Advantage
FERIC
Restricted to FERIC Members and Partners Vol. 1 No. 32 October 2000

Methods for decreasing disturbance levels during the site preparation of burned sites

Contents

Abstract

This report discusses various methods for improving operational effectiveness and decreasing the severity of the disturbances typically associated with regenerating burned sites. The report compares methods proposed for more difficult conditions with conventional windrowing, and also discusses lighter and more economical site preparation techniques. It emphasizes the importance of carefully targeting each type of treatment to the appropriate conditions to avoid unnecessarily high costs and levels of site disturbance.

Keywords:

Burned sites, Site preparation, Windrowing, Crushing, Bulldozers, Rehabilitation cut, Scarification.

Author

Denis Cormier
Eastern Division

Introduction

In Quebec, several major forest fires in recent years have produced sites with low or poor levels of regeneration. In the Parent region, a large fire devastated 74 000 ha, of which 54 900 ha represented productive forest. Several of the burned sites with poor regeneration levels were also difficult to reach, and thus, many did not undergo salvage operations to recover standing trees. Because of the quantity of debris on the ground and still standing, this type of terrain is very difficult to plant.

Conventional site preparation under these terrain conditions involves windrowing of the debris. However, many stumps must be removed, so the work generally requires the machine's rake to enter the soil, thereby contributing to pushing a large quantity of soil into the windrows. This type of treatment could have negative effects on soil productivity in the mid-term, particularly on coarse-textured soils. In addition, the tangled piles of wood and debris created by this technique are high, occupy considerable space, and are unattractive.

A project proposed by Kruger Inc. (Scierie Parent) in collaboration with FERIC set out to measure the operational impacts of various alternatives to conventional windrowing in burned areas and especially to determine whether these options could decrease the amount of scalping of soils and windrow size (Figure 1). One solution expected to decrease the impact of windrowing involved preliminary crushing of the stems. Because stump removal would no longer be required, the bulldozer's rake could more easily remain above ground level during piling of the debris. Felling the trees using a feller-buncher would also help minimize soil disturbance, and aligning the felled stems in the windrows could help to decrease windrow size.

The effectiveness of a rehabilitation treatment can be improved by carefully accounting for the difficulty of the site conditions. For example, disk trenching could prove sufficient under certain conditions.

Equipment and methods

Various types of site preparation work were performed on burned sites during the summers of 1998 and 1999 in the Parent region of Quebec. The work consisted of windrowing with or without prior crushing using 130- to 225-kW bulldozers equipped with piling rakes (Figure 2). Trials of rehabilitation cuts, in which the cut stems are felled and arranged in windrows by the feller-buncher, also took place (Figure 3). Lastly, a single light scarification was performed under the easiest site conditions (Figure 4).

FERIC monitored the trials to determine the operational impact of the alternative techniques for site preparation of burned sites and to compare these techniques with the conventional windrowing treatment. In particular, we focused on the impact of various crushing intensities (complete or partial) on the overall productivity of the site preparation operation (crushing plus windrowing), on the level of soil disturbance, and on the work quality (expressed in terms of the number of plantable microsites). The study also considered the effects of a time lag between the crushing and windrowing phases (delayed treatment) to investigate its influence on treatment quality and the intensity of soil disturbance.

Table 1 describes the various treatments in the study. In the first area ("Crushing"), we observed a 130-kW Caterpillar D6R bulldozer performing various crushing and windrowing treatments. A more powerful bulldozer (a 225-kW Fiatallis FD-30B) was also used to compare its operational effectiveness in windrowing. Treatments on the

Figure 1. (*Left*) The results of conventional windrowing on a burned site.

Figure 2. (*Right*) A bulldozer performing preliminary crushing before windrowing of burned stems.

Forest Engineering Research Institute of Canada (FERIC)

Eastern Division and Head Office
580 boul. St-Jean
Pointe-Claire, QC, H9R 3J9
☎ (514) 694–1140
🖹 (514) 694–4351
💻 admin@mtl.feric.ca

Western Division
2601 East Mall
Vancouver, BC, V6T 1Z4
☎ (604) 228–1555
🖹 (604) 228–0999
💻 admin@vcr.feric.ca

Find us Online! www.feric.ca

Publications mail #1677314 ISSN 1493-3381

Disclaimer

This report is published solely to disseminate information to FERIC's members. It is not intended as an endorsement or approval by FERIC of any product or service to the exclusion of others that may be suitable.

Cette publication est aussi disponible en français.

"Delayed" site were carried out during normal operations and were not timed. On this site, approximately 3 weeks had elapsed between the crushing and windrowing treatments. On the "Felling" site, the two rehabilitation-cut techniques differed primarily in terms of how windrows were created. In the first approach, the feller-buncher traveled so that it could create windrows at a spacing similar to that obtained during conventional windrowing, but in the second approach, a narrower spacing was used; here, the trees were simply deposited at the limits of the boom's reach.

Figure 3. (*Left*) A feller-buncher with a full-lateral-tilt head felling and windrowing burned stems.

Figure 4. (*Right*) A Percheron passive-disc trencher treating young burned stands under easy terrain conditions.

Table 1. Description of the treatments and equipment used in FERIC's study

	Treatment name	Machine	Description
Crushing	Windrows 1	Fiatallis FD-30B bulldozer with rake	Conventional windrowing in a single operation (powerful prime mover).
	Windrows 2	Caterpillar D6R bulldozer with rake	Conventional windrowing in a single operation (average prime mover).
	Double partial	Caterpillar D6R bulldozer with rake	Partial crushing of the block (every second row) followed by windrowing of both crushed and standing stems.
	Double complete	Caterpillar D6R bulldozer with rake	Crushing of the complete block followed by windrowing of crushed stems (two consecutive phases).
Delayed	Windrows 3	Combination of bulldozers with rakes	Conventional windrowing in a single operation.
	Delayed partial	Combination of bulldozers with rakes	Partial crushing of the block (every second row) followed by delayed (around 3 weeks) windrowing of both crushed and standing stems.
	Delayed complete	Combination of bulldozers with rakes	Crushing of the complete block followed by delayed (around 3 weeks) windrowing of the crushed stems.
Felling	Felling (normal spacing)	Timberjack 618 harvester with Machinatech full-tilt head	Rehabilitation cut with normal spacing of windrows.
	Felling (narrow spacing)	Timberjack 618 harvester with Machinatech full-tilt head	Rehabilitation cut with narrow spacing of windrows.
Scarification	Scarification	Timberjack 480B with disc trencher	Scarification with the Percheron passive-disc trencher.

Description of the sites

The trials occurred on four sites that had been burned by the same fire. The two sites selected for crushing and windrowing (hereafter referred to as “Crushing” and “Delayed”) had long, gently rolling slopes bordering on wet zones. The slopes ranged from none to light (0 to 15%) and all the study blocks had various amounts of deep sandy soils, with a few zones that had deep organic soil. The Felling and Scarification trials occurred on well-drained sandy soils with regular, light slopes (less than 10%).

The sites (Crushing and Delayed) on which the crushing treatments were studied supported a relatively young burned stand that retained traces of 30-year-old stumps from a previous harvest (Table 2). The quantity and size of the brush and residual trees suggested that the stand had not yet reached maturity. The sites contained just over 40 m^3/ha of debris. On the Crushing site, the fire had already exposed mineral soil in 37% of the total area. In both sites, few boulders were present and stoniness levels were relatively low. The residual humus layer was thinner on the Crushing site than on the Delayed site.

In contrast with the Crushing and Delayed sites, which supported nearly pure softwood stands, the Felling site contained nearly 50% intolerant hardwoods. The residual trees on this site were more numerous and were larger than those on the softwood sites. The amount of debris on the ground before the treatment was negligible, but breakage of the stems during felling produced a volume of debris on the ground comparable to that on the first two sites.

Table 2. Site and stand conditions (— = not available)

	Site			
	Crushing	Delayed	Felling	Scarification
Stumps				
Density (number/ha)	693	863	—	833
Diameter (cm)	14	13	—	12
Height (cm)	25	32	—	23
Residual trees				
Density (stems/ha)	736	853	1000	150
Diameter (cm)	10	12	18	12
Saplings				
Density (stems/ha)	2521	1305	—	2533
Height (m)	5	4	—	5
Debris on the ground				
Volume (m^3/ha)	41	45	46[a]	9
Height (cm)	17	10	12[a]	5
Percentage coverage (%)[b]				
Exposed mineral soil	37	—	—	33
Debris on the ground	17	—	—	8
Boulders	1	0	0	0
Vegetation (ericaceous)	48	43	—	47
Stoniness (%)	20	13	20	0
Humus thickness (cm)	9	20	5	2

[a] Volume and height were measured between the windrows after the treatment; these data thus include pieces broken during felling.
[b] The percentage coverage of the ground is a partial measure of the full ground coverage.

Before the fire, the Scarification site had been regenerating after a recent harvest. Few trees had reached a diameter of 10 cm (residual trees). In addition, the low quantity of brush, the nearly complete absence of debris on the ground, and the thin humus layer all offered relatively easy treatment conditions.

Results

Time studies

Under the study conditions, the productivity of windrowing without prior crushing averaged 0.37 and 0.42 ha/PMH (respectively) for the average and more powerful prime movers (Table 3). For a prime mover of average power, prior crushing (partial or complete) of the residual stems facilitated subsequent windrowing and improved windrowing productivity by 5 and 22%, respectively. However, the combination of the two treatments remained less productive than windrowing alone. The operator was not yet experienced with the Felling treatment, and the treatment was done on a very small scale under the most difficult conditions (in terms of residual trees); these factors mostly explain the low productivity obtained. In contrast, the scarification treatment was performed under the easiest conditions, and this permitted very high productivity.

The partial crushing did not, as had been hoped, significantly speed up the crushing operation, despite treating only 51% of the area (Table 4). On average, each pass covered a 7.6-m-wide swath (a 3.9-m treated strip plus a 3.7-m leave strip), versus 4.9 m between passes for the complete crushing treatment. However, the machine traveled somewhat more slowly in the partial crushing treatment and performed far more maneuvers. The stems in the leave strips appeared to bother the operator. This type of operation probably requires a longer break-in period before it will show appreciable productivity improvements.

The rehabilitation cut was not yet an operational technique. Performed for the first time, it exhibited a high proportion of delays (Table 4) that indicate the operation had not yet been optimized. In addition, the use of a windrow spacing similar to that in conventional windrowing required considerably more maneuvering than did creating windrows at a spacing determined by the maximum reach of the harvester's boom.

Table 3. Productivities of the treatments studied

	Treatment	Area (ha)	Productivity (ha/PMH)
Crushing	Windrows 1	2.2	0.42
	Windrows 2	1.6	0.37
	Double partial		
	Partial crushing	3.1	1.11
	Windrowing	2.4	0.39
	Combined	—	0.29
	Double complete		
	Complete crushing	4.4	1.09
	Windrowing	2.4	0.45
	Combined	—	0.32
Felling	Felling (normal spacing)	0.6	0.17 (157 stems/PMH)
	Felling (narrow spacing)	2.0	0.20 (197 stems/PMH)
Scarification	Scarification	4.8	1.38

	Crushing		Felling	
	Complete	Partial	Normal spacing	Narrow spacing
Distribution of cycle time elements				
Effective productive time (%)	83	78	45	54
Misc. maneuvers (%)	5	12	39	26
Delays (%)	12	10	16	20
Distance between passes (m)	4.9	7.6	44.6[a]	34.2[a]
Average speed (m/min)	41	40	n.a.	n.a.

Table 4. Time and motion study of two crushing and two felling methods (n.a. = not applicable)

[a] The distance between passes for the Felling treatment equals the average distance between two windrows (center to center).

Disturbance and plantability

Once the treatments were complete, FERIC measured the areas covered by windrows, the level of scalping, and the relative quantity of plantable microsites for all treatments (Tables 5 and 6). It's noteworthy that prior crushing of the stems decreased both the area occupied by windrows and the level of scalping. However, despite substantially increasing the total area of intact litter compared with the conventional windrowing treatment, the area scalped still remained greater than 80% of the cleared surface (excluding windrows) for the crushing treatment followed immediately by windrowing, and greater than 70% for the delayed treatment. In contrast, felling caused very little scalping of the mineral soil. The use of narrower corridors decreased machine travel but resulted in greater coverage of the site by windrows.

The plantability level that was evaluated does not correspond to an evaluation of the quality of the plantable microsites; instead, it illustrates the ease of placing a seedling in a microsite judged to be suitable for planting (Table 6). Plantability decreases as the effort required by the planter to make the microsite suitable increases. Except for the Felling treatment, in which site preparation would facilitate planting, all the other treatments produced quite acceptable plantability levels. The high percentage of scalping created by the more powerful bulldozer during windrowing (Windrows 1) also improved plantability. The presence of rocks and debris on the ground decreased the number of suitable microsites in the Felling treatment with narrow corridors.

Implementation

From the standpoint of productivity alone, scarification was the most productive and least expensive treatment (generally less than $200/ha), but its application is limited to easy stand conditions (few burned residuals). The good results obtained by this technique demonstrate the importance of selecting the right technique for the terrain conditions and thereby avoiding unnecessary costs and soil disturbance.

Windrowing in a single operation with a powerful bulldozer was the most productive of the treatments for clearing the debris produced by fire. Under the study conditions, the 14% greater productivity of the more powerful bulldozer did not appear sufficient to justify its higher operating costs (around 25%) compared with an average

Table 5. Percentage coverage by windrows and level of scalping for all treatments (— = not available, n.a. = not applicable)

	Treatment	Windrows	Cleared area (between windrows)	
		Percentage of the total area (%)	Litter intact (%)	Scalping (%)
Crushing	Windrows 1	—	6.7	93.3
	Windrows 2	18.1	8.8	91.2
	Double partial	12.4	15.5	84.5
	Double complete	12.1	17.5	82.5
Delayed	Windrows 3	17.4	10.3	89.7
	Delayed partial	15.2	28.8	71.2
	Delayed complete	14.7	25.6	74.4
Felling	Normal spacing	14.9	89.7	10.3
	Narrow spacing	20.7	89.2	10.8
Scarification	Scarification	n.a.	n.a.	n.a.

Table 6. Plantability level for all the treatments

	Treatment	Plantability (%)[a]		
		Good	Marginal	Unacceptable
Crushing	Windrows 1	99.0	0.0	1.0
	Windrows 2	93.9	2.8	3.3
	Double partial	90.0	5.5	4.5
	Double complete	94.2	5.8	0.0
Delayed	Windrows 3	96.0	3.0	1.0
	Delayed partial	90.0	8.0	2.0
	Delayed complete	95.7	4.3	0.0
Felling	Normal spacing	10.3	84.6	5.1
	Narrow spacing	10.9	74.4	14.7
Scarification	Scarification	90.0	10.0	0.0

[a] Calculated within the cleared area (i.e., excluding windrows).

bulldozer. However, the terrain conditions in the study blocks were relatively easy compared to the overall conditions on the sites that required treatment, and the productivity differences between the two bulldozers could increase in more difficult terrain, perhaps enough to justify the use of the more powerful machine. The cost of this type of operation would be around $400/ha.

Felling could also be used under very difficult conditions with a substantial residual stand present, but the treatment's productivity remains relatively low. Cormier and Warren (1998) suggested that this method has good potential and that its productivity could improve to the point that treatment costs would be similar to those of the windrowing treatments.

Prior crushing of residual trees slightly improved the productivity of the windrowing phase, but the combination of the two treatments remains less productive and its cost (around $500/ha) greater than that of windrowing alone. However, crushing before windrowing greatly decreased the area occupied by windrows, and the windrows created by this treatment were also more discrete, since the stems lie within the windrow. More compact windrows were also expected when the feller-buncher deposited its stems directly in the windrows, but since the machine was working in a stand with a large hardwood component, the larger tops of these trees produced windrows that actually covered more area.

The project's main objective was to identify a method capable of reducing the level of soil disturbance during the windrowing of burned sites. Although a prior crushing treatment decreased scalping levels, these levels still remained higher than 70%. The operator's skill and comprehension of instructions are crucial when the goal is to decrease the impact of soil disturbance during windrowing. As a result of their training and to improve their comfort, operators (particularly those with powerful machines) tend to level the terrain by removing all obstacles in their path. They should thus be reminded periodically not to remove too much organic matter in the upper soil horizons. The operator's attention to the work has considerably more impact on the results than any other efforts to decrease scalping during windrowing.

The Felling treatment let the operator avoid almost all scalping of the soil. However, other trials (of winter treatments) have shown that the elimination of scalping is not necessarily an attractive solution because it may produce insufficient plantable microsites, except in very specific situations (Cormier and Warren 1998). The addition of a supplementary scarification treatment could become necessary to create an adequate number of well-distributed plantable microsites. This scarification would increase costs by an additional $100 to $150/ha.

From the evidence, it is difficult to restore a site covered by large, burned standing trees to production in a single treatment while still maintaining relatively low levels of soil disturbance. It could be advantageous to rely on a two-phase treatment, with initial removal of standing stems to minimize disturbance, followed by scarification of the cleared area. This initial treatment could be felling, or winter windrowing using bulldozers. Felling has the advantage of being suitable for use throughout the year.

Reference

Cormier, D.; Warren, C. 1998. Winter treatments for decreasing soil disturbance caused by the rehabilitation of burned sites. For. Eng. Res. Inst. Can. (FERIC), Pointe-Claire, Que. Field Note Silviculture-112. 2 p.