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Natural Resource Stewardship and Science

Monitoring Hazardous Fuel Reduction in Wrangell-St. Elias National Park & Preserve

Lessons Learned from the Chokosna Fuels Reduction Project

Natural Resource Data Series NPS/AKRO/NRDS—2013/484

ON THIS PAGE
Photo of the same hazard fuels monitoring plot one year after the fuels treatment (2010) was completed. Trees were thinned, dead branches have been limbed and down woody fuels were removed (WRST_SS_2010_TX-02_N_H).
Photograph by: Elle Kramer, Alaska Regional Office National Park Service

ON THE COVER
Hazard fuels monitoring plot prior to thinning and limbing (2009) shows dense dead branches on white spruce that create flammable fuels for fires (WRST_SS_2009_TX-02_North_H).
Photograph by: Jennifer McMillan, Alaska Regional Office National Park Service

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

This report is available from the National Park Service Alaska Region Fire Management Program (http://www.nps.gov/akso/nature/fire/monitor.cfm) and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/).

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Abstract

The National Park Service (NPS) fire management program conducts hazardous fuel reduction projects around infrastructure, values at risk, or near private property boundaries adjacent to park lands to provide defensible space and mitigate wildfire hazards. Within Wrangell-St. Elias National Park and Preserve in Alaska, there are many private property inholdings that are surrounded by fire-prone boreal forests on NPS lands. A resident within the park area had completed an adequate Firewise hazardous fuel reduction treatment on their property, but was concerned about the risk of wildfire coming from adjacent undeveloped NPS lands. The area was predominantly white spruce and black spruce forest types, with some level of spruce bark beetle activity present in the area. The NPS Fire Management Program conducted a hand-thinned fuels reduction project on preserve lands adjacent to the property to increase the defensible space in the area. The NPS Fire Ecology Program monitored the fuels reduction project to document pre- and post-treatment forest structure and fuel loads within the fuels treatment area and to evaluate treatment effectiveness. Overall the objectives for the fuels project were met, while some objectives were exceeded. The trees were thinned to increase the space between the crowns of spruce trees; however the thinning objective was exceeded. The objective of reducing 100 and 1000 hour woody fuels to 50% of pre-treatment levels was met. The retention of deciduous trees and the reduction of spruce beetle damaged trees were also achieved. Based on the results of this fuels reduction project, several recommendations for future project planning, implementation, and monitoring activities are provided.

Acknowledgments

Thanks to the staff of the NPS Alaska Eastern Area Fire Management Program for their help in monitoring this project during the 2009 and 2010 field seasons. Special thanks to the former Eastern Area Fire Management Officer, James Savage, for his collaboration and feedback on this monitoring project. Finally, thanks to the reviewers of this report.

Introduction

Most residential homes in Alaska are, to some degree, surrounded by areas of undeveloped, fire-prone landscapes. The Firewise Communities program provides guidelines and actions that homeowners can take to reduce the risk of wildfire damage to their homes and communities (http://www.firewise.org/communities.aspx). This program is utilized within Alaska and many Alaskan residents have elected to create a Firewise buffer to reduce hazardous fuels on their private properties.

There are cases where the risk of wildfire to homes may still be high even after Firewise actions have been taken by the homeowner, particularly in rural areas. This may occur for several reasons, including: 1) distance from fire protection services, and 2) few or no useful artificial fire breaks (e.g., roads). Furthermore, these homes are often adjacent to large undeveloped tracts of fire-prone landscape through which wildfire can burn unimpeded.

A rural resident in the Chokosna area owned a home and other structures on land abutting National Park Service (NPS) property in Wrangell St. Elias National Park and Preserve (WRST). The property was situated near the McCarthy Road but greater than 30 road miles from a local fire service area. The resident had completed a Firewise hazard fuel reduction treatment around their infrastructure, but the risk of wildfire coming from surrounding undeveloped NPS lands was still potentially high. Given the situation, the landowner discussed the possibility of having the park service reduce hazard fuels on preserve lands adjacent to the private property boundary.

The private property and adjacent preserve lands were located within a full fire management option, in which the primary goal of the Fire Management Program is to protect resources of values by minimizing the size of uncontrolled fires (WRST, 2010). The NPS Fire Management Program utilizes hazard fuels reduction techniques to reduce the risk of wildland fire to infrastructure or other values at risk. Consequently, the decision was made to conduct a hand thinned fuels reduction treatment to create a shaded fuel break along a 30 m (100 ft) wide buffer strip on NPS lands adjacent to the 3.4 ha (8.5 acre) private land parcel.

Project Objectives

Treatment Goals and Objectives

The purpose of the project was to create a shaded fuel break to provide improved defensible space along the NPS boundaries adjacent to the private land boundary. The fuels treatment was designed with the intent to 1) reduce the risk of crown fire, 2) improve the ability to provide structure protection, and 3) improve wildland firefighter safety by providing easier access to structures. The specific hazard fuels reduction treatment goals and prescription objectives were as follows:

1) Goal: Forest structure modification
    - Prescription Objective:
        - Increase spruce tree crown spacing to 3-5 foot (0.9 - 1.5 m) spacing between crowns.
        - Ladder fuel heights (lowest limb height) on remaining trees increased to 4 feet (1.2 m) above the forest floor.
        - Hardwood (deciduous) trees not removed during thinning treatment.
    - Purpose:
        - Reduce the risk of crown fire initiation and spread.
        - Maintain a mixed age stand with the hardwood component left intact.
        - Hardwoods (deciduous) left intact to minimize grass colonization.

2) Goal: Down woody fuel reduction
    - Prescription Objective :
        - Decrease 100 hour and 1000 hour down woody fuel loading by 50%.
    - Purpose
        - Reduce surface fire spread.

Monitoring Objectives

According to the NPS Wildland Fire Management Reference Manual 18, "Fuels management activities and treatments must be monitored in order to assess treatment effectiveness and to determine whether management objectives were met" (RM-18, Ch. 7, Section 3.4, USDI NPS 2008). The Alaska NPS Fire Ecology program monitors fire management fuels treatments, prescribed fires, and wildfires as needed in the park units.

The purpose of this monitoring study was to document pre- and post-treatment forest structure and fuel loads where the fuels treatment was conducted and to evaluate treatment effectiveness. Specific monitoring objectives were to:

1. Determine if spruce tree crown spacing was increased to 0.9-1.5 m (3-5 ft) spacing, which would result in a tree density of approximately of 1329 -2196 trees/ha (538 – 889 trees/acre) within 1 year post-treatment.
2. Determine if remaining trees were limbed up to 1.2 m (4 ft) in the treated area within 1 year post-treatment.
3. Determine if fuel loading of 100 and 1000 hour fuels was reduced by 50% within 1 year post-treatment.

Additionally, this monitoring project provided an opportunity to note insect and disease damage to trees and allowed for photo documentation of the monitoring plots for future reference.

Study Area and Monitoring Plots

The hazard fuels reduction treatment was conducted within a 30 m (100 ft) buffer on Wrangell-St. Elias preserve lands bordering the southern and western boundaries of the Chokosna property, approximately 1.4 forested hectares (3.5 ac) (Figure 1).

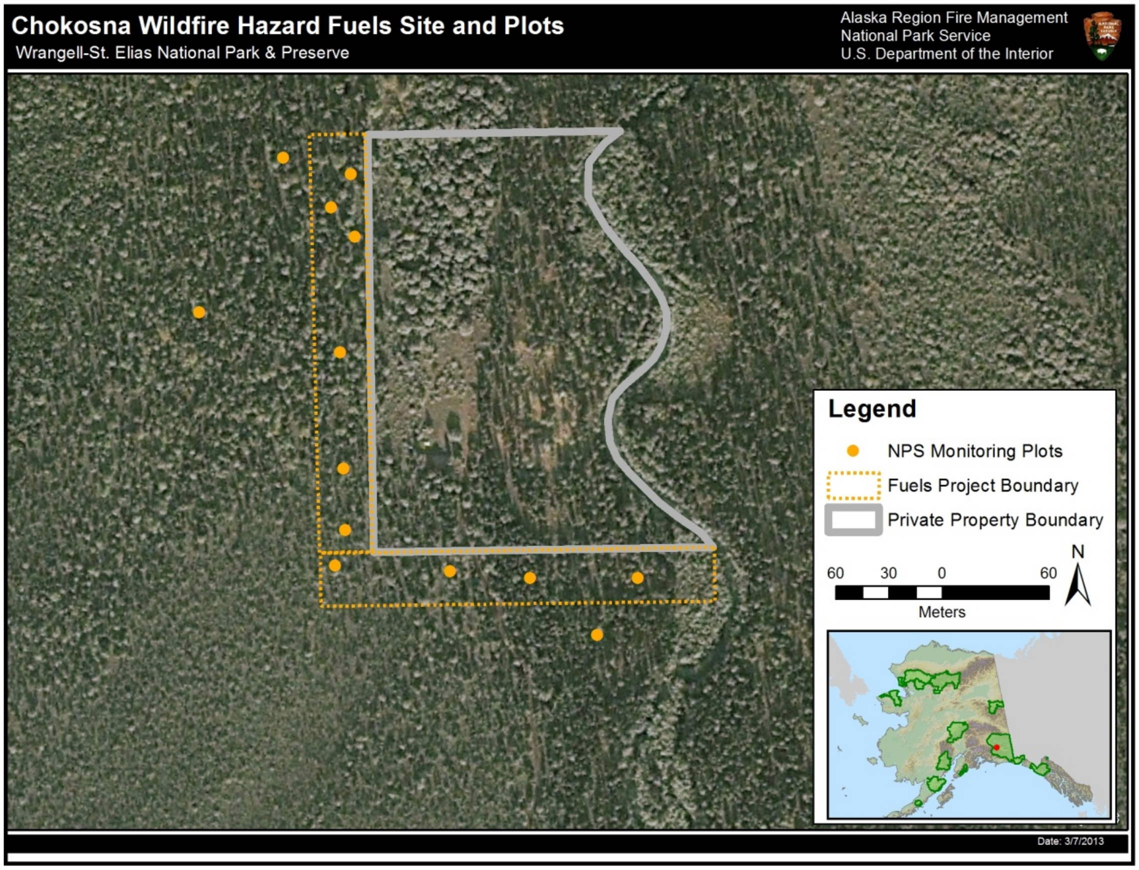

Figure 1. Thinning treatment and plot distribution within the Chokosna fuels project.

Both pre- and post-thinning treatment, the primary vegetation communities were Needleleaf Woodland, Open Needleleaf Forest and Open Mixed Forest as defined by Viereck et al. (1992) (Table 1). Needleleaf trees included white and black spruce (*Picea glauca* and *P. mariana*). Some areas had a significant deciduous tree component, primarily Alaska paper birch (*Betula neoalaskana*) and balsam poplar (*Populus balsamifera*).

A GIS random point generator was used to select 10 plots within the treated area. Additionally, 3 control plots were randomly selected outside the treated area, which were not included in all the analyses presented in this report. Pre-treatment data was used for comparison to post-treatment data. Monitoring plot locations are listed in Appendix A.

Monitoring data was initially collected in 2009, prior to treatment implementation (referred to as "pre-treatment"). The thinning treatment was conducted later in the summer of 2009 with the help of a state Type 1 fire crew. The second set of monitoring data (referred to as "1 year post-treatment") was collected in 2010. During each field data collection visit to the monitoring plots, a fire ecologist from the NPS Alaska Region was accompanied by various members of Alaska NPS Eastern Area fire staff.

Methods

Plot Layout

Monitoring plots were either 4-m or 8-m radius circular plots to count tree density by diameter size class. A 16-m transect was laid out for recording woody debris (Figure 2). The plot centers of the plots were marked with a wooden stake and the locations were recorded with a Garmin GPS unit.

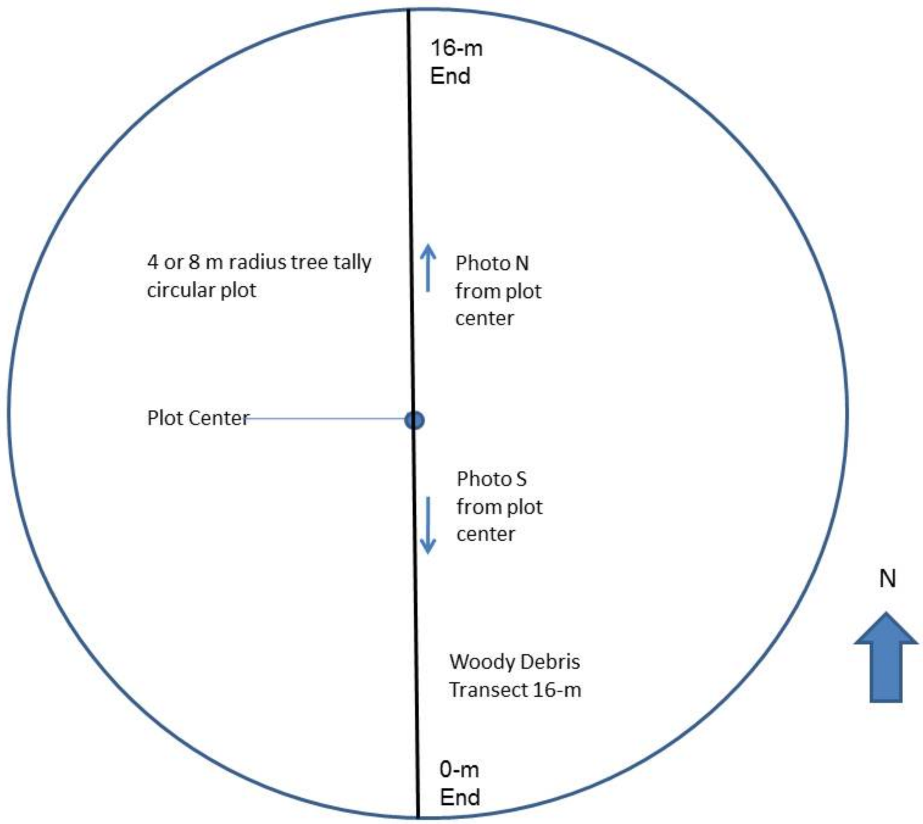

Figure 2. Hazard fuels monitoring plot layout

Site Attributes

At each site, crews recorded the location (GPS coordinates), elevation, and dominant aspect and slope, as well as site descriptors including the Viereck Vegetation Class (Viereck et al, 1992), evidence of disturbance (e.g., fire) and estimated time since disturbance. Photographs of each monitoring plot were taken from the plot center and are presented in Appendix B.

Trees

All monitoring plots were forested. Mature trees taller than 1.37 m and rooted within the circular plot were tallied by species and diameter size class (Figure 2). Diameter size classes were based on measures of tree diameter at breast height (DBH) in the following size classes: < 5.0 cm, 5.1-10 cm, 10.1-15 cm, 15.1-23 cm, >23 cm. If plot was densely forested (>25 trees within the 8-m radius circular plot) then a 4-m radius circular plot was used to count tree density.

Woody Fuel Loading

To calculate down woody fuel load, woody fuel was tallied by diameter size class following the planar intersect method outlined by Brown (1974) and the National Park Service Fire Monitoring Handbook (USDI National Park Service 2003). The number of woody debris particles along the 16 m transect were tallied by diameter size class at the plane of intersection with the transect line Woody fuels are defined by the diameter size class: 1 hour fuels = ≤ 0.25 inches; 10 hour fuels = >0.25 to ≤1.0 inches, 100 hour fuels = >1.0 inches to ≤3.0 inches, 1000 hour fuels = > 3.0 inches diameter. Only 100 hour and 1000 hour fuels were tallied in this study. The 100 hr fuels were tallied for the first 8 m of the transect and 1000 hr fuels were tallied along the full length of the 16 m transect and the diameter of each log was recorded.

Analysis

Calculations

The calculated metric for tree density was an extrapolation of plot-level data to be expressed on a per hectare basis. An average two foot (0.6 m) crown radius was used to calculate expected tree densities under a given crown spacing. The calculated metric for down woody fuel loading was an extrapolation of plot-level data to be expressed as kilograms per meters squared. Down woody fuel loading values were computed using FFI (FEAT/FIREMON Integrated) Version 1.04 which uses the fuel loading equations provided in Brown (1974).

Statistics

Values are presented as means ± 80% confidence intervals in the text as well as in the tables and figures. Simply stated, 80% confidence intervals indicate an at least 80% chance that the true population mean falls within the given range. This somewhat low level of certainty was deemed appropriate given the low sensitivity of the management decisions associated with this monitoring study (USDI National Park Service 2003).

Results

Vegetation Classification

Vegetation communities are classified to Viereck Level IV vegetation classes (Viereck et. al., 1992) for each monitoring plot (Table 1). A majority of the plots were white spruce or white spruce deciduous mix forests. Of the thirteen total plots measured, seven plots had some level of tree mortality due to spruce bark beetle (shown by asterisks in the table). Five of the ten treatment monitoring plots were re-classified into different vegetation classes immediately following the treatment. The dominant change in vegetation classification was a shift from open forest canopy cover (25-60%) to a woodland forest canopy cover (10-25%) (See Appendix B for photos of treatment plots listed below). Forty percent of the treatment plots shifted to a more open canopy (4 out of 10). One monitoring plots transitioned from a forest type to an open low shrub vegetation class.

Table 1. Viereck Level IV vegetation classifications by plot and monitoring year. "TX" in the plot name indicates a treatment plot and "C" is a control plot. Asterisks after pre-treatment class indicates spruce beetle impacted trees were present at the plot prior to treatment.

Monitoring Plot	Pre-treatment Viereck Class	1 Year Post-treatment Viereck Class
WRST-SS-TX-01	1C2A Open Spruce-Paper Birch Forest*	1C2A Open Spruce-Paper Birch Forest
WRST-SS-TX-02	1C2A Open Spruce-Paper Birch Forest*	1C3A Spruce-Paper Birch Woodland
WRST-SS-TX-03	1A3C White Spruce Woodland	1A3C White Spruce Woodland
WRST-SS-TX-04	1C3A Spruce-Paper Birch Woodland*	1C3A Spruce-Paper Birch Woodland
WRST-SS-TX-05	1A2F Open Black Spruce Forest	1A3D Black Spruce Woodland
WRST-SS-TX-06	1A2F Open Black Spruce Forest	1A3D Black Spruce Woodland
WRST-SS-TX-07	1A2F Open Black Spruce Forest	2C2C Open Low Mesic Shrub Birch-Ericaceous Shrub
WRST-SS-TX-09	1A3C White Spruce Woodland*	1A3C White Spruce Woodland
WRST-SS-TX-10	1A2E Open White Spruce Forest*	1A3C White Spruce Woodland
WRST-SS-TX-11	1C2D Open Spruce-Balsam Poplar Forest*	1C2D Open Spruce-Balsam Poplar Forest
WRST-SS-C-01	1C2A Open Spruce-Paper Birch Forest	1C2A Open Spruce-Paper Birch Forest
WRST-SS-C-02	1C2A Open Spruce-Paper Birch Forest*	1C2A Open Spruce-Paper Birch Forest
WRST-SS-C-04	1C2D Open Spruce-Balsam Poplar Forest	1C2D Open Spruce-Balsam Poplar Forest

Tree Density

The thinning treatment resulted in a lower spruce tree density than prescribed. Assuming a 0.6 m (2 ft) crown radius, the desired post-treatment density for spruce trees was approximately 1329 - 2196 trees/ha (538 – 889 trees/acre) given a 0.9-1.5 m (3-5 ft) crown spacing. Pre-treatment density of spruce averaged 1880 (80% CI: 1069 - 2664) trees/ha (Table 2, Figure 3), which is approximately a 1 m (3.5 ft) crown spacing. Post-treatment spruce density was an average of 563 (80% CI: 464- 662) trees/hectare (Table 2, Figure 3), nearly a 3 m (10 ft) crown spacing. Deciduous tree density, which was initially low (45 trees/hectare), was not altered by the hazard fuels reduction treatment (Table 2).

White spruce trees were present in a majority of the monitoring plots (85%). Prior to the thinning treatment, spruce bark beetle infestation was noted on white spruce trees in six of the ten treated monitoring plots; a total of 13 trees (8 dead and 5 live) recorded. Following the thinning

treatment, only a single, dead, white spruce tree with spruce bark beetle evidence was noted in one of the monitoring plots.

Table 2. The mean, confidence interval (80%), and range of tree densities by tree type at the Chokosna monitoring plots pre-treatment (2009) and 1 year post-treatment (2010) for thinned (n=10 plots) and control plots (n=3).

Plot Type	Tree Type	Value	Pre-treatment (trees per hectare)	1 Yr post-treatment (trees per hectare)
Thinned	Spruce	Mean (80% CI)	1880 (1096-2664)	563 (464-662)
		Min - Max	398-5200	298-800
Thinned	Deciduous	Mean (80% CI)	45 (10 - 79)	50 (9–91)
		Min - Max	0-249	0-298
Control	Spruce	Mean (80% CI)	879 (495-1263)	895 (452-1339)
		Min - Max	498-1194	448-1244
Control	Deciduous	Mean (80% CI)	166 (83-248)	166 (83-249)
		Min-Max	99-249	99-249

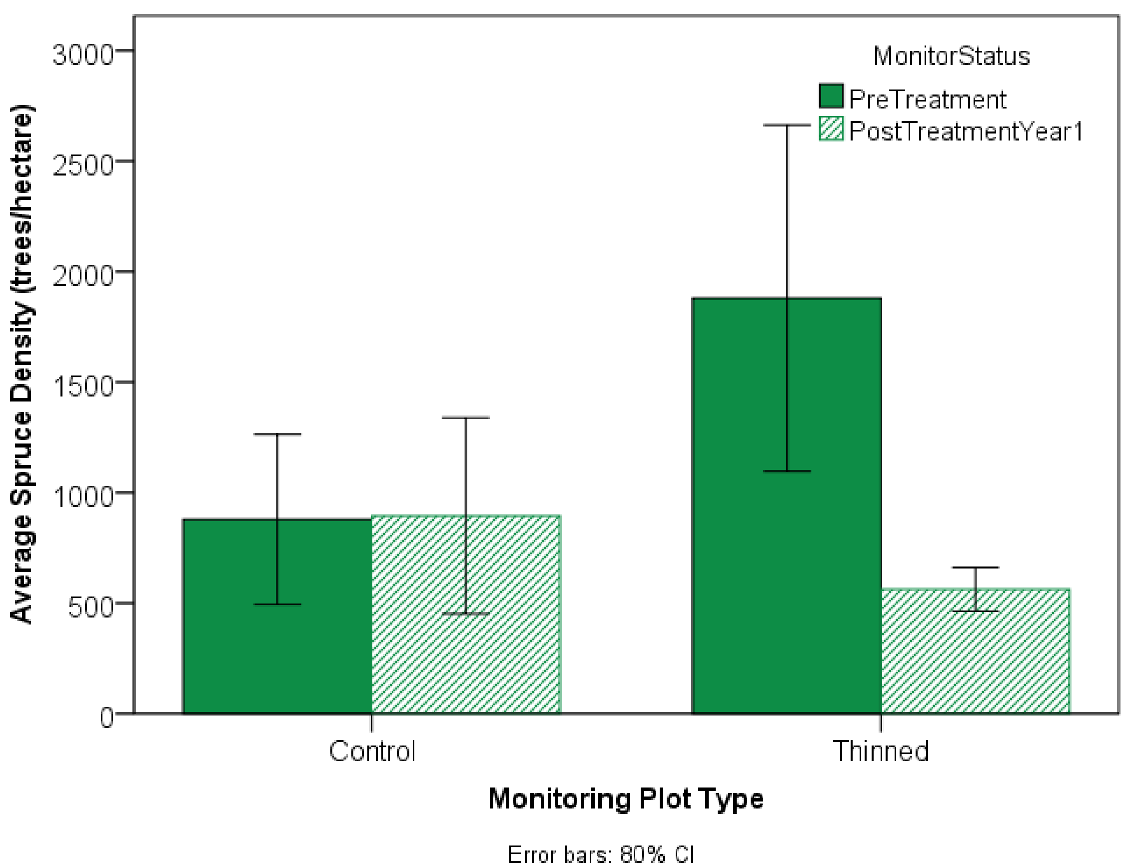

Figure 3. Average spruce tree density for Chokosna Hazard Fuels monitoring plots for pre-treatment (2009) and 1 year post-treatment (2010) monitoring years. Values are means ± 80% confidence interval.

Tree Ladder Fuel Heights

The treatment prescription was to limb remaining spruce trees to 4 feet (1.2 m) above the ground to increase ladder fuel heights. Ladder fuel heights were not directly measured in this study, but photo documentation suggests that the 4 foot limbing prescription was likely accomplished (see photos in Appendix B).

Woody Fuels

Woody fuel loading (combined 100 hour and 1000 hour fuels) was reduced by 81% as a result of the hazard fuels reduction treatment. The reduction was more pronounced for 100 hour fuels and solid 1000 hr fuels (Table 3). The fuel loads were variable by plot (Figure 4). In general there was more large woody debris detected at the white spruce plots, and a trend to have more down woody debris in plots with spruce bark beetle activity.

Table 3. Down woody debris fuel loading detected along transects at the Chokosna monitoring plots pre-treatment (2009) and 1 year post-treatment (2010) for the 10 thinned plots.

	Average Fuel Load kg per m^2 (80% C.I.)		
Fuel Type	**Pre-Treatment (2009)**	**Post-treatment (2010)**	**Average Percent Reduction**
100 hr fuels	0.21 (0.14-0.28)	0.05 (0.01-0.09)	60%
1000 hr solid fuels	1.16 (0.55-1.76)	0.03 (-0.01-0.08)	57%
1000 hr rotten fuels	0.34 (0.12-0.55)	0.37 (0.13-0.61)	36%
Total 100-1000 hr fuels	1.71 (1.13-2.28)	0.45 (0.21-0.68)	81%

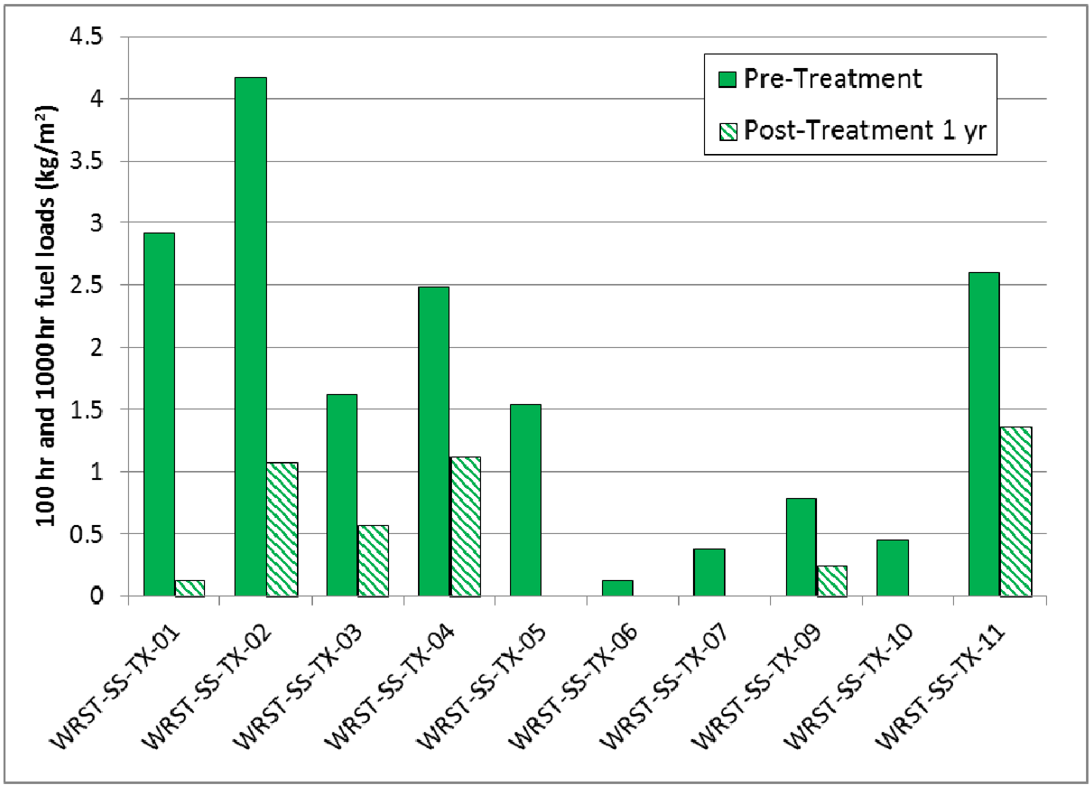

Figure 4. Total down woody fuel loading of 100 hr and 1000 hr fuels for Chokosna Hazard Fuels treatment plots for pre-treatment (2009) and 1 year post-treatment (2010) monitoring years.

Summary

Overall the treatment objectives for the fuels project were met, while some objectives were exceeded. The treatment objective of a 0.9-1.5 m (3-5 foot) crown spacing between spruce trees was met and exceeded the prescription. The objective of reducing 100 and 1000 hour fuels to 50% of pre-treatment levels was met. The retention of deciduous trees and the reduction of spruce beetle damaged trees were also achieved.

The tree reduction resulting from the thinning treatment exceeded the crown spacing identified in the project objective. This is most strikingly exemplified by the reduction in tree density in monitoring plots from woodland (10-25% tree cover) to shrub vegetation classes with less than 10% tree cover (see photos in Appendix B, Plot 7). Furthermore, the average pre-treatment tree crown spacing was 1.1 m (3.5 feet) which fell within the prescription for a 0.9-1.5 m crown spacing prior to the thinning treatment. It is important to note the high degree of variability of tree densities within the fuels treatment site. Some plots had over 4400 trees per hectare pre-treatment (Appendix B, Plots 7 and 5), while other plots with larger white spruce were already below prescription prior to the thinning treatment (tree densities of 398 trees/hectare; see Appendix B, Plots 2 and 9).

The general purpose of reducing tree densities and increasing limb heights (or ladder fuels) is to reduce the potential for crown fire. The treatment prescription of 0.9-1.5 m crown spacing was a fairly conservative thinning prescription for trees. This prescription was implemented in this project to reduce the potential for wind throw and lessen the increase of understory grasses. Results from a similar study in Interior Alaska suggest that a reduction of tree density or canopy bulk density will reduce the crown fraction burned and crown rate of spread (Barnes and McMillan, in review). The largest driver of crown fire initiation in these crown fire behavior models are ladder fuel heights (canopy base heights) and winds, while tree density or canopy bulk density will influence the crown rate of spread (Scott and Reinhardt 2001). Although fire behavior modeling was not completed for this project, it is likely that the reduced stand density and increased ladder fuel heights will help reduce crown fire potential.

However, unnecessary removal of overstory trees should be avoided because it can lead to a more open overstory canopy than desired. A large reduction in canopy cover can cause 1) an increase in surface winds to a site which could increase the rate of spread and flame lengths of a fire (Theisen 2003, Andrews 2012); 2) an increase in grass-like plant fuel loading which may allow for rapid fire spread through thinned areas (Agee 2000); and 3) reduced moisture content of live moss, dead moss and upper duff which can contribute to greater ignition probability and rate of spread (Horschel 2007).

Management & Monitoring Recommendations

Based on the results of this fuels reduction project, several recommendations for future project planning, implementation, and monitoring activities have been identified are provided here:

1. The prescription for this project was developed prior to collecting and analyzing the pre-monitoring data. Prescriptions for fuels treatments in the future should be developed based on knowledge of the current stand conditions, developed for specific vegetation types, and utilize fire behavior software programs to model fire behavior. Pre-treatment monitoring should be conducted and reviewed before final objectives are developed for each project.

2. The tree spacing prescription for this project was conservative (0.9-1.5 m crown spacing) with the intent to not increase grass cover and lessen the potential for wind throw. However within Alaska, a tree spacing of 2.4-3 m (8-10 ft) is more commonly used (Theisen 2003, Horschel 2007, personnel communication). Use of a more standard prescription of tree spacing for defensible space in Alaska should be considered in future plans (however see recommendations #1, 4 and 5). This could improve how interagency crews or workforce implement prescriptions. In addition, the use of the term “tree spacing” needs to be clarified within plans and to personnel on the ground, as to whether it refers to tree bole or crown spacing.

3. NPS fire management personnel should provide better oversight of crews working on fuels reduction projects to ensure that prescription objectives are met and not exceeded. A project lead(s), familiar with the project design, objectives, and compliance constraints needs to be on site at all times.

4. Fuel treatment prescriptions may need to be adjusted for different vegetative communities within a project area.

5. Additional research on Alaskan crown fire initiation and propagation is needed to better formulate treatment prescriptions.

6. This monitoring protocol was designed to provide a rapid assessment to determine if the fuels treatment objectives were met. However, the following suggestions would provide additional benefits:

    a. Due to concerns over the potential increase of grass cover, it should be one of the key monitoring parameters for each project.

    b. A quick and easy method for measuring ladder fuel heights should be developed and used for each project.

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Appendix A: Monitoring plot coordinates for treated and control plots at the Chokosna hazard fuels reduction site in Wrangell-St. Elias National Preserve, Alaska

Monitoring Plot	Treatment	Latitude (NAD83)	Longitude (NAD83)	Elevation (feet)
SS-C-01	Control	61.47619190	-143.77538608	532
SS-C-02	Control	61.47542126	-143.77629980	529
SS-C-04	Control	61.47376919	-143.77212678	524
SS-TX-01	Treated	61.47610464	-143.77467102	538
SS-TX-02	Treated	61.47593876	-143.77488568	531
SS-TX-03	Treated	61.47578906	-143.77463968	525
SS-TX-04	Treated	61.47520996	-143.77481000	529
SS-TX-05	Treated	61.47462431	-143.77479575	520
SS-TX-06	Treated	61.47431334	-143.77478158	523
SS-TX-07	Treated	61.47413565	-143.77489935	521
SS-TX-09	Treated	61.47410011	-143.77367777	523
SS-TX-10	Treated	61.47405929	-143.77283346	521
SS-TX-11	Treated	61.47405141	-143.77168849	532

Appendix B: Paired pre and post treatment photographs of Chokosna hazard fuels monitoring plots

2009 - Chokosna Monitoring Plot # 1 from plot center to north (WRST_SS_2009_TX-01_North_H)

2010 - Chokosna Monitoring Plot # 1 from plot center to north (WRST_SS_2010_TX-01_N_H)

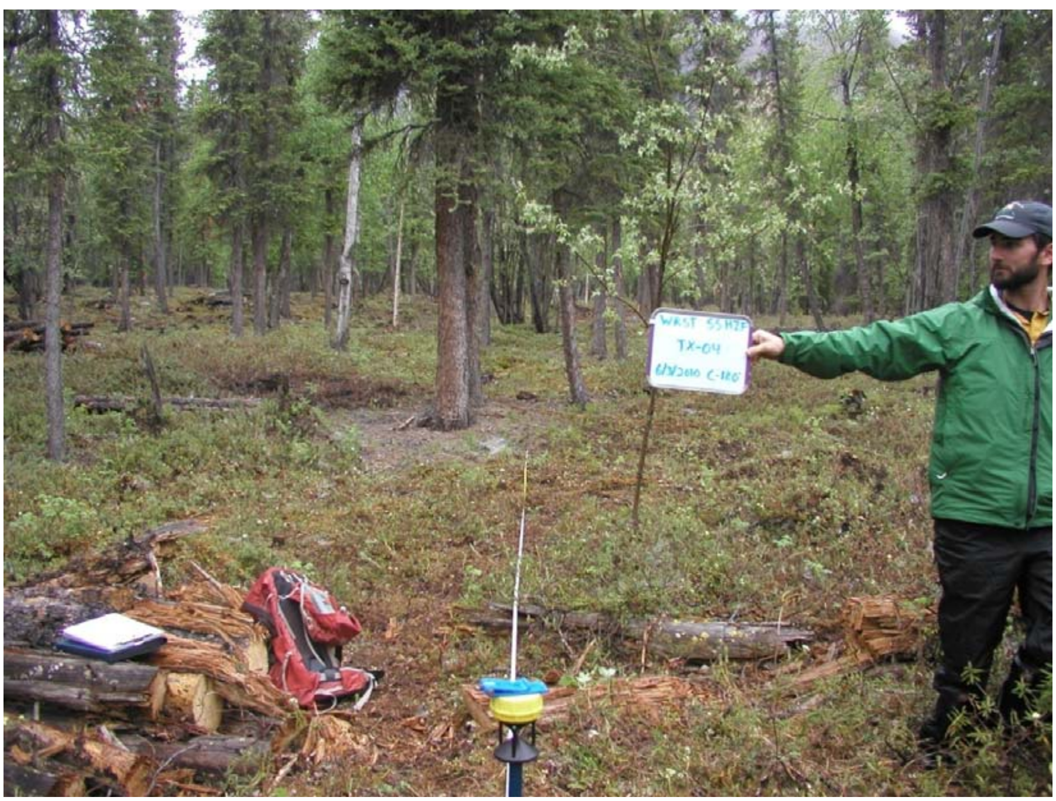
2009 - Chokosna Monitoring Plot # 2 from plot center to north (WRST_SS_2009_TX-02_North_H)

2010 - Chokosna Monitoring Plot # 2 from plot center to north (WRST_SS_2010_TX-02_N_H)

2009 - Chokosna Monitoring Plot # 3 from plot center to north (WRST_SS_2009_TX-03_North_H)

2010 - Chokosna Monitoring Plot # 3 from plot center to north (WRST_SS_2010_TX-03_S_H)

2009 - Chokosna Monitoring Plot # 4 from plot center to north (WRST_SS_2009_TX-04-North-H)



2010- Chokosna Monitoring Plot # 4 from plot center to north (WRST_SS_2010_TX-04_S_H)

2009 - Chokosna Monitoring Plot # 5 from plot center to north (WRST_SS_2009_TX-05-North-H)

2010 - Chokosna Monitoring Plot # 5 from plot center to north (WRST_SS_2010_TX-05_S_H) (photo board mis-labeled).

2009 - Chokosna Monitoring Plot # 6 from plot center to north (WRST_SS_2009_TX-06-North-H)

2010 - Chokosna Monitoring Plot # 6 from plot center to north (WRST_SS_2010_TX-06_N_H)


2009- Chokosna Monitoring Plot # 7 from plot center to north (WRST_SS_2009_TX-07-North-H)

2010 - Chokosna Monitoring Plot # 7 from plot center to north (WRST_SS_2010_TX-07_N_H)

2009 - Chokosna Monitoring Plot # 9 from plot center to south (WRST_SS_2009_TX-09-South-H)

2010 - Chokosna Monitoring Plot # 9 from plot center to south (WRST_SS_2010_TX-09_S_H)

2009 - Chokosna Monitoring Plot # 10 from plot center to south (WRST_SS_2009_TX-10-South-H)

2010 - Chokosna Monitoring Plot # 10 from plot center to south (WRST_SS_2010_TX-10_S_H)

2009 - Chokosna Monitoring Plot # 11 from plot center to south (WRST_SS_2009_TX-11_South_H)

2010 - Chokosna Monitoring Plot # 11 from plot center to south (WRST_SS_2010_TX-11_S_H)

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