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Productivity of motor-manual forest fuel reduction treatment operations:

Developing a user-friendly data collection protocol

PROJECT NUMBER: 301014651

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Forest fuel treatments are conducted at a stand level in the wildland–urban interface to reduce the potential for catastrophic loss caused by wildfire. Given the considerable expense of conducting motor-manual fuel treatments, fuels managers want to better understand the productivity and cost of commonly applied fuel treatments in order to prescribe cost-effective treatment techniques. Due to the limited data available and the myriad combinations of fuel treatment options and equipment types used in a diverse range of ecosystems, cost projections for fuel treatments are difficult to forecast reliably.

Fuels managers and Wildfire Operations advisory members asked that a simplified data collection protocol be developed to collect more data across a broader range of ecosites. The streamlined and simplified process presented in this document includes a user-friendly format for in-field data collection by field crew supervisors.

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INTRODUCTION

Forest fuel treatments are conducted at a stand level in the wildland–urban interface to reduce the potential for catastrophic loss caused by wildfire. Given the considerable expense of conducting these fuel treatments, fuels managers want to better understand the productivity and cost of commonly applied fuel treatments in order to prescribe cost-effective treatment techniques. Due to the limited data available and the myriad combinations of fuel treatment options and equipment types used in a diverse range of ecosystems, cost projections for fuel treatments are difficult to forecast reliably.

Similar questions and concerns regarding cost and efficiency have been addressed in harvest operations in the forest sector. Forest harvest and silviculture operational staff have collaborated with forestry researchers to address these concerns by developing data collection programs, monitoring operations, and conducting productivity studies. FPInnovations Wildfire Operations group has applied these data collection methods and technologies in vegetation management projects to measure the productivity of equipment (primarily mulchers) that is used to conduct commonly applied treatment techniques in boreal and montane ecosites (Hvenegaard, 2021).

To a lesser extent, productivity trials of motor-manual fuel treatments have been conducted to assess the performance of workers using hand tools (mechanical and manual). Rigorous productivity trials can be time-consuming; hence, case studies and fuel treatment productivity data are limited.

OBJECTIVES

Fuels managers and Wildfire Operations advisory members have asked that a simplified data collection protocol be developed to allow more users to collect a greater volume of data across a broader range of ecosites. FPInnovations has addressed this request by modifying existing data collection methods to:

- produce a streamlined and simplified process that includes a user-friendly format for in-field data collection by crew supervisors; and
- provide guidelines for field application in order to minimize the amount of data input required and create efficiencies in the data collection process.

EVOLVING DATA COLLECTION METHODS

FPInnovations has assessed productivity of motor-manual fuel treatment operations in two different treatment units at the Pelican Mountain FireSmart Fuel Management Research site[1]. In the initial productivity study in Unit 1, a rigorous data collection method was employed by two researchers on-site for 4 days in early December 2016 (Hvenegaard & Hsieh, 2017). The data collection included daily measurement of the area processed and the operational time. The specific daily tasks included:

- recording time—travel, on-site, and start/stop for breaks or delays;
- determining the number of productive worker hours for the day; and
- recording a GPS track of the area processed for the day.

This daily routine allowed researchers to evaluate the data collection processes and identify sources of error, inefficiencies, and redundancies. For example, initially a GPS track recorded at the end of the day was flagged to establish the start point for the next day's work; this likely provided questionable data since a portion of the entire area may not have been completely treated, with all debris piled and burned. It was decided that recording a daily GPS track did not provide value in the overall productivity measurement since the entire treated area could be measured at the completion of the treatment operations. Additionally, an overall measurement of productivity for the entire project area was deemed to be a more representative indicator than a daily measurement. One exception to this would be if there was an obvious change in stand characteristics such as density or species and there was a need to compare productivity in these distinct fuel environments.

Adjustments to the data collection process were made so that the crew supervisor did not record a daily track of the treated area but only daily working times. Recorded data were later processed by FPInnovations researchers.

This streamlined data collection process was formalized for use in Unit 5 at Pelican Mountain in December 2017 (Hvenegaard, 2021). FPInnovations researchers provided a user-friendly data collection sheet to the crew supervisor so they could collect daily productivity data, including start/stop times for daily activities and breaks through the day. After a minimal amount of training, the crew supervisor completed the daily data sheets and submitted them to FPInnovations. Manual entry and compilation of the data in a spreadsheet yielded basic productivity data as hectares/productive worker hour (PWH).

FPInnovations proposes using this streamlined approach as an alternative to rigorous and expensive data collection protocols. Fuels managers will be able to collect a larger volume of data that are more relevant to local fuel environments, and will be able to evaluate productivity specific to local crews, which may have unique skill sets, experience, or equipment types.

[1] For more information about the Pelican Mountain FireSmart Fuel Management Research Site, see the Canadian Wildland Fire & Smoke Newsletter.

Using the streamlined data collection approach

Currently, the proposed productivity data collection method involves a condensed paper-and-pen process (Appendix A). Most of the input fields are straightforward, but a brief explanation is included in this guide. No complex measurement tools are required, but an easily accessible wristwatch (or cell phone) is necessary. A basic understanding of terminology for fuel treatment techniques and forest stand characterization is useful; however, a project supervisor (fuels manager) will be able to clarify these details and input appropriate data.

Data entry

The data collection sheet provides separate sections for recording times of general events and breaks/delays. This simplified data collection process should not hinder a crew supervisor in their daily supervisory activities. The crew supervisor may not be able to record all events and breaks immediately on the data sheet, but they should make a note of breaks or equipment delays. At the end of the day, the crew supervisor should fill in all fields on the data sheet. To determine productivity, the following fields must be completed:

- Total number of workers for the day
- Start work time
- End work time
- Duration of breaks and delays

Section One: Logistics and administration – Data in this section will likely be the same for all data sheets for the entire treatment unit unless there is a change in crew supervisor. It will still be important to complete these fields each day, especially the date and treatment unit to ensure data sheets do not get mixed up.

- **Treatment unit** – Wildfire management agencies or other sponsoring administrations may use a designated convention for naming and numbering a treatment unit. The appropriate naming and numbering should be included on the data sheet. If a crew works on more than one treatment unit in the same day, a separate sheet must be completed for each unit.
- **Treatment description** – Treatment methods and metrics are typically stated in a fuel treatment prescription; therefore, they do not need to be copied onto the data sheet. However, a general description of the treatment will be useful for categorizing treatment techniques. Some basic treatment descriptions include (but are not limited to) the following:
    - thinning – 3-m crown spacing with limbing to 2 m
        - or other spacing and limbing specifications
    - piling and burning debris on-site
    - mulching debris on-site
    - transfering debris from the site
    - stand cleaning – removal of dead standing stems and debris in surface layer
    - broadcast burning debris and surface fuels in the treatment area

- **Forest stand type –** Details should be available from the fuel treatment prescription; however, those naming conventions may not appropriately represent the site conditions that affect working conditions and productivity. For example, C-2 was the FBP fuel type applied for the treatment units at Pelican Mountain. A more useful description of these sites would be something like “high-density (10 000+ stems/ha) immature black spruce in boggy areas”. These are factors that will affect productivity.

Section Two: Resources – The number of workers is important in determining the total number of worker hours for the day. The number of sawyers and/or the type of tools are not included in the productivity calculation; however, these data may give the project manger a greater understanding of the factors that influence productivity.

Section Three: Times – This list of events is suggestive of a routine that a crew might follow in a day of fuel treatment work. The most important times to record (with respect to productivity) are the “start work” and “end work” times because they determine the number of productive worker hours.

As a general guideline, the “start work” time is when the crew has moved into the treatment area and has started actively conducting treatment activities, such as cutting and limbing stems, moving debris, etc. Safety briefings and site orientation are generally conducted prior to starting work; therefore, they are not included as productive time. “End work” is when the entire crew has stopped work on fuel treatment. Packing up gear to leave the site is not included.

The other times (“depart base” and “arrive at base”) may be useful to managers in assessing the driving time as an input to the overall cost of a fuel treatment. That cost is often elevated when long travel distances are required to reach remote communities.

Section Four: Breaks/Delays – Crew members may not have coffee or lunch breaks at the same time, and it is not critical that the times for these separate breaks are recorded. These breaks should be recorded for the entire crew as a one-line item. It may be difficult to accurately record more frequent or extended warming/cooling breaks, but an attempt should be made to estimate them for the entire crew for the day.

Delays for equipment maintenance are recorded if more than 15 minutes are required. Refueling saws is not considered equipment maintenance.

Data processing

The most commonly used productivity metric for mechanical fuel treatment operations is area/productive machine hours. This is typically expressed as ha/PMH. A motor-manual fuel uses the same convention except that “worker hours” replaces machine hours.

On a daily basis, the number of productive worker hours (PWH) will be calculated as follows:

PWH = (number of workers × number of daily hours) - total breaks/delays

Daily hours will be calculated as (end work time - start work time)

An example data sheet (Appendix B) provides times for a typical day of fuel treatment work. Calculations for productive worker hours are as follows:

- PWH = (number of workers × number of hours) - total breaks/delays
- Daily hours = 1550–0910 = 6 hours 40 minutes (6.66 hours)
- Breaks/delays:
    - Lunch: 8 workers × 0.5 hour = 4 hours
    - Coffee: 8 workers × 0.25 hour = 2 hours
    - Chain saw repair: 2 workers × 0.5 hour = 1 hour
- Total breaks/delays = 7 worker hours

PWH = (8 workers × 6.66 hours) - 7 worker hours

PWH = 53.28 - 7.00 = 46.28 productive worker hours

Productive worker hours is calculated separately for each day. When the treatment unit is completed, the PWH for all days is totalled to provide the total PWH for the entire treatment unit. This total is used to calculate the overall productivity as overall area (ha) per total PWH.

OPPORTUNITIES

At a local level, a fuels manager can use this data collection system to better understand and assess productivity in commonly treated fuel types in that area. When the same treatment technique is consistently repeated in similar fuel types using the same crew configuration, a fuels manager can develop a solid data set to produce a reliable productivity rate. They can apply a standard productivity rate (ha/PWH) to more reliably estimate the amount of productive working time that would be required for future treatment projects.

A project planner can use this estimate of working time to determine the number of working days required and factor in other considerations such as travel time (driving and walking), length of work day, and season to determine the projected cost for the treatment unit.

At a regional or national scale, fuels managers could benefit from a larger productivity data set for motor-manual fuel treatments. To optimize value from a shared data set, it is critical to standardize inputs to the data collection form. Fuel treatment technique and forest stand type are inputs that can be classified in several ways; therefore, commonly accepted terminology should be developed to ensure accurate data entry. The Canadian Wildfire Fuel Management Knowledge Base[2] has developed terminology for treatment tactics that can be applied in this data collection process.

Fuels managers will evaluate this process and provide feedback for continued development. At this time, data collection is still in the pen-and-paper phase, but future iterations of the process could evolve to an electronic data input format that could transfer data to a shared database.

This data collection process in not intended as a means of comparing productivity of crews.

[2] https://wildfire.fpinnovations.ca/Research/ProjectPage.aspx?ProjectNo=204

REFERENCES

Hvenegaard, S., & Hsieh, R. (2017). *Productivity of a motor-manual forest-fuel reduction treatment: A case study in Central Alberta* (Technical Report No. 51). FPInnovations.

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APPENDIX A: DAILY PRODUCTIVITY DATA COLLECTION SHEET

Section One – Logistics and administration			
Date*		**On-site supervisor**	
Location		**Phone number**	
Treatment unit*			
Treatment description			
Forest stand type			

Section Two – Resources			
Personnel		**Number of tools (specify below)**	
Total number of workers*		Chain saws	
Number of sawyers		Brush saws	
		Pole saws	
		Propane torches	
		Other	

Section Three – Times				
Typical daily routine of events				
Event	Time	Event	Time	Notes
Depart base		End work*		
Arrive at treatment unit		Depart treatment area		
Start work*		Arrive at base (end of day)		

Section Four – Breaks/delays				
Breaks*	Start	Stop	Number of personnel	Notes (lunch, coffee, warming/cooling, etc.)
Times				
Equipment maintenance*				Type of maintenance

* These fields must be completed.

Conditions that may influence operations (optional)

Temperature (C)			
Wind (km/h)			
Snow cover depth (cm)			
Stand density (circle one)	Sparse	Medium	Dense
Slope	Flat	Moderate	Steep
Other			

General treatment work activities for the day		

Examples of work activities. Several of these can be included on the same data sheet:

- Limbing to 2 m height
- Thinning stems to 3-m crown spacing
- Raking and piling limbs and stems
- Moving debris off-site
- Burning piles

Other comments

Please take photos that reflect weather conditions, snow depth, stand density, work practices, or other factors that may influence operations.

Thank you for completing this data collection sheet; your time and effort are appreciated! The data from these daily reports will assist local fuels managers in planning and budgeting for future projects. On a larger scale, shared data at a national scale can also benefit fuels managers in planning fuel treatments in similar fuel stands in other regions.

APPENDIX B: SAMPLE OF DAILY PRODUCTIVITY DATA COLLECTION SHEET

Section One – Logistics and administration			
Date*	April 25, 2020	**On-site supervisor**	
Location	Pelican Mountain	**Phone number**	
Treatment unit*	Unit 1		
Treatment technique	Thinning to 3-m crown spacing, limbing to 2 m, pile and burn residue and dead wood in surface layer		
Forest stand type	Dense black spruce. Some clumps of trees with open patches		

Section Two – Resources			
Personnel		**Tools (specify below)**	
Total number of workers	8	Chain saws	2
Number of sawyers	2	Brush saws	
		Pole saws	1
		Propane torches	1
		Other	Rakes, machetes, backpack pumps

Section Three – Times				
Typical daily routine of events				
Event	Time	Event	Time	Notes
Depart base	0800	End work	1550	
Arrive at treatment unit	0845	Depart treatment area	1615	
Start work		Arrive at base (end of day)	1700	

Section Four – Breaks/Delays				
Breaks	Start	Stop	Number of personnel	Notes (lunch, coffee, warming/cooling, etc.)
Times	1200	1230	8	Lunch
	1430	1445	8	coffee
Equipment maintenance				Type of maintenance
	1000	1030		Chain saw repair; repair recoil mechanism

*** These fields must be completed.**

Conditions that may influence operations (optional)

Temperature (C)	10 C		
Wind (km/h)	Light		
Snow cover depth (cm)	10 cm		
Stand density (circle one)	Sparse	Medium	**Dense**
Steep slopes	**Flat**	Moderate	Steep

General treatment work activities for the day		
Thinning to 3 m crown spacing	Limbing to 2m	Pile and burn debris

Examples of work activities. Several of these can be included on the same data sheet:

- Limbing to 2 m height
- Thinning stems to 3-m crown spacing
- Raking and piling limbs and stems
- Moving debris off-site
- Burning piles

Other comments

Please take photos that reflect weather conditions, snow depth, stand density, work practices or other factors that may influence operations.

Thank you for completing this data collection sheet; your time and effort are appreciated! The data from these daily reports will assist local fuels managers in planning and budgeting for future projects. On a larger scale, shared data at a national scale can also benefit fuels managers in planning fuel treatments in similar fuel stands in other regions.

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