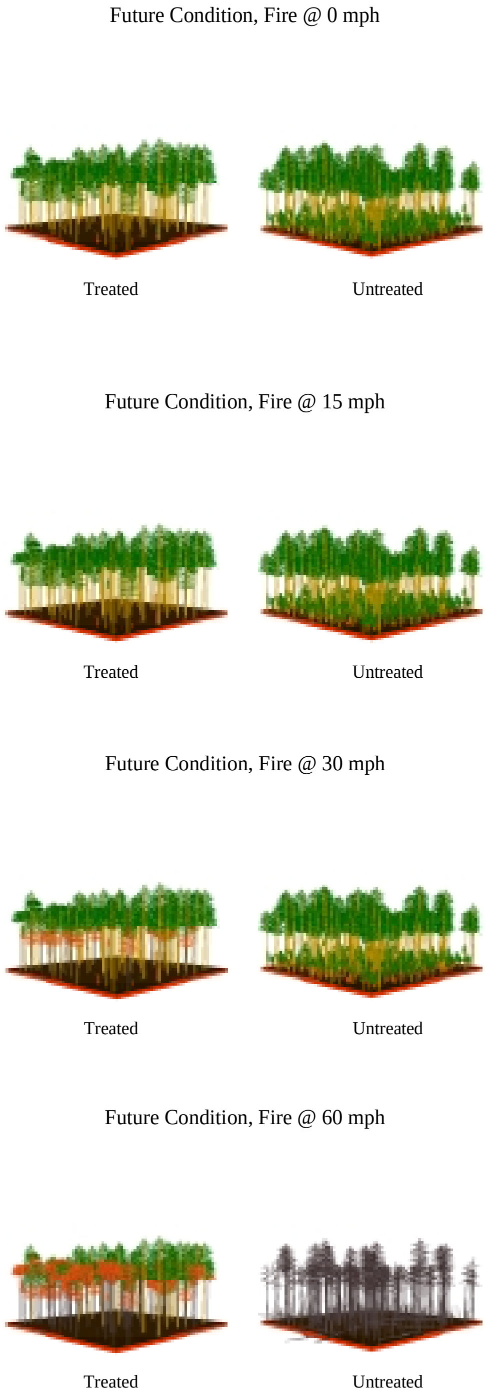


Figure 3. The future projection of the same forested areas as Figure 1 in 20 years without any further silvicultural modification.

Using the same process in the FVS editor as in the SVS editor above, the treated stand was grown to the year 2018 (20 years). The crown bulk density had increased to .06 kg/m^3, and the fire behavior at 60m.p.h. was projected to be a surface fire with a scorch height of 66 feet. The bundled SVS produced the 'no fire' visual while modifying the stand-alone SVS for fire effects produced the visuals with fire effects (See Fig. 3.).

DISCUSSION

We were able to link the models and meet our objectives of projecting fire behavior on a small scale for different stand scenarios over time that produced a product the general public could easily understand.

CROWN2 provided us with a simple method to determine crown bulk density while providing stand tables generated by different prescriptions. CROWN2 also gave us with two important pieces of information. One was a graph that plotted crown bulk density versus the height of the stand. Comparing the graph to the treatments (based on crown bulk density levels) we could alter the trees per acre and crown ratio and very quickly produce a silvicultural prescription. Second, the modified stand data represented a table of trees left on-site and a table of removed trees, including the amount of slash produced from the crown fuels.

Nexus provided us with the previously unavailable ability to determine at what point a surface fire would become a crown fire. For our purposes, Nexus provided 2 key outputs, whether a fire was either surface or crown, and scorch height. However, the model provides many other outputs, which should allow flexibility within our methodology for modeling fire behavior on a small scale.

Finally, the FVS\SVS\SUPPOSE program bundle provided a fairly painless method of growing the 1-acre areas and getting an abstract look all in one stop. The FVS\SVS\SUPPOSE package provided a number of benefits. FVS produced the projected tree growth, along with other data, such as predicted mortality and regeneration. Such data would be valuable to the forestry professional, and with forethought, could allow multidisciplinary planning efforts with a single data collection effort. FVS contains many extensions that would allow for great flexibility in modeling different scenarios.

The linkage of these models was fairly straightforward, the most awkward areas were the movement of data between the different file types and editors. To be used by the general public, a more convenient arrangement would have to be arranged.

Despite some of the tedious data conversions, the concept worked fairly well. We were able to take field data and represent current stand conditions, treatment alternatives, apply fire to them, do it again under future conditions, and visually display it so that the layman could understand it. Whether such a linkage of these models becomes well used would depend on verification of their accuracy and simplification of use. All the models are highly precise, however, the efficacy of the assumptions and accuracy of the models needs to be determined.

CONCLUSION

With the goal of reducing crown fire hazard in the urban intermix, we were able to link three models together by manipulating the data inputs and outputs for each program such that they could be used to get a previously unattainable result. By using CROWN 2, NEXUS, and FVS/SVS/SUPPOSE, we were able to reduce all the many factors associated with stand data to a crown bulk density number. By using this as our base fire behavior prediction factor, different prescriptions for different landowners can be written with the same end product – an area that is resistant to crown fire.

We modeled 4 different treatments, a treatment consisting of a crown bulk density of 0.1 kg/m3 and a treatment of crown bulk density of 0.05 kg/m3. Each treatment was then either pruned to a height of 17 feet (trees less than that height were removed), or left in their unpruned condition. Keeping environmental factors constant, we simulated four different windspeed scenarios: 0, 15, 30, and 60 m.p.h. A landscape designed for a 60 m.p.h. wind represented the lowest risk while the lower speeds represented higher levels of risk.

Our final outputs resulted in predicted fire behavior, whether crown or surface fire, and associated computer-generated visuals for the current stands, treated stands, and future stand conditions. Combining these models allows managers to visually simulate landscapes as they currently exist, what they look like if a fire occurs under conditions they specify, and what they will look like in the future, again with or without treatments and with or without fire.

We realize that this set of data and environmental conditions is very small and is but a first step. That being said, some preliminary results were surprising. High crown bulk densities, by themselves, did not support crown fire. Likewise, stands opened up from thinning to reduce crown bulk density did not necessarily have less tree mortality. More expected were the trends of ladder fuels contributing to crown fire initiation and fuel model factors contributing to fire behavior considerations, such as scorch height and fireline intensity.

By combining these tools, we believe we are beginning to create a sum that is greater than its parts that will allow fire management to enhance their current prediction skills, produce future expected outcomes, interact using visual representations, and produce data that is not discipline specific. The computer graphics, especially when combined with on-site photos, allow fire managers to portray the consequences of no treatment to the benefits of treatment, and allow landowners and public land managers to select a silvicultural treatment based on the level of appropriate fire risk and invasive treatment.

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