

**BULLDOZER PRODUCTION RATES AND
GUIDELINES FOR CONSTRUCTING FIREGUARD
IN BOREAL FOREST COVERTYPES**

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CANALTA ENVIROTECH¹

This is a joint publication of Forestry Canada
and the Alberta Forest Service pursuant to the
Canada-Alberta Forest Resource Development Agreement

¹Fairview, Alberta

Project # 1457-69

DISCLAIMER

The study on which this report is based was funded in part under the Canada/Alberta Forest Resource Development Agreement.

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Catalogue No.: F0 42-91/71-1989E
ISBN: 0-662-17140-3

Additional copies for this publication are available at no charge from:

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Edmonton, Alberta
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ACKNOWLEDGEMENTS

Appreciation is extended to members of the Alberta Forest Service, Canadian Forestry Service and the University of Alberta, who made this publication possible. Editorial reviews were conducted by Dale Huberdeau, Barry Congram, Terry Van Nest, Ed Johnson, Ken South, and Joe Smith, all of the Alberta Forest Service; Chuck Ogilvie of the Canadian Forestry Service, as well as Dr. P. Murphy and Dr. P. Woodard of the University of Alberta. Appreciation is also extended to Florence Beaulieu and Darren Beveridge who graciously helped with the editing.

The lengthy discussions, and advice of Dennis Quintilio, Forest Technology School, Hinton; and Dr. P. Murphy, University of Alberta, who reviewed and critiqued earlier drafts, as well as the final draft is very much appreciated.

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INTRODUCTION

The evolution of improved fire suppression methods and techniques continues to improve fire-fighting effectiveness under adverse conditions. The availability of superior designed bulldozers, combined with an accumulation of knowledge regarding use, has improved organization and increased productivity. Safety, productivity and infinite environmental concerns will continue to influence the bulldozer's role on forest fires. The use of bulldozers is a privilege and could be subject to restrictions being imposed if any aspect of prescribed use is not adhered to.

Bulldozers have become an important component of an integrated fire suppression network which includes helitanks, bombers, specialized ground crews, aerial and ground retardant and foam application, etc., all with the purpose of subduing fire spread quickly and efficiently with minimum cost, loss, and environmental damage.

Ideally, forest officers placed in the position of supervising dozer operations on wildfires would possess extensive experience however; due to the manpower shortages during periods of high fire hazard and frequency, less experienced personnel are often utilized to fill positions such as cat boss and line locator. These people have demonstrated that a good job can be performed with only a basic knowledge of forest agency expectations if they have the inclination to utilize the knowledge and experience of bulldozer operators and overhead staff.

The primary role of a dozer is to provide a fuel break, thus containing any further fire spread. The type, size, and mechanical condition of dozer, as well as operator skill, supervision, and organization, will determine suppression success and the amount of reclamation work required.

To date, little information is available regarding actual bulldozer production levels for boreal forest types. An attempt is made in the forgoing to consolidate the results of a Northern Forest Research Centre bulldozer productivity study and the experience of forest personnel and contractors in order to relate common problems and provide solutions for a range of fireline conditions. Results of the N.F.R.C. study was derived from a data base of approximately 200 kilometers or 600 hours of actuarial bulldozer fireguard construction on wildfires. Hopefully, this information will provide a better understanding of each parties concerns and result in safer work conditions, greater productivity, and improved worker morale.

It is not expected that all or perhaps anyone in fire control will be in total agreement with all aspects of this report. This is based on a number of peoples experiences which may or may not correlate with the experiences of others.

There is probably no other circumstance where contractors and forestry personnel are scrutinized more intensely than large campaign fires. The stories of how well or how poorly parties responded continue long after the fire. Good organization and supervision will contribute greatly to how the public cites all participants.

CHAPTER I - BULLDOZER ORGANIZATION

A. ROLE OF BULLDOZERS FOR FIRE CONTROL

Bulldozers are capable of performing a wide range of duties when properly organized and supervised. Duties include the following:

1. Upgrading roads to the fire
2. Clearing, leveling campsites, and constructing garbage pits.
3. Constructing fireguard
4. Constructing helispots
5. Mop-up duties
6. Restoration of fireguards
7. Integrated functions such as "walking down" fuels prior to back burning, constructing creek crossings, etc.

B. ORGANIZING DOZER UNITS

1. Normal Dozer Unit Layout:

The various suppression agencies across Canada have prescribed similar organizational formats, consisting of two or more dozers followed and/or preceded by a combination of specialized crews and equipment. Under most circumstances such formats have proven more effective than simplified versions.

The optimum number of dozers per unit will vary with the size and quantity of fuel to be removed and how efficiently the dozers can perform in a particular fuel type. This will depend primarily on soil and moisture conditions, as well as topographical features. Dozer units consisting of three properly selected machines have proven effective for most boreal forest conditions; although circumstance may dictate that fewer or more machines be employed. Research studies have shown that production per dozer may decrease as the number of dozers increases. In boreal forest types, a degree of production may have to be sacrificed to maintain optimum efficiency and safety standards. The use of one dozer working alone is usually limited to very short jobs in settlement areas. Operators frequently become stuck (Photo 1) or are so cautious of getting stuck that little guard is normally achieved. A two dozer unit is not recommended for wetter types, as the possibility of both dozers becoming stuck simultaneously does exist. Three dozers are manageable, while units consisting of more machines frequently result in wasted time, and more dangerous working conditions (Photo 2).

Dozer foremen must assess each machine and operator as they arrive at the fire. The lead operator is usually selected as the one having the most fire experience, and one operating a dozer capable of "walking down" timber at an acceptable pace. For mature forest cover types, the lead dozer is most often the largest dozer in the unit. The blade is angled so that material is pushed away from the fire.

The second dozer will also have its blade angled away from the fire, performing rough cleanup duties by removing brush and part of the organic layer if required. The second and third dozer must synchronize their work load to avoid either falling behind or having to wait.

The third dozer is responsible for completing the guard, which normally involves removing all organic material. This machine also has its blade angled away from the fire. The operator of the third dozer normally constructs seepage holes for backpack and power pumps when required, knocks down snags and trees leaning towards the guard, and breaks-up fuel accumulations which may provide an escape route for the fire.



Photo 1. The sad reality of one dozer attempting to construct
guards.



Photo 2. Consideration should be given to splitting large
natural units.

2. Reclamation Conscience Bulldozer Unit

Reclamation of dozer guard has become a major consideration for forest fire suppression personnel during initial fire assessment. A balance between constructing effective guard without creating undue environmental damage and expense must prevail over simply extinguishing the fire.

One bulldozer unit, consisting of six dozers, has been used successfully. Three dozers spaced a safe distance apart walk down the timber, for a total width of two to three dozer blades. Care is taken not to push trees into the standing timber. The following three dozers clear the fire side of the line, of all timber and organic material. The result is a guard approximately one blade wide on the fire side of the walked down line and all debris "windrowed" on the opposite side.

The main advantage of this type of unit is that roll back of debris during reclamation can be carried out much easier than normal operations where the debris must be pulled out from the standing timber. This method is best suited to unmerchantable stands and is not recommended by all agencies regardless of circumstance.

G. RESPONSIBILITIES AND JOB DESCRIPTIONS OF BULLDOZER UNIT PERSONNEL

1. Line Locator

On large fires, the line locator reports to the sector boss, and therefore is not part of the actual bulldozer unit. However, on smaller fires or when direct attack methods are utilized, this position may become optional or be assumed by the dozer foreman. If parallel or indirect attack methods are incorporated, this position becomes vital, and may require the hiring of a helper (assistant line locator). Under these circumstances, the importance of having a qualified person locating and marking line, can not be over emphasized. Such qualifications include:

- a. good physical condition; the position involves much walking over long work days
- b. a good understanding of fire behavior
- c. extensive knowledge regarding bulldozer use and limitations
- d. sound knowledge of environmental concerns and reclamation practices.

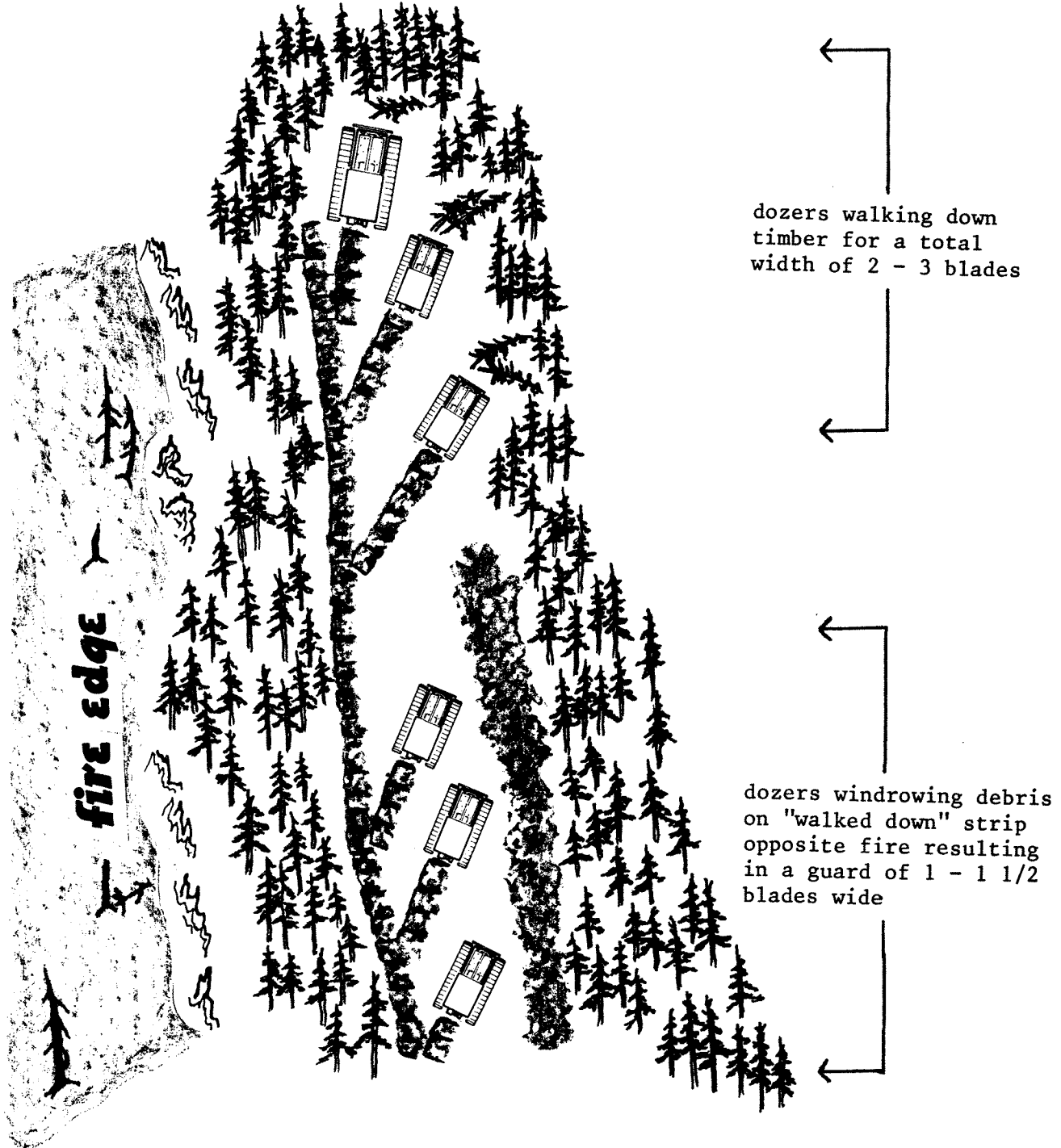
When helicopters are available, the line locator's job can be simplified by flights to search for natural breaks, areas sensitive to disruption, creeks and other beneficial or detrimental features. The line locator may want to land and further examine various areas on the ground. Once a route has been established, he can walk back towards the dozers, locating and marking line; or, he may return to the dozers and work from that point forward.

The question of how far to locate line ahead of the dozers cannot be answered simply for all situations. A balance must be maintained between working a safe distance ahead of the lead dozer, and not laying out line which may be burn over prior to the dozers arriving. Some contributing factors to consider when locating line are:

- a. time of day
- b. present and expected fire behavior
- c. present and expected weather
- d. topography
- e. forest covertypes

Reclamation - Conscious Bulldozer Unit

**line
locator**



Generally speaking, the line can be marked at some distance ahead of the unit when the fire is expected to move slowly. Fires tend to move slower from evening to mid or late morning, in aspen stands, and when burning downhill. When applicable, it is advantageous to locate line for the night shift prior to darkness. If possible, this stretch of line should also be walked down before dark. When a fire is expected to move rapidly, the line locator will work much closer to the dozer unit. Fire spread rates usually increase during the afternoon when fuel moisture decreases, when travelling uphill, as winds increase, temperature increases or when relative humidity decreases.

The line locator must keep informed of weather reports, and assess other factors affecting spread rates, when deciding on how far to work ahead of the dozers.

2. Spotter

This position is required on fires where the line locator works well ahead of the dozer unit. The spotter, working at safe distance ahead of the lead dozer, establishes the final route previously "roughed out" by the line locator. This position is not required under all circumstances, or may be assumed by the line locator or dozer foreman only in those areas where the lead dozer operator requires additional help in determining the route. The lead dozer operator frequently requires the assistance of a spotter under the following situations:

- a. when walking down trees during night operations
- b. in very dense brush
- c. in very wet areas where operators may require help to avoid "bogging down".

3. Swampers

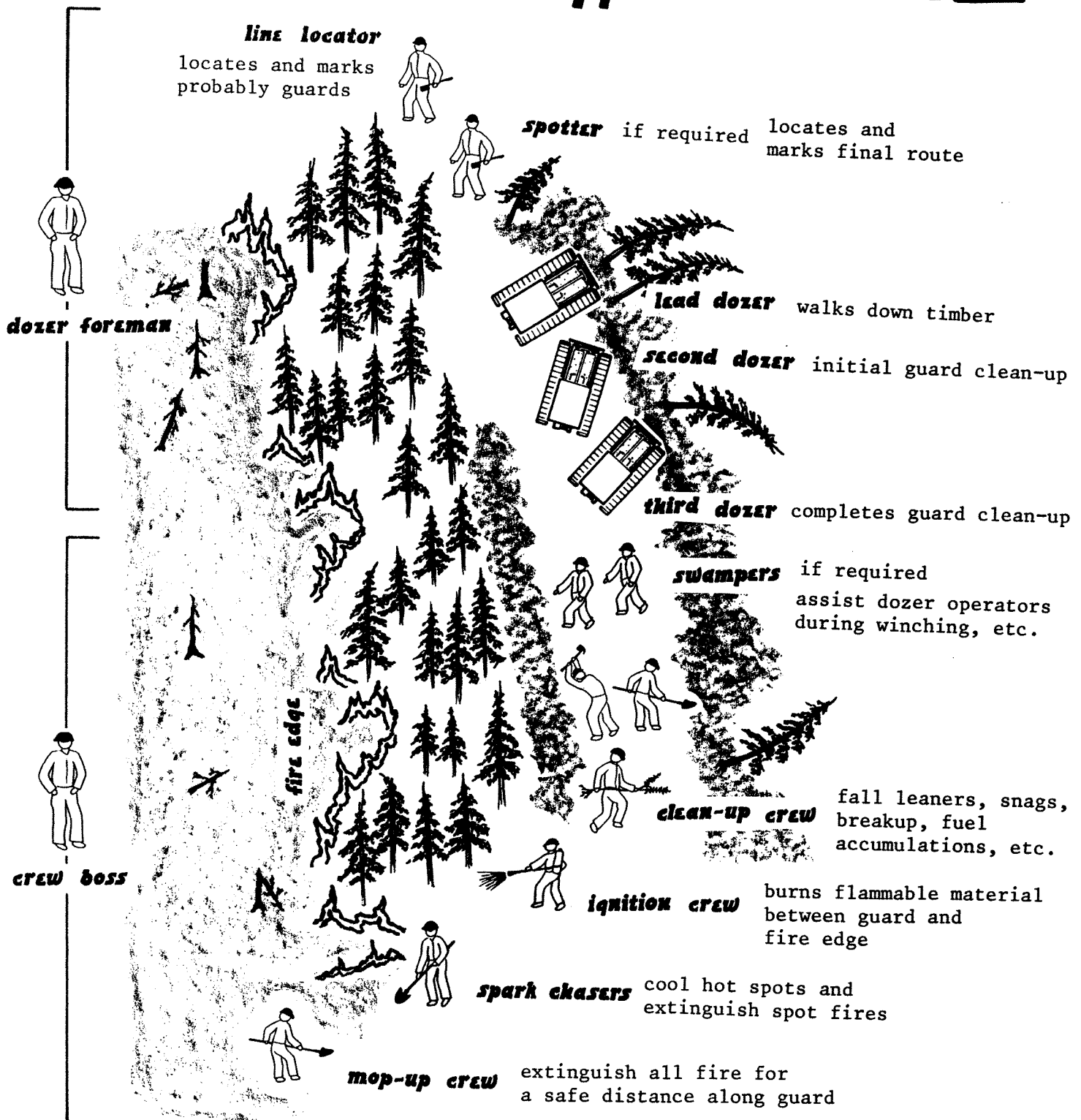
Swampers are hired to assist dozer operators. The Workers Compensation Board requires that a swamper be present when a dozer is working alone in the forest. However, dozers seldom work alone during construction of fireguard. Good swampers have proven beneficial under most circumstances, while poorly trained swampers have proven to be a liability under other situations. Swampers can speed up the operation by performing such duties as helping change blade positions and handling winch cables, but must be aware of the hazards of working close to the dozers and maintain a safe working distance between themselves and the dozers during the actual winching.

4. Dozer Foreman

This position, more commonly referred to as "cat boss" or "cat foreman", involves overseeing the entire bulldozer unit operation, including dozer operators, swamper, spotter, cleanup crews and burnout crews. The dozer foreman answers directly to the fire boss, the line boss, or most often to the sector boss; depending on the manning level of the fire.

The dozer foreman position is essential to the efficient operation of any dozer unit. The individual designated as dozer foreman should be well versed in all aspects of bulldozer use relative to fire suppression, reclamation obligations and agency policy. Duties and obligations include:

A Typical Three Dozer Unit Complete With Support Personnel



a. Upon Arrival at Fire

1. Conducts mechanical inspections of all equipment
2. Assesses dozer size for placement in the dozer unit
3. Assesses operators
4. Ensures safety features such as canopies, lights and fire extinguishers are serviceable
5. Informs all participants of their safety obligations
6. Makes arrangements for sleeping accommodations and meals
7. Assigns dozer numbers.

b. Delegation of Work

After receiving instructions from his immediate supervisor, the dozer foreman reviews details of the action plan with all participants of the dozer unit. This briefing should ensure that each person, or crew receives detailed instruction regarding safety, suppression objectives, environmental concerns and the distribution and proper use of communications equipment.

c. Supervision of Dozer Unit:

1. Ensures that the guard is constructed in accordance with the suppression plan, utilizing acceptable methods and techniques.
2. Ensures that all work is conducted in accordance with safety standards which should including two potential escape routes.
3. Ensures environmental disruption is kept to a minimum.
4. Replace personnel failing to comply to work or safety ethics.
5. Maintains a continuous dialogue with the immediate supervisor regarding progress.
6. Recommends changes to the original suppression plan or safety program when required.
7. Ensures an acceptable morale level is maintained and encourages constructive feedback from dozer operators, crew bosses, etc..
8. Authorizes and completes time records for all men and equipment in the unit.

D. BULLDOZER DESIGN CHARACTERISTICS BENEFICIAL TO BOREAL FOREST CONDITIONS

Bulldozer manufacturers are well aware of both existing and potential northern markets, and have responded by designing machines to overcome perplexities unique to boreal forest types. The main focus of concentration has been in the area of producing powerful medium sized dozers with increased flotation capabilities and ground clearance without significantly sacrificing traction and stability.

The theory behind such advances is quite simple; the weight of the dozer is spread more evenly over a larger track to ground surface. Ground clearance has been improved by increasing the distance between the dozer's undercarriage, and the draw bar mechanism, in order to decrease the chance of becoming hung up on stumps and rocks, and snagging brush and debris. These improvements also reduce environmental problems by minimizing disturbance to the soil surface and cutting of ruts. Such features include the following:

TABLE 1
MACHINE WEIGHT AND NET HORSE POWER
FOR VARIOUS DOZERS

SMALL DOZERS			MEDIUM DOZERS			LARGE DOZERS		
Model	Power KW	Net H.P.	Model	Power KW	Net H.P.	Model	Power KW	Net H.P.
D6C	89-104	120-140	D7F	134	180	D8K	224	300
D6D	104	140	D7G	149	200	D8L	250	335
Case 1450	104	140	TD-20E	157	210	TD-25E	231	310
TD-15C	104	140	TD-25C	213	285	TD-25G	239	320
JD850	104	145	D85A,E	134-164	180-220	D155A	239	320
JD850G	123	165	D-700	150	201	D-800	261	350
D60E	104-127	140-170	D-750	194	260	D9H	287	385
D65E	116-123	155-165	82-20B	153	205	D9L	343	460
M.F. 600C	107	144	82-30B	194	260	TD-40	335	460
D600D	107	144	82-40	205	275	D355A	306	410
HD11B	104	140	HD21B	204	273	D375A	383	508
HD14C	112	150	FD20	166	223	82-50	276	370

TABLE 2
MANUFACTURERS' DESIGNATIONS

MANUFACTURER	PREFIX	EXAMPLES
Caterpillar	D	D7, D8K, D8L, D9G, D9H, D9K
International	TD	TD20, TD25B, TD25C
Fiat Allis (Allis Chalmers)	FD or HD	FD30, HD21C
Terex (Euclid)	C and TC (earlier models) number only (later models)	82-20B, 82-80
Komatsu	D (number and letter)	D120A, D150A, D355A
Case	number and letter	1450, 1150, 1150B
John Deere	JD number series	JD 450C, JD 750, JD 850
Massey Ferguson	MF number series	MFD 600C, MFD 700C

1. Wide Pad

The fitting of standard dozers with wider than normal tracks was the first step in revolutionizing the range of muskeg conditions that dozers could effectively work. Flotation and stability, for soft ground application, was increased to the point that construction of fireguards could take place where it had previously been impractical.

2. Extended track

On "Low Ground Pressure" (L.G.P.) models, the length of track has been extended marginally and the neutral point centered so the weight of the dozer is spread more evenly over extra track, resulting in better flotation. Low ground pressure dozers have proven extremely valuable, especially dozers in the 200 H.P. range which can work effectively in muskeg types, mature white spruce, pine, and aspen.

The critics of L.G.P. models use the argument that the difference in performance between L.G.P.'s and ordinary wide pads is marginal, frequently putting them just beyond the maximum winching distance. Undoubtedly there is some merit to this concern, but one may recall similar distress regarding wide pads approximately 20 years ago. Obviously, good judgement and personal preference play an important role in the employment of dozer type. Experience and discretion on the part of the dozer foreman and lead dozer operator is essential.

3. Elevated Sprocket

The elevated sprocket, or suspended undercarriage, allows the track to conform more readily to uneven ground surfaces. The rear sprocket dictates the location of the rear of the track, and consequently the center of balance. The Caterpillar "Low Ground Pressure" model is designed primarily for dozing while the "Logging and Petroleum Special" is designed primarily for winching; this difference is achieved by simply altering the center of balance. Suspended undercarriages have been basically confined to medium size dozers (D6's and D7's).

4. Fire Suppression System

This system is designed to extinguish any fire originating near the dozers motor from hot diesel, oil, wood particles, leaf and other debris. It is recommended for hostile work environments, such as forest fires, and can be activated manually or can be set to function automatically.

5. Special Track Shoes Designed for Muskeg

Various types of track designs are presently being tested for muskeg types. Komatsu has introduced a self cleaning circular arc shoe, designed to increase traction and maneuverability over soft terrain. These shoes supposedly result in minimal ground surface damage, thereby increasing trafficability.

CHAPTER II. BULLDOZER FIREGUARD CONSTRUCTION PRODUCTIVITY

A. RESULTS OF PREVIOUS PRODUCTIVITY STUDIES

Unfortunately, most previous dozer-guard productivity studies had been conducted in the U.S., and bore little relevance to boreal forest conditions. However, a pilot study was conducted by Canadian Forest Service personnel during the 1970's. The bulk of this data was collected on spring campaign type fires in which resistance to dozer-guard construction was high. Despite this fact applicable resistance classes and production rates were established for a number of fuel types.

During this study an attempt was made to determine the types, sizes and number of dozers per unit best suited for constructing guard in individual timber types, as well as any aspect of the total operation which appeared to affect efficiency. The parameters affecting bulldozer fireguard production were found to be much different in boreal forest fuel types than other forest regions where the influence of soil and moisture conditions are less significant.

In most forested areas, productivity correlates directly to the amount of material to be removed and the horsepower of the dozers. In contrast, production in boreal forest types is affected to a greater degree by how well the dozers can perform under adverse soil and moisture conditions. Research data from other studies have shown that production per dozer decreases as the number of dozer per unit increases. This theory cannot be applied under normal boreal forest conditions since the chance of dozers becoming stuck is much greater than in other forest regions. Therefore a dozer unit consisting of two or more medium sized dozers, with good floatation capabilities, are recommended for a variety of boreal forest fuel types. Three dozers per unit has proven to be a good balance between productivity, operation efficiency and safety standards.

B. MANPOWER VERSUS BULLDOZERS

Fireline constructed by crews using handtools is generally confined to very small fires, or sections of larger fires where bulldozers can not work effectively (wet, rocky, or steep areas), or areas of environmental concern. As well, greater quantities of handguard is constructed in the more remote areas where distance to the fire or adverse ground conditions are not conducive to the use of dozers. "Handline" can be constructed at a rate of approximately 40 m. per man hour in pine, and 20 m. per man hour in aspen, white spruce, black spruce, and slash for a maximum duration of one hour. Production rates for sustained action (up to 8 hours) is approximately one half the initial attack (one hour) value.

On the other hand, "hotspotting" is a more viable alternative to dozer line construction on small fires or sections of larger fires. Initial results from a hotspotting productivity study show that one man can contain 100-400 m. of fire perimeter per hour on low and moderate intensity surface fires in black spruce and jack pine. However, these initial attack rates could probably not be sustained for more than 15 to 30 minutes. Depending on the intensity of heat, smoke, and ambient temperature, production rates for longer periods would be much lower, perhaps 20-70 m. per man hour.

It would therefore be impractical to extend handline or hotspotting productivity operations over a ten or twelve hour whereas patrol or mopup

activities may be sustained for that period. A realistic approach may involve starting crews with the more physically demanding work; switching them to less demanding activities before they become critically fatigued. Fatigue studies have shown that rate of production drops dramatically after approximately five hours under extremely adverse conditions. Also, the smoke released by some vegetation, such as labrador tea, is a irritant to fire-fighters and cannot be tolerated for extended periods.

C. FUEL RESISTANCE TO BULLDOZER FIREGUARD CONSTRUCTION

The size, quantity and type of flammable material to be removed, and the difficulty of moving these fuels will have a major effect on the speed and ease in which an adequate guard can be constructed. Contributing factors include the following:

1. Upper Story
 - a. Size
 - b. Density
 - c. Rooting Habit
 - d. Wood Characteristics
 - e. Snags
2. Under Story
 - a. Size
 - b. Density
 - c. Rooting Habit
 - d. Down Material
3. Soil
 - a. Depth of Organic Layer
 - b. Moisture Regime
 - c. Frost
 - d. Rocks
4. Topography
 - a. Slope -- Up, Down, Side, Degree, Aspect
 - b. Continuity of Topographical Types
 - c. Creeks, Muskeg etc.

D. RESISTANCE CLASSES

The effect and degree of resistance of the foregoing are fairly self explanatory, but will be discussed in more detail as they apply to individual fuel types in the following chapters.

Forest fuels are therefore classified by the degree of resistance to fireguard construction. The number and variation of different fuel types makes classification impossible for all conditions. However, the more common fuel types have been classified by resistance to bulldozer fireguard construction categories.

1. Low Resistance To Fireguard Construction

- range types, grasses and other large openings where the organic layer does not exceed 12 cm, and soil moisture is not detrimental to guard construction

- open and fully stocked pine stands having less than a 8 cm of organic material
- pine regeneration if stumps and windfall do not affect production significantly
- open muskeg types where the frost layer is adequately strong to support the weight of the dozers and where a satisfactory "track guard" results from simply walking the dozers over the muskeg or where a guard can be constructed by just skimming a thin layer of the organic material of the surface.
- young open aspen stands where the organic layer does not exceed 10 cm.

2. Moderate Resistance to Fireguard Construction

- range types, grasses and other openings when the organic layer exceeds 12 cm or when the organic layer is less than 12 cm and soil conditions marginally reduce productivity.
- dense, mature pine stands or when the organic layer exceeds 8 cm.
- young, open white spruce stands when the organic layer does not exceed 12 cm and moisture conditions do not retard productivity.
- most immature aspen stands.
- slash blocks where the organic layer does not exceed 12 cm and removal of stumps does not slow production greatly.
- open black spruce stands where a shallow guard will be effective and frost is adequate to support the weight of the dozers.

3. High Resistance to Fireguard Construction

- most recently-cut black and white spruce cut-over blocks.
- most white spruce height and density classes.
- most black spruce stands with a relatively shallow organic layer and the dozer can work on the frost layer most of the time.
- most mature aspen stands.

4. Extreme Resistance to Fireguard Construction

- most muskeg types when frost is not present.
- clear-cuts having a large volume of slash, deep organic layer, very wet, or where stump removal proves very difficult.
- dense, mature white spruce stands.
- mature or over-mature aspen stands.

E. BULLDOZER PRODUCTIVITY

Results of the Northern Forestry Centre (N.F.C.) study show that significant differences in production do exist between fuel types and bulldozers used. A rate of 40 m per dozer-hour was observed by 2-D6's in a B3SwA stand (Table 3). This rate contrasted with 2-D8's constructing 1200 m per dozer-hour of fireguard in mature pine. However, if the two D6's produced only 40 m of guard because of soil and moisture conditions, the D8's may have produced even less or may not have been able to construct guard in this particular B3SwA stand because of being much more prone to becoming stuck.

Calculated production rates are based on actual working time while the dozers were constructing guard (Figure 1). Productive guard construction accounted for only 60% of the total time for which dozers were being paid. The remaining 40% of the time dozers were held back for various reasons such

as; conditions unsafe to proceed with construction, stuck time, repair and service, and dozers waiting for other machines to arrive to make up units.

Fuel resistance to line construction is similar for both dozers and handline crews, although some differences do exist. Dozers are affected more greatly by the capacity of the ground surface to carry the weight of the machines. Table 3 shows that significant variations exist between, as well as within various fuel types. Fuel type where soil moisture and frost have a major effect on production are also the most difficult to estimate. For example, the presence and amount of frost may be the determining factor when deciding if a specific black spruce type will be in the moderate , high or extreme resistance class.

F. ESTIMATING PRODUCTIVITY

A relatively simple method for estimating bulldozer fireguard productivity is being field evaluated (Table 5). These tables are not intended to provide accurate rates under all circumstances; rather the tables aid field personnel in determining the number and size of dozers required to complete a given section of guard in the time frame. Further assessment may conclude that these tables may have to be adjusted for local conditions.

Productivity is determined primarily by height, density and covertime of the stands. The basic table rate may then be adjusted for such factors as:

- a. number of helispots required
- b. night operations if applicable
- c. initial attack or campaign fire production
- d. excessive windfall if applicable
- e. slope

Because of the wide range of bulldozer horsepower ratings, production is estimated in metres per 100 net horse power hour rather than in metres per dozer hour.

TABLE 3
SUMMARY OF N.F.C.
BULLDOZER FIREGUARD PRODUCTIVITY STUDY

BULLDOZERS	TOTAL TIME	PRODUCTIVE TIME	COVER TYPES	METRES PER 100 NET H.P HR.
3-D6's		0.50	Old burn	616
1-D6	5.00	5.00	B1P1	556
1-D4 (1)	39.00	2.50	B1A SLASH	503
3-D6's		2.00	Sw & Sb	472
1-D8	1.00	1.00	C2SsP1	425
1-D8	4.00	4.00	B1P1	351
1-D8		1.00	B1P1	340
2-D8's, 1-D7, 2-D6's (5)	21.00	15.00	A1ASw	280
1-D7, D17A, 1-D6WP (2)	15.00	14.06	B2P1Sw	223
2-D6's, 2-D7's (4)	0.16	0.16	B2SwFb	202
1-D8		1.00	B1P1Sw	170
2-D8's, 2 D-6's, 1-Td15 (5)	10.00	6.00	A1Pj & A1Sb	145
2-D8's, 2-D6's, 1-TD15 (5)	12.50	5.00	B1SbPj & C2SbPj	145
1-D7, 2-D8, 1-D6 (4)	6.50	6.00	C2Pj (180 CHNS.)	143
			C1A (100 CHNS.)	
			C3SwA (40 CHNS.)	
2-D6's, KUM (60A & 60E) (4)	0.33	0.33	B2SwFb	142
3-D6's		2.50	Sw & Sb	136
1-D7, 5-D6's (6)	2.25	1.75	C2Sb	123
1-D8	4.00	4.00	C2SsP1	111
1-D8, 1-D7, 2-D6's WP (4)	14.30	9.00	C3Sb & C3Sw	109
1-D7E, 1-D4 (2)	2.34	2.17	A2Fb	102
4-D7's, 3-D6's (7)	18.00	10.00	B2SbA	93
4-D7's, 3-D6's (7)	18.00	9.00	C2Sb	82
1-D6, 1-D7 (2)	5.00	4.00	B3P1 & B2ySb	72
1-17A, 1-D6WP (2)	14.30	6.00	B4Sw	70
5-D7's, 3-D6's (8)	14.00	11.00	C2YSw	69
3-D6's (3)	5.00	3.89	B4Sw	67
1-D8H36A, 2-D6Cs (3)	12.50	10.00	B2ySb	64
4-D7's, 3-D6's (7)	14.00	7.00	C2ySb	60
4-D7's, 2-D6's (6)	14.00	9.50	C2ySw	59
5-D7's, 3-D6's (8)	18.00	9.00	C3Sw & C2xSb	59
1-D8H, 1-D7, 1-D6 (3)	9.00	5.00	B3SwA	59
1-8280, 1-D7E, 1-D6 (3)	9.00	6.00		57
1-D8, 2-D6 (3)	12.50	9.66	B3P1 & B2ySb	53
1-17A, 1-D6WP (2)	14.30	9.00	B3SwPjA	53
1-D8H, 1-D7, 1-D6 (3)	7.30	2.00	A1SbSw	50
2-D8's, 1-D7, 2-D6 (5)	126.00	75.00	C3SwA	50
1-D6, 1-D7 (2)	12.00	9.00	C3ASw	43
2-D7's, 2-D6's (4)	7.00	5.00	C2xA	33
1-D7, 5-D6's (6)	14.00	10.00	A1Sw	33
5-D7's, 3-D6's (8)	18.00	10.00	B2xASw (60%)	33
			B2yPSw (40%)	
1-D6, 1-KUMS, 60E (2)	14.30	9.00	B4Sw	31
1-D8, 1-D7, 2-D6's (4)	14.30	11.00	B4Sw	28
2-D8's, 1-D7 (3)	5.00	4.25	C3FbA	25
1-D6, 1-KUMS, 60E (2)	14.30	9.00	B3SwA	25
1-D8, 1-D6WP, 1-17A (3)	14.30	9.00	B4Sw	21
1-D8, 1-D846A, 2-717A's				
2-D6's, 1-D4 (6)	52.00	31.00	A2SbP1A	13
			(PIA ON RIDGE)	

TABLE 4
BULLDOZER FIREGUARD PRODUCTIVITY BY
RESISTANCE CLASSES

RESISTANCE CLASS	COVER TYPES	METRES/100 NET HORSE POWER/HOUR
LOW	PlPj (immature, mature) PlSb ¹ (immature)	416 268
MODERATE	PlSw (immature) SwFb (immature) PjSb ¹ (immature) SbPj ¹ (immature) Sw (immature)	196 172 145 145 109
HIGH	SbA ² (immature) Fb (mature) PjASw (mature) PlSb ² (mature) Sb ² (mature) Sw (mature)	93 64 96 63 79 79
EXTREME	SwA, SwPjA, SwSb ³ (mature) ASw - SwA (mature) A SLASH Sb ³ (immature, mature) Sw (mature) A (mature)	57 34 57 13 43

Adequate frost to carry dozers¹

Some frost - will not carry dozers continuously²

No frost³

FIGURE 1
BULLDOZER PRODUCTIVITY AS A FUNCTION
OF FUEL RESISTANCE
(m/100 horsepower hour)

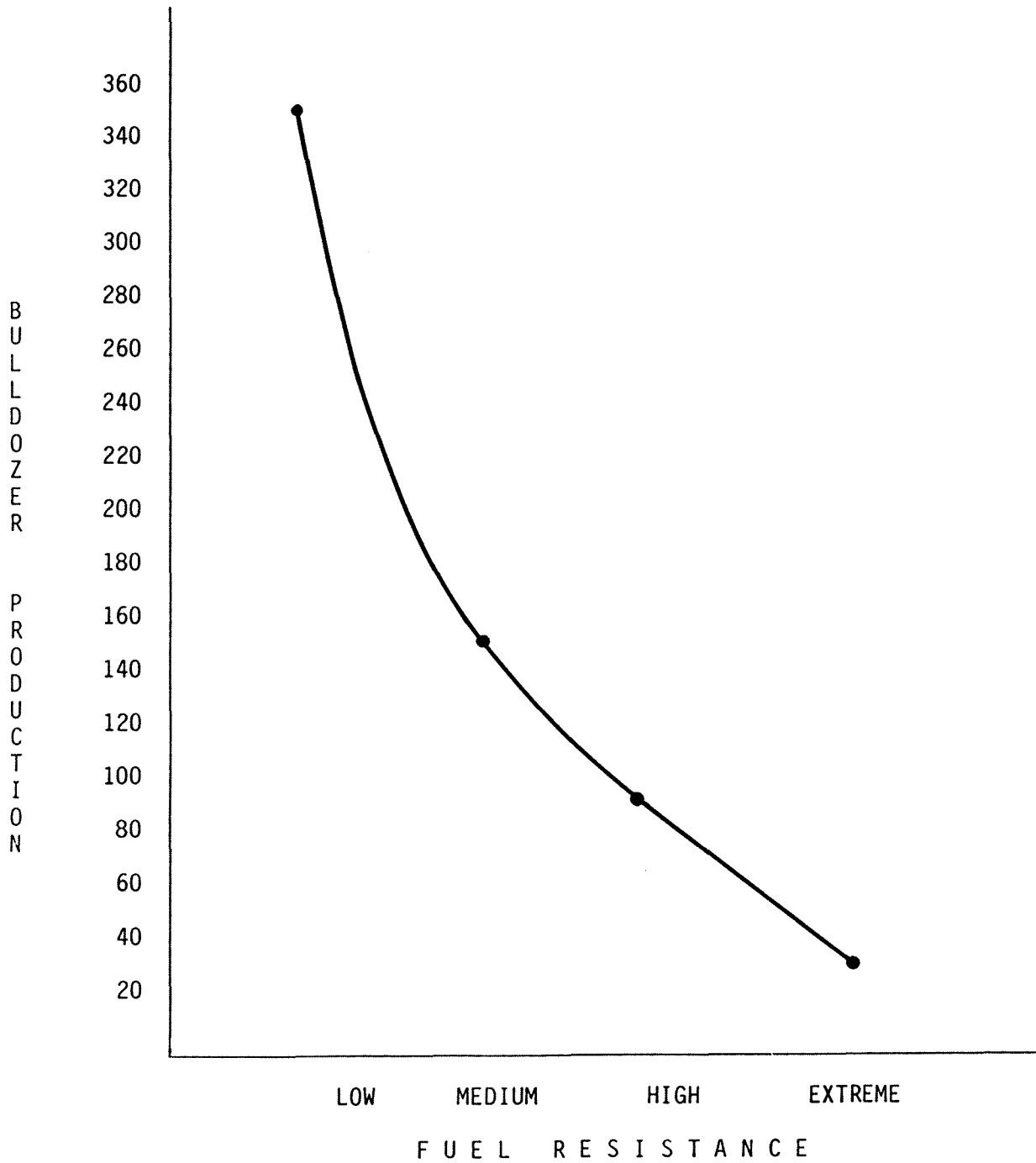


TABLE 5. BULLDOZER FIREGUARD PRODUCTIVITY
(METERS PER 100 NET HORSE POWER HOUR)

1. Basic table rate

DENSITY CLASS	INDEX (METRES)	HEIGHT CLASS	INDEX (METRES)	COVER TYPE	INDEX (METRES)
A	80	1	140	PINE	160
B	40	2	80	ASPEN	60
C	25	3	30	Sw-Frost	40
D	10	4	10	Sw-No-Frost	30
				Sb-Frost	20
	* 30% of Sb-frost rate			Sb-No-Frost	*
	** 150% of original type			Clear Cuts	**

2. Adjustment Factors

- HELISPOT CONSTRUCTION - 1 HOUR PER HELISPOT
- NIGHT TIME - 80% OF DAYTIME RATE
- INITIAL ATTACK - PRODUCTIVE TIME AVERAGES 90% OF TOTAL TIME
- CAMPAIGN FIRES - PRODUCTIVE TIME AVERAGES 70% OF TOTAL TIME
- EXCESSIVE WINDFALL - 75% OF ORIGINAL RATE
- EFFECT OF SLOPE EXPRESSED AS A % OF PRODUCTION ON THE LEVEL

+30	20	10	0	10	20	-30
50%	65%	80%	100%	115%	125%	115%

3. Instructions

CALCULATE PRODUCTIVITY IN METRES PER 100 NET HORSE POWER HOUR BY ADDING THE INDEX VALUES FOR: DENSITY, HEIGHT AND COVER TYPE. THE RATE CAN THEN BE ADJUSTED FOR INITIAL ATTACK, CAMPAIGN FIRES, NIGHT CONSTRUCTION, WINDFALL AND NUMBER OF HELISPOTS.

THE ABOVE INDEX IS BASED ON DOZER UNITS CONSISTING OF 3 PROPERLY SELECTED DOZERS.

4. Example

C2A type: $25 + 80 + 60 = 165$ m
Initial attack: 90% of 165 = 148 m
Night operation: 80% of 148 = 118 m
Windfall, Slope--no effect
*4.8 (horse power) X 118 = 556 m per hr.
1 helispot is required every kilometre:
this unit could complete 371 m per hr. or
approx. 1 kilometre every 3 hr. c/w helispot

*Dozers consist of 2-D6's and 1-D7 or 480 net horse power

1 chain = 20 metres

CHAPTER III—BULLDOZER REQUIREMENTS FOR INDIVIDUAL FOREAL FOREST TYPES

A. FUEL RESISTANCE

1. Black Spruce

Results from the N.F.C. study showed that black spruce (Sb) was usually in the high or extreme resistance to fireguard classes. However, on some spring fires where frost was sufficiently strong to support the weight of the dozers, guard could be constructed quite rapidly through sparse black spruce types, and offered only moderate resistance. Occasionally an adequate line can be constructed through very wet areas by simply walking the dozer across the muskeg with the blade in an upright position; or, by just pushing enough material with the blade to make the dozer spin, leaving deep tracks which usually fill with water.

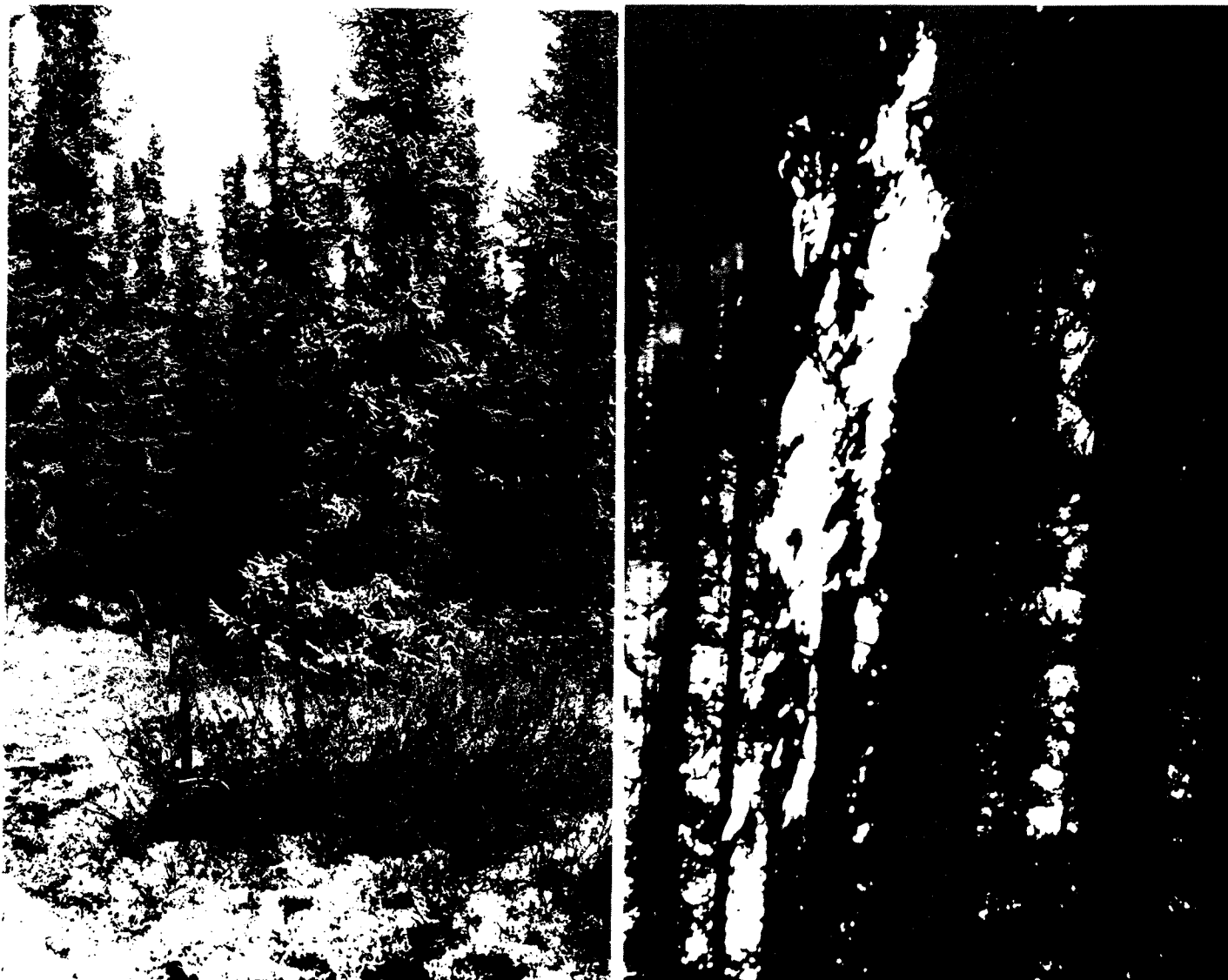
In general, good floatation-type dozers (140-225 H.P.) equipped with wide pads or extended tracks (L.G.P.) are best suited to black spruce and other muskeg types. Most experienced dozer foremen prefer having at least 3 dozers, complete with winches per dozer unit, thus keeping stuck time to a minimum while maintaining acceptable production. It is neither necessary nor practical to remove all organic material under all conditions, as it may exceed thirty or more centimetres. Quite often moisture will seep into the depression, keeping the guard surface adequately wet to prevent fire from burning across the guard. However, if moisture does not mix with the organic layer, a few hours of sunlight may dry out the organic matter enough to allow the fire to cross the guard. It is therefore necessary to have crews patrol such lines.

Sector bosses and dozer foremen must be adaptable when working under adverse conditions and remain open to alternative techniques (Photos 3a,3b). If moisture and soil conditions prevent achieving acceptable dozer guard construction rates, hotspotting crews, bombers, etc. may have to be utilized instead, and usually the dozers are walked around the muskeg to continue guard construction in the next type.

Discretion is urged when crossing muskeg with bulldozers. If frost is not present the normal procedure for taxiing across muskeg types involves travelling quite fast and avoiding unnecessary use of steering clutches to prevent tearing through the rooted surface layer. High speed appears to work well when the muskeg is relatively smooth. Speed should be reduced when going over hummocks to avoid the front end from coming down with sufficient impact to break through the surface. Dozers may be difficult to winch under such circumstances; they are usually suspended from the blade which tends to pull a large amount of material as they are being winched backward. Muskegs should be skirted when possible.

2. SLASH

Data results from the N.F.C. bulldozer study indicate that slash blocks are normally in the low to high "resistance to bulldozer fireguard construction categories". Many of the same resistance factors for the original cover type remain after clear-cutting: such as soil, topographical, and size, density and rooting habits of the original cover type. Stumps are



Photos 3a+3b. Dozer guard is normally difficult to construct in black spruce; as well "torching-out" and crowning can occur at lower fire hazards than other boreal forest cover types.

are difficult to remove for several years after cutting, and usually requires a 200 H.P. lead dozer. Some resistance factors resulting from clear-cutting include: elapsed time since cut, quantity of material left behind, regeneration and secondary growth and the existence of skid trails and roads.

The combination of these factors will dictate the number, size, and types of dozers required. Productivity can be increased substantially by utilizing skid trails, logging roads, landings. Large stumps may have to be avoided to maintain a good production level. Several dozer bosses have mentioned the mistake of assuming clear-cuts are drier than what they actually are. They may be drier than the surrounding stands for a short period in the spring as moisture loss from evaporation increases significantly after removal of the stand; however water loss from transpiration practically ceases after cutting and the overall moisture regime remains similar or wetter than before cutting.

3. ASPEN

Aspen (A) stands are generally considered ideal for suppressing fires as spread is relatively slow and confined to the surface, except for a few days during the spring when leaves are just emerging. Following leaf emergence and "greening up" of minor vegetation, pure aspen stands can often be utilized as a natural fire break, except during periods of extreme fire hazard and/or high winds.

Hotspotting crews can usually contain aspen fires during midsummer without great difficulty. If dozers are present, normally it is easier and less risky to construct a dozer guard through the stand and utilize the men for burning out and patrol on more hazardous types.

Despite the fact that soil conditions are generally quite good for operating dozers, production is normally quite low (table 3). It is usually necessary for the lead dozer to remove a few centimetres of soil to cut the young aspen sapling off. Their flexibility allows them to bend forward as the blade passes over, snapping back to an upright position if some top soil is not also removed. Depth of organic material varies between stands, but is normally from 10 to 15 centimeters (cm).

In comparison to other boreal forest types, mature aspen are hard to push over because of their strong tap root system. A lead dozer, having at least 200 H.P. (net) is recommended. Smaller dozers can create havoc for the clean up dozer, as larger aspen tend to break off above ground level, rather than push over with the stump and roots intact. One cleanup dozer can frequently remove all organic material without great difficulty. In Mature open stands the line locator should consider construction guard around and between large trees where possible, even though the line may be slightly longer.

Aspens crowns structure, frequently results in more problems regarding "hanging up" in the crowns of standing trees. Despite the time factor, these trees must be knocked down as guard construction progresses, for obvious safety reasons. The underbrush common in aspen stands is usually more of a nuisance than a serious resistance factor.

The direct attack method is well suited to most fires burning in aspen types, as fire intensity is usually low and the rate of spread slow. A maximum width of one dozer blade is usually adequate for fires burning in aspen. If sufficient, a narrower guard can be constructed by tilting the blade, resulting in a guard less than one blade width.

4. JACK - LODGEPOLE PINE

Normally, pine (Pj,Pl) types offer less resistance to bulldozer fireline construction than most other major boreal forest types. Most can be pushed over without great difficulty, (with the exception of very large pine) as the sandy sub-soil provides excellent traction; as well, only limited quantities of organic material has to be removed. Non-productive time delays are usually minimal.

Smaller dozers (D6's) are probably large enough even as a lead dozer for immature pine types. However, a D7, or D8 is recommended when very large pine are encountered. If continuous pine types are encountered the dozer foreman may want to take advantage of larger dozers and smaller dozer units (ie. 2 - D8's). In short, young pine stands permit greater versatility when selecting dozer sizes, and types. If low areas or creeks are encountered, a minimum of two dozers should be used.

Young pine types, resulting from recent fires may have a large quantity of windfall which will slow production. "Case hardened" snags also tend to slow production as operators must be alert to avoid broken tops falling onto the dozer. Another safety concern is that flare ups and crown fires can occur quickly and without warning. This may be reason enough to maintain dozer units of at least 2 dozers as people tend to be a bit more relaxed and less apt to panic if an emergency should occur.

Because pine stands normally grow on sandy sub-soil areas, forest officers must be aware of the possibility of erosion gullies occurring. Firelines should not be constructed straight up and down steep slopes. As well, dozer operators may remove more soil than necessary as the duff layer is usually less than eight centimeters in depth.

5. WHITE SPRUCE

White spruce (Sw) stands are normally in the high to extreme "resistance to bulldozer fireline construction" categories (Table 4) depending on height, density, soil condition, moisture regime, and topography. Immature white spruce are pushed over quite easily; mature trees present some difficulty for smaller dozers (D6's). Moisture conditions and depth of organic matter (averaging approx. 15 cm in depth) can vary dramatically from stand to stand and within stands.

The southern and central portions of the boreal forest region is very susceptible to erratic spring fire behavior and occurrence. During this period the presence, or absence, of frost is of utmost importance when predicting productivity or selecting dozers.

A dozer unit consisting of three medium size dozers with good flotation capabilities has been used with excellent results for most boreal forest types. In immature Sw stands, a 150 H.P. lead dozer is adequate, while a 200 H.P. lead dozer is recommended for mature stands. Low ground pressure per unit area, high ground clearance, and high blade lift capability may be of importance when encountering adverse ground conditions. Low ground pressure D7's or equivalents are probably the best for meeting this criteria.

The arrangement of dozers within a unit may be different for various conditions. For example; if a dozer boss has one D7 (LGP) and two D6 wide pads in his possession, the arrangement of dozers may be different for immature and mature Sw stands. Arrangement in immature Sw stands may be D6 lead, D7 second, and D6 cleanup, as opposed to D7 lead followed by the two D6's in mature Sw spruce stands. Unless the dozer boss has extensive fire

experience, the arrangement may be best left to the operators.

CHAPTER IV - BULLDOZER STRATEGY

A. PRE-CONSTRUCTION ANALYSIS

If a fire is to be brought under control, the total fire suppression effort must be successful in containing more fire perimeter than the increase in fire perimeter due to growth of the fire. This difference will ultimately determine how quickly the fire is brought to a "being held" state and consequent final fire size. If the suppression plan includes bulldozer fireline construction, a number of basic questions must be considered:

1. Fireline Location

- a. How close can the guard be constructed to the fire edge? Firelines should be as short as possible, and under normal circumstances be as close to the fire's edge as possible.
- b. Can natural breaks, or previous "manmade" barriers such as seismic lines be utilized?
- c. Where can the line be constructed with the least environmental disruption?
- d. Can topographical features be utilized for subsequent burnout? (ie. crest of hills opposite the fire)
- e. Fireline should be located where the least amount of fuel is added to the fire. Avoid constructing line above a fire on steep slopes.
- f. Could escape routes be put in place instantly at any given time if blowup should occur?

2. NUMBERS, SIZES, AND TYPES OF DOZERS

- a. Determine what the minimum lead dozer horse power requirements for the most difficult forest types.
- b. Are low ground pressure or wide pads required in any types?
- c. The operator of the lead dozer, normally the largest dozer, should have extensive fire and dozer experience as he will be setting the pace for guard construction, as well as, following the line previously marked by the line locator.
- d. Will existing roads, bridges, and terrain support the weight of the desired equipment?

3. REQUIRED WIDTH OF GUARD

- a. Width of fireguard should correlate with expected fire intensity along the guard, whether it be the fire itself, or as a result of burning out.
- b. Fireguard construction should add as little fuel to the fire as possible.
- c. The wider the fireguard, the more debris created which results in less production and more reclamation work.

B. BULLDOZER ATTACK TECHNIQUES

The method, or more often the combination of methods utilized, will depend on present fire behavior, expected fire behavior, and the specific fireline tactics previously mentioned. Normally fires are contained using the direct and parallel techniques; that is, constructing guard around the rear and flanks, eventually pinching in on the fire head, and completing a guard across the head of the fire.

1. DIRECT ATTACK METHOD

"Direct attack" method means literally attacking the fires edge, or constructing guard very close to the edge (within approximately ten metres), in an effort to contain the fire. This type of action is normally restricted to cooler burning fires where heat and smoke are not too intense for the people involved; or it is used on small, hot burning spot fires or sections of fires where further spread must be curtailed at once. The two types of direct attack are distinguished by where the debris is pushed.

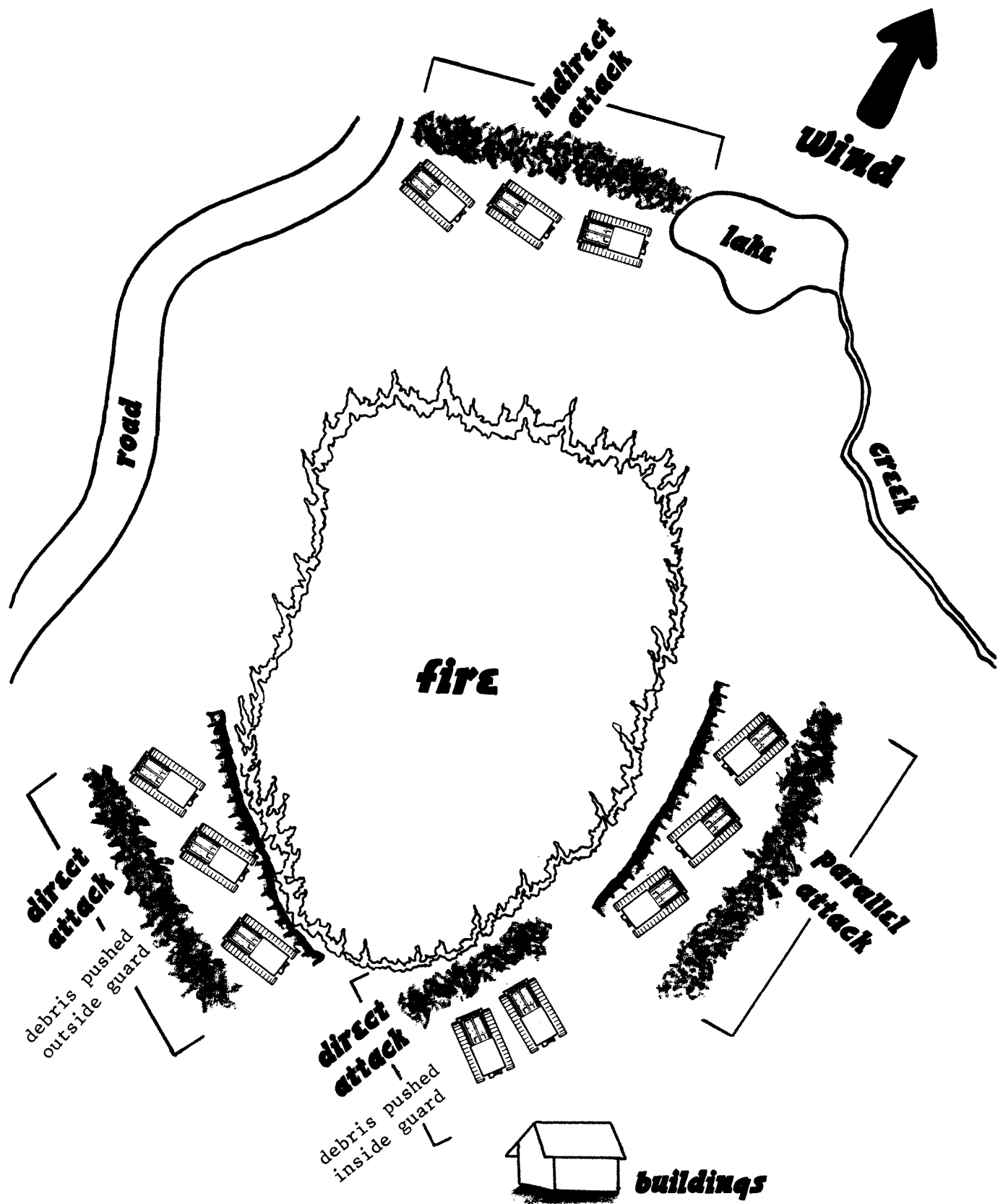
a. Direct Attack-Debris Pushed Towards Fire

This method should only be considered in urgent situations when other methods are deemed impractical, as the addition of debris to the fire increases fire intensity, possibly creating convection columns which may cause spotting, generally complicating both patrol and mop up activities.

Some circumstances where this method could be used effectively are:

- a. small lightning strikes
- b. spot fires outside the fireline
- c. desperate attempt to save buildings or other manmade structures.
- d. a section of fire just about to enter an extremely flammable fuel type

The primary objective is to push all flammable material with as much mineral soil as required to smother flames, and stop spotting.



Attack Methods

In this case the dozer operator works at right angles to the fire, pushing a mixture of non-flammable and flammable material into fire. This method can be supported by helitank action cooling the fire adequately so the dozer can work close to the fire edge.

This technique does accomplish the primary objective of stopping fire spread, however it will require extensive patrol as burning may continue for some days or weeks. The dozed piles eventually have to be torn apart and wetted down.

b. Direct Attack - Debris Pushed Away From Fire

This method of attack is most frequently used in conjunction with the parallel attack method on the cooler, slower moving sections of larger fires. It is commonly used along the rear and flanks of a fire, and can be supported effectively by airtankers and helitankers to cool any hot sections (Photo 6).

When using this technique, the dozer operator works close to the fire, pushing all debris away from the fire. This method requires a concentrated effort on the part of the operators to maintain a distance of several feet from the fire's edge; thus eliminating any chance of burning material being pushed outside the guard. The few metres of unburned fuels between the fire's edge and guard should be burned out.

Dozer operators should break up any larger accumulation of fuel remaining inside the guard so it can be burned out before the heat of the day. The line can also be widened along such sections.

ADVANTAGES OF DIRECT ATTACK:

- a. Because of the limited quantity of fuel between the fire edge and dozer line, the fire has little chance of gaining momentum and spotting across the guard.
- b. Firelines can be kept to minimum width, usually one blade.
- c. Burning out may not be required.
- d. It takes advantage of fire perimeter which has subsided or gone out on its own (Photo 5).
- e. Lesser volumes of timber burned.

DISADVANTAGES OF DIRECT ATTACK:

- a. Because of the irregular shape of a fire, greater lengths of fireguard are required.
- b. A concentrated effort is required to ensure live fire embers are not pushed outside the guard.
- c. Cannot be used on hot-burning fires.
- d. May require airtankers, or helitank support to reduce safety risk.
- e. Efficiency of both men and equipment can be negatively affected by intense smoke and heat.

2. PARALLEL ATTACK METHOD

The parallel attack method is usually used when a fire is considered too hot for direct attack. The guard is therefore constructed a safe distance from, and parallel to, the fire's edge. The fireguard is not tied to the irregularities of the fire perimeter, cutting across bays and fingers results in straighter, shorter line. The distance between the fire's edge and guard, may vary from approx. ten metres to a hundred or more metres. The line locator has more freedom in selecting routes which will present the fewest problems for constructing line, holding the fire, and performing burnout operations.

The parallel method of attack is commonly used in conjunction with direct attack; dozers work along the fire's edge (direct attack) when possible, and move back where conditions become too hot or smokey (parallel attack). The parallel technique is commonly used on fires of moderate intensity, or the rear and flanks of high intensity fires. Because more flammable material is left between the fire's edge and guard than the direct method, the guard may have to be wider, but seldom exceeding more than two blade widths. Distance from fire's edge, and width of guard will depend on expected fire behavior adjacent to the guard.

Organization is somewhat more elaborate than the direct attack requirements. Burning out must be conducted in conjunction with guard construction, or as soon as possible in the morning when line is constructed at night. If burning out is not employed the guard is of little more value than an access trail. Burning out increases the effectiveness of the mineral bared line, with a much wider "burned-over" strip.

Debris should be pushed outside the fireline, with few exceptions. Fireguards are not normally constructed above and ahead of a fire on a steep slope; but when this does occur, debris may have to be pushed to the fire side of the guard. The debris can be covered with mineral soil to reduce fire intensity along the line.

ADVANTAGES OF PARALLEL ATTACK:

- a. It can be used on hotter fires than direct attack.
- b. The length of guard required is less than with direct attack; guard is constructed across bays and fingers, rather than following the irregularities of the fire perimeter.
- c. Men and equipment are not subjected to heat and smoke to the same degree as direct attack.
- d. Parallel attack allows for greater flexibility when dealing with minor environmental concerns.
- e. The line locators can take advantage of natural breaks and less flammable fuel types.
- f. Less timber is usually sacrificed than when using indirect attack method.

DISADVANTAGES OF PARALLEL ATTACK:

- a. Organization is complicated by the fact that burning out becomes an integral part of parallel attack.
- b. Burn out fires can become uncontrollable.
- c. Fire size will be larger than with direct attack.
- d. Parallel attack fails to take advantage of sections that have burned out on their own.

- e. Safety concerns become more relevant as "blow-ups" can occur quickly, resulting in hazardous conditions for men and equipment. Aerial surveillance as well as excellent communication is essential during critical burning periods.

3. INDIRECT ATTACK METHOD

Indirect attack is the "exception rather than the rule", where overhead fire personnel have decided that the chance of other methods succeeding are not great enough to warrant their use, or when the safety of men and equipment is at risk. Indirect attack is normally utilized during periods of high fire hazard, and must include burning out.

Indirect attack is frequently utilized for "frontal action", or potential frontal action, on very hot burning fires. This method involves constructing a guard well back of the fire's edge (usually more than 100 metres), taking advantage of any existing natural barriers and less flammable fuel types (Photo 8). As with most other methods, debris is normally pushed outside the fireline.

This method is complicated by the fact that a comprehensive burning out program must follow line construction. Ignition should not commence until all fireguard has been completed, the conditions favorable, and resources in place. A common ignition pattern for burning out involves burning consecutive strips, starting at the guard, whether natural or manmade. The first line can sometimes be ignited by ground crews while subsequent ignition is normally carried out by using aerial ignition devices (Photo 7).

The actual construction of guard differs little from the parallel method. The backfire may be hotter in which case the guard may have to be slightly wider; greater care must be taken to break up fuel accumulations and provide for escape routes.

ADVANTAGES OF INDIRECT ATTACK:

- a. This method can be used successfully on more intense fires than other methods.
- b. Men and equipment are not affected by heat and smoke from the main fire while constructing guard.
- c. Because of the distance between fire and guard, men and equipment can work more safely on hot burning fires than other methods.
- d. Allows for more flexibility when dealing with environmental aspects.
- e. Length of "man-made" guard can be kept minimal by utilizing natural barriers.
- f. Burning out can take advantage of favorable topography, and less flammable fuel types.
- g. Because of the distance between fireguard and edge of fire, burning out timing is more flexible.

DISADVANTAGES OF INDIRECT ATTACK:

- a. More timber area is sacrificed than with other methods.
- b. Risk of fire escape can be high due to the volume of fuel to be burned out.
- c. Can result in more "mopping-up" if main fire subsides.
- d. All line must be constructed before backfiring.
- e. Escape routes are more critical during indirect attack.
- f. Aerial ignition may be the only viable technique for igniting backfires.



Photo 4. On fast moving fires, indirect attack techniques may be conducted, utilizing existing barriers.



Photo 5. Direct attack methods should be used on slower moving fires since portions of the perimeter may go out on it's own.



Photo 8. Helitankers can frequently cool fires of this intensity
 AIRTANKERS
 consequently, permitting dozers to construct effective guard.



Photo 7. Indirect attack is the only alternative on more intense
 fires.

C. MOP-UP

Regardless of the technique, or combination of techniques used to control fire spread, "mop-up" should progress in conjunction with line construction to ensure the fire has no chance of escaping. The bulk of this work is carried out by ground crews, and for larger fires, involves extinguishing all burning material on a wide strip widening the fireguard. On smaller fires all burning material is extinguished.

Bulldozers and skidders can speed up "mop-up" and increase effectiveness, by breaking up piles of burning material, rolling logs, uprooting burning stumps, and pushing over burning snags, thus allowing ground crews to extinguish any smoldering material. In some cases smoldering material is buried in mineral soil.

Skidders perform similar functions as dozers during "mop-up", but can travel much faster, are more versatile, and can be mounted with a watertank. In areas with limited water supplies, one skidder may do the work of 10 or more men.

CHAPTER V - FUNDAMENTAL STANDARDS FOR CONSTRUCTING DOZERGUAARD

As with any other suppression technique, certain criteria must be met to ensure utmost success of the operation, while maintaining high safety standards at all times. Dozers are not a solution by themselves, but must be properly supervised and integrated with other methods and techniques to be effective. Where applicable, burning out and patrol should be part of any dozerguard construction operation.

A. DOZERGUAARD WIDTH

The width of a fireguard should correlate to fire behavior expected along that line, whether it be the actual fire or a result of burning out. There is a tendency to substitute extra width for the proper integration of techniques (Photo 8). A dozerguard, one or two blades wide, reinforced by other means, is usually more effective than wider guards; and requires less restoration work.

Some common methods for reinforcing dozerguard are:

1. Men with hand tools.
2. Pump crews.
3. Tanked skidders or tracked vehicles accompanied by pump crews.
4. Helitankers or airtankers.
5. Burnout crews.
6. Treatment of unburned fuels inside the guard (walking down trees adjacent to the guard).

Dozerguard width can be minimized by incorporating one or more of the techniques listed above. This approach has proven to be more effective for subduing fire spread, and creates less environmental damage than wide guard with no reinforcement. The presence of an excessively wide guard is generally an indication of lack of responsible supervision, availability of the required support, lack of knowledge regarding the use of bulldozers, or the failure of fire overhead staff to utilize proper suppression techniques (Photo 8). **RULE OF THUMB: CONSTRUCT THE NARROWEST GUARD UTILIZING AVAILABLE TOOLS, TACTICS, AND TECHNIQUES THAT WILL STOP FIRE SPREAD.**

Some of the factors which will dictate guard width are:

1. Short, sparse stands do not generally require as wide a guard as taller, more dense stands of the same species.
2. Fuel arrangement will dictate the width of guard:
 - a.) Black spruce usually has a combination of moss and dead branches from near the ground surface to the living crown and is ideal for promoting torching out or crown fires.
 - b.) Concentration of heavy fuels which generate intense radiant heat.
3. Tree species and age will affect fire behavior:
 - a.) Immature pine and white spruce are relatively fire resistant.
 - b.) Black spruce stands are very volatile and will promote rapid fire spread even under moderate fire hazard conditions.
 - c.) Aspen stands can often be used as a fuel break after "greenup". Crown fires are very rare but can occur when leaves are just emerging.



Photo 8. Excessively wide guards are generally less effective than reinforced narrower guards.



Photo 9. Fuel accumulations adjacent guards should be broken up and spread out prior to "burning out".

4. Current or forecasted weather factors.
 - a.) Increasing temperatures and decreasing relative humidity will increase fire intensity.
 - b.) Changes in wind direction and higher speed may affect desired guard width.
5. Topography
 - a.) Fires burn faster and with more intensity up-hill than fires burning downhill.
6. Availability of additional forces to reinforce the guard and time required to have them in place.
 - a.) Can the guard be reinforced before the fire arrives or should the dozers construct a wider guard?
7. Environmental Impact
 - a.) What technique or combination of techniques would subdue fire spread with the least environmental damage?

B. FIREGUARD DEPTH

The purpose of any fireguard is to provide a fuel break, thus stopping any further fire spread. In the case of manmade guards all combustible materials must be removed, which usually means constructing the guard down to mineral soil. Some important factors regarding this practice are:

1. A properly constructed fireguard virtually eliminates the possibility of a fire burning across the line.
2. Caution must be exercised to insure all roots have been severed as this is also a potential fire route, especially in black spruce stands during extended periods of drought.
3. In some cases such as muskeg types, it may be impractical and unnecessary to construct the guard down to mineral soil. Under these conditions, all flammable material must be removed to an unburnable fuel; or an unburnable fuel must be created in one of the following ways:
 - a.) A guard constructed to the frost layer is effective until the frost thaws and the organic layer dries out.
 - b.) In deep duff areas, a manmade "non-combustible" layer can be made by letting water seep into the guard or by wetting down the organic matter with power pumps.
 - c.) In some cases, an adequate fire break can be made with a dozer just pushing enough material to cause it to make ruts which will fill with water.

C. AVOIDANCE OF ADDING FUEL TO THE FIRE

When constructing fireguards either by crews or dozers, it is generally accepted that **ALL UNBURNED FLAMMABLE MATERIAL SHOULD BE PUSHED AWAY FROM THE FIRE**. This is extremely important when constructing dozer guard because of the volume of material being removed and will have a direct bearing on the effectiveness of the guard, as well as the effort required to subdue fire spread. Some considerations include:

1. Removing flammable fuel reduces the possibility of the fire gaining adequate momentum and intensity to spot across the guard, or cause fires on the opposite side of the line through heat radiation.
2. It reduces the quantity of fuel with the potential to burn, thus reducing manpower, equipment and time requirements so a successful burn-out can take place with less risk to men and equipment.
3. It reduces the possibility of fire getting into the resulting mixture of dirt, wood, duff, and other debris, reducing the time effort required to extinguish the fire. Such fires may smoulder unnoticed for days or weeks and erupt with disastrous consequences.
4. Reclamation work is not delayed by crews having to extinguish these fires.

THERE ARE CIRCUMSTANCES WHEN IT IS ACCEPTABLE TO PUSH DEBRIS TO THE FIRE SIDE OF THE GUARD. Such as the following:

1. The degree of side slope may make pushing the debris uphill impractical. In these cases the debris may be pushed toward the fire, but an effort should be made to minimize the quantity of material pushed toward the fire. This can be accomplished by working on the edge of the fire if possible.
2. Any material that is burning or has burned previously should be pushed into the fire as a precautionary measure.
3. Fires may burn for a distance of several metres along black spruce roots. If the parallel method is used the fire may never reach the guard and if the direct method is utilized burning roots may be pushed outside the guard. If these fires occur in the fall it may be necessary to push debris towards the fire side, with the hope of containing the fire until snowfall when the piles can be broke up and spread.

D. USE OF NATURAL BREAKS AND BARRIERS

Fire overhead personnel must continually analyze their existing strategies to insure the fastest, most effective guard building programs are in place, creating the least amount of environmental damage. Dozer foremen must therefore be kept aware of any natural firebreak which can be utilized (Photos 10a, 10b). The effectiveness of these barriers will depend on the type and size of the barrier, and the intensity of the fire. Narrow creeks or wet areas may be effective for stopping low intensity fires; while, even rivers or lakes may not be effective for stopping intense fires, which have been known to spot for distances of several kilometres from the main fire. Poplar stands are effective for low and moderate hazard situations for the period following leaf emergence, and before fuels "cure" in the fall (Photo 11). Lakes, rivers, roads and creeks are effective if their size is adequate.



Photos 10a+10b. "Burning-out can be conducted from manmade guards or natural barriers(10a), but should be supported by helitanker, airtanker or crews, to suppress spotfires(10b).



Photo 11. Fire suppression personnel are urged to take advantage of less flammable fuel types.

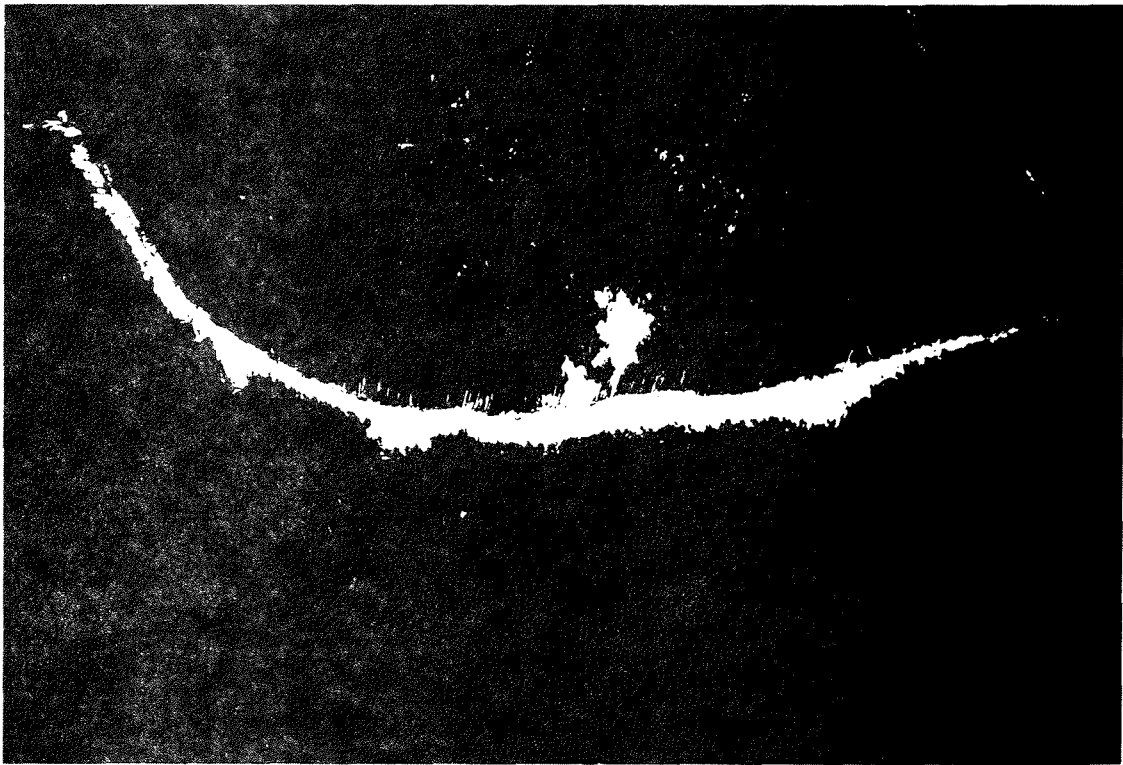


Photo 12. "Burning-out" should be completed before the heat of the day on "highly constructed guard".

Pipeline, powerline, and seismic right of ways, as well as cutlines and swamps can frequently be utilized in part. The duff layer may have to be removed or the barrier can sometimes be reinforced with power pumps, handtool crews or aircraft. By recognizing and utilizing such barriers, suppression efforts are accelerated, often with minimal environmental impact, and allowing the dozer boss to concentrate on priority areas or further line construction.

E. CONSTRUCTING DOZERGUAARD AT NIGHT

ADVANTAGES AND DISADVANTAGES OF TWO SHIFTS

The most effective time for fighting fires is often lost due to the reluctance of overhead personnel to initiate a night shift or when safety precautionary measures can not be put in place. If two shifts are not part of the suppression strategy, the dark hours plus several daylight hours are usually jeopardized for a number of reasons:

- a. Personnel cannot and should not be expected to work the entire daylight span during the spring or summer months.
- b. The first few hours of daylight, as well as the last hour or two before dark, is often lost, due to organizing and transporting crews.

As all reasonable effort must be put in place to bring a fire under control, advantages of running two shifts cannot be overlooked. Some reasons include:

- a. In many cases the only effective dozerguard is the result of night or early morning construction.
- b. It may also be the only period during the day that guards can be safely constructed along the flanks and head of the fire due to the fact that fires usually burn with less intensity during this period.
- c. Even if night construction is slower, the dozers should be in full production at the break of day.
- d. Accident frequency increases significantly when shifts exceed ten hours. When running one shift, the tendency is to exceed this limit more dramatically than when running two shifts.
- e. Smoke and heat are usually less intense during the night and early morning, allowing dozers to work closer to the fire's edge.
- f. Guard constructed at night should be "burned out" or reinforced prior to the peak late afternoon burning period (Photo 12).
- g. Worker morale is usually more positive when working shorter shifts.

The principle of constructing fireguard around the clock does not go without some negative aspects. Some examples are:

- a. Organization and safety programs must be more elaborate.
- b. Guard construction is generally slower at night.
- c. Locating line is very demanding and difficult at night.
- d. Some dozer operators become disoriented at night and should not be persuaded to work this shift if they are hesitant.
- e. Dozerguard construction at night can be more dangerous even with all reasonable safety measures in place. For example, conditions may be such, that fire behavior remains or becomes very erratic. "Walking down" trees is dangerous, especially if snags are present, and should be done during daylight if possible.

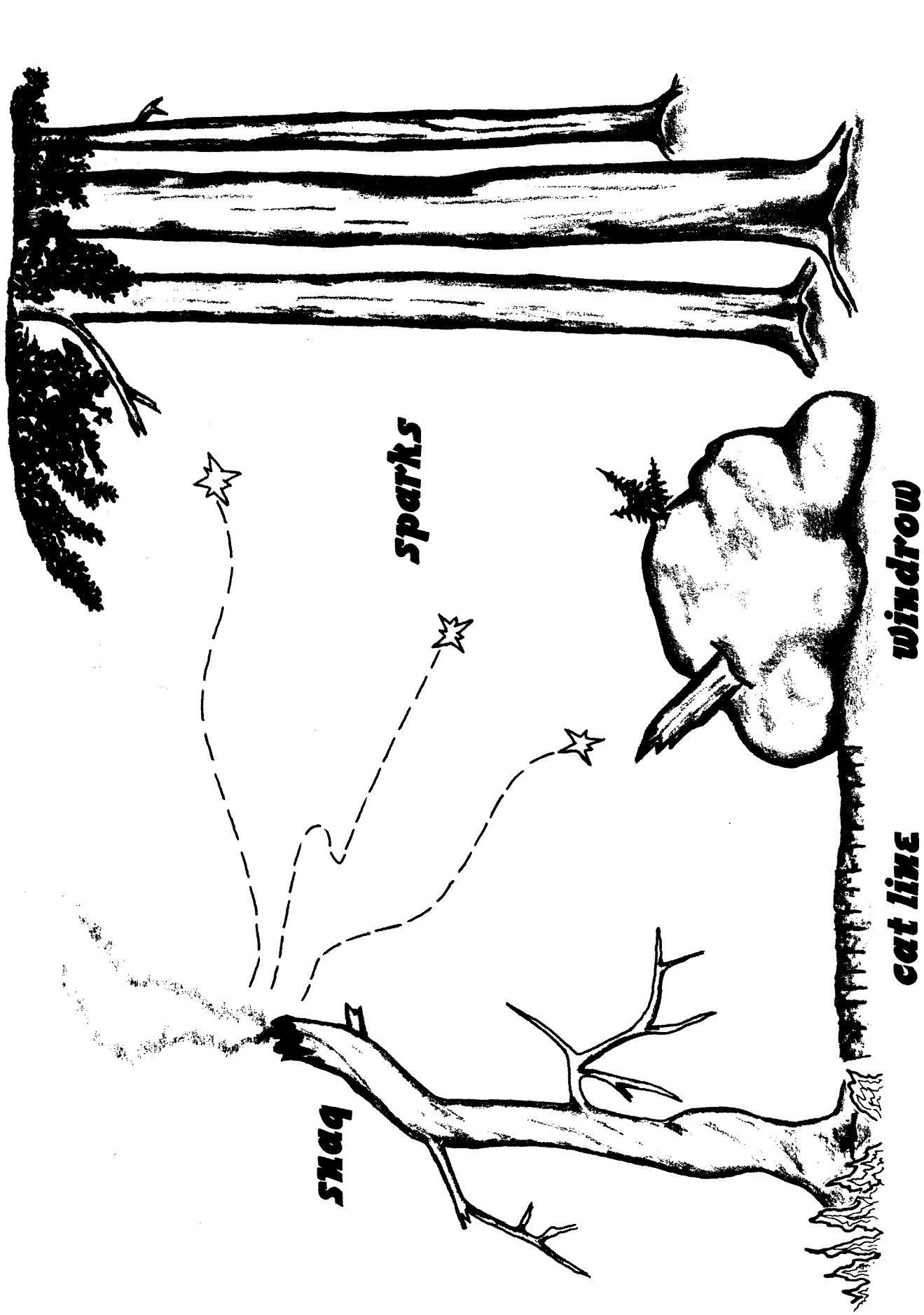
1. Guidelines for Dozerguard Construction at Night

Dozerguard construction at night should only be carried out in accordance with agency policy and safety standards. A number of guidelines have been suggested by forestry personnel, dozer operators, and contractors, for the purpose of increasing both safety and effectiveness of a night operation. Ambiguity prevails when dealing with individual fires, thus this list only covers some major concerns:

- a. Dozers should never be allowed to work at night without proper supervision and safety considerations in place.
- b. The dozer foreman should have radio contact with someone in camp in case an accident does occur.
- c. The sector boss should be aware of available helicopter pilots licensed for night flights, should a rescue mission be necessary.
- d. Both line locator and dozer boss should be equipped with communications kit and good halogen or seal beam flashlights.
- e. Flashlight signals must be established with the lead dozer operator prior to construction.
- f. Shift change - The line locator may want to be dropped off during the evening at the location where he feels the dozer operators are capable of constructing guard during the night-shift. He can then locate and mark line back to the dozers.
- g. Key areas should be marked and crews brought to creek and pipeline crossings to provide assistance.
- h. Because walking down trees is the most dangerous aspect of night dozerguard construction, there are advantages to locating line and walking down timber prior to dark, so this aspect of the operation does not take place during the night.
- i. Shift changes should take place two or three hours before darkness to allow the dozer team adequate time to familiarize themselves with the terrain and the fire.
- j. If the dozer team is being dropped off by helicopter, a flight over the work area will provide the dozer team with a better idea of what to expect during their shift. Areas of concern should be noted and possibly marked at this time.
- k. A proper job of locating line can not be done while riding on the lead bulldozer. This procedure also exerts unnecessary pressure on the dozer operators, who should not be expected to be responsible for the safety of a passenger.
- l. Helispots should be constructed frequently in case anyone should have to be removed during the night.
- m. Night dozerguard construction should only be carried out in accordance with existing safety programs. Some safety factors are covered in Chapter VIII of this report.

F. REINFORCING DOZERGUARD WITH DOZERS

If suppression personnel are to be successful in their attempts to bring a fire under control, they must be as adaptable as the fire is unpredictable. Concentrated unburned fuel remaining between the guard and fire, safety consideration, changes in fire behavior or weather variation, may dictate a change in strategy. Guards constructed at night or other hastily constructed guards may have to be reinforced by one or more of the following:



Chimney fire

- a. Guards may have to be deepened if all combustible material was not previously removed.
- b. Guard may have to be widened to contain the actual fire or to accommodate burning out operations (Photo 15).
- c. Unburned accumulations of fuel may have to be broken up and spread out.
- d. Trees which have fallen across the line, or are likely to fall across may have to be removed.
- e. If a crowning potential exists, trees may be walked down inside the guard. Black spruce stands and stands having a balsam fir understory are very susceptible to crowning because of the "laddering" type fuel arrangement. By removing aerial fuels the fire is confined to the surface. This technique is very effective if the ground is moist as the branches will absorb some of this moisture and become more fire resistant.

G. DOZERS AS AN INTEGRATED TOOL

Obviously, no suppression technique is totally effective on its own for a wide range of conditions (Photo 13). To achieve safety, as well as environmental and fire suppression objectives, dozer units may have to precede, succeed or be interchanged with other tactics such as the following:

1. FIRE CREWS

Fire crews can increase the effectiveness and speed of a dozer operation in several ways:

- a. Clean-up, burnout, and patrol crews should be an integral part of any dozer unit.
- b. Fire crews should be considered when encountering steep banks along coulees, creeks, or rivers. If handtool, powerpump, or hotspotting crews can be utilized to stop the fire in such areas, both environmental damage and restoration costs will be minimal compared to dozer guard construction.
- c. Crews should be placed ahead of the dozer unit when creek or pipeline crossings are required, ensuring completion prior to the arrival of the dozers.
- d. Fire crews should be considered when encountering soil and moisture conditions which may have an adverse effect on dozer guard productivity.
- e. Crews can be used to strengthen the guard along key problem areas.

Although manuals for other forested areas advise that chain saw crews be placed ahead of the dozer to buck windfalls and other duties preparation of the dozer unit; the general consensus among fire personnel is that any dozer not capable of breaking trees common to the boreal forest is not worthy of hire.

2. HELITANKERS

Helitankers have proven to be extremely valuable for cooling hot spots ahead of the dozers, allowing the dozers to work closer to the fire's edge than would otherwise be possible. They are also useful as a support tool behind the dozer unit for cooling flare-ups and to hold any spot fires across the line.



Photo 13. The common result of guard not properly reinforced or where burning-out was neglected.

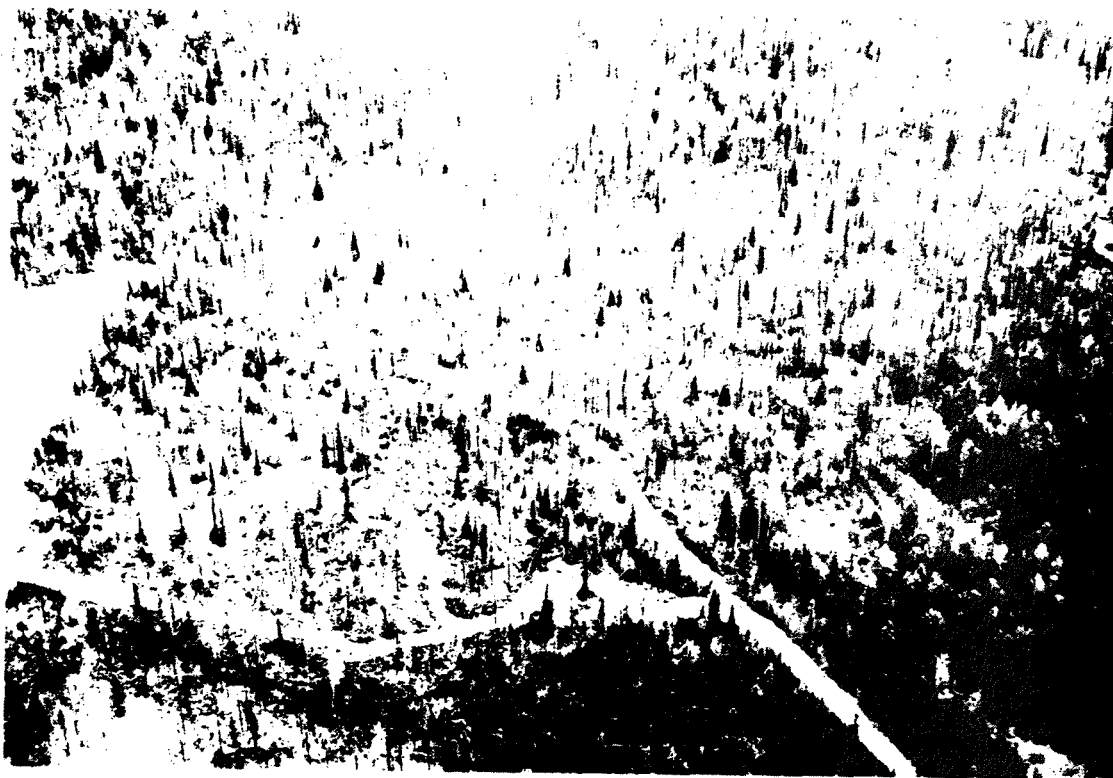


Photo 14. An effective guard reinforced with airtanker action.



Photo 15. Dozers reinforcing previously constructed guard prior to burning out.



Photo 16. Tanked skidders have proven very beneficial for reinforcing existing guard and to enhance mop-up activities.

Helitankers hover when making a drop and can therefore work very close to the dozers or crews without creating a safety hazard to the men below. When working in close proximity to men and equipment, helicopter pilots are usually in the position to notice any changes in fire behavior and can keep ground personnel posted.

Helicopters equipped with aerial ignition devices now enable suppression agencies to backfire and burnout areas which would be considered unsafe for ground ignition.

3. AIRTANKERS

Fixed winged aircraft are frequently utilized to cool hot spots or flare-ups on the fires edge, enabling dozers to work closer to the fire perimeter (Photo 14). They can not work as close to men and equipment as helicopters can without creating a safety hazard. Therefore all precautionary safety considerations must be followed.

4. SKIDDERS

Although skidders are occasionally utilized to construct limited quantities of fireguard, their main functions are in the area of support. They are sometimes used for initial attack on smaller fires in light fuel types. One advantage of skidders over dozers is that skidders require much less time to get to a problem area. Skidder mounted water tanks can increase the effectiveness of direct attack crews and mop-up crews significantly (Photo 16).

Skidders are particularly valuable for supplying water and dozing out smoldering material during mop-up. Water tanks can be mounted without sacrificing winching capabilities.

Care should be taken to ensure skidder tires do not catch fire as they are extremely difficult to extinguish.

5. WATER TRUCKS, NODWELLS, HILDEBRANDTS, ETC.

A wide range of equipment has been used successfully to support one technique or another as a means of transporting men, equipment, and water.

H. HELISPOT CONSTRUCTION

The wide scale use of helicopters is a result of their versatility and the ability to integrate them into a range of suppression modes. Because of the costs, ranging from \$300 to \$1800 plus fuel per hour, an all out effort must be made to ensure the best possible return on this investment.

In many instances, helicopters can land in natural openings or previously constructed openings such as roads, seismic lines. Otherwise, the dozer foreman must assume the role of making sure an adequate number of well constructed helispots are available to utilize the helicopters efficiently. The following points are suggested prior to the actual construction.

1. Helispots should be located and constructed during initial guard construction rather than having the dozer backtrack at some later time.
2. Helispots are normally located at intervals of one to two kilometre.
3. Natural clearings or short cover types should be utilized whenever possible. Helispots constructed in tall timber types must be larger, takes longer to construct and result in a waste of timber.
4. Drier areas are preferable over wetter sites.

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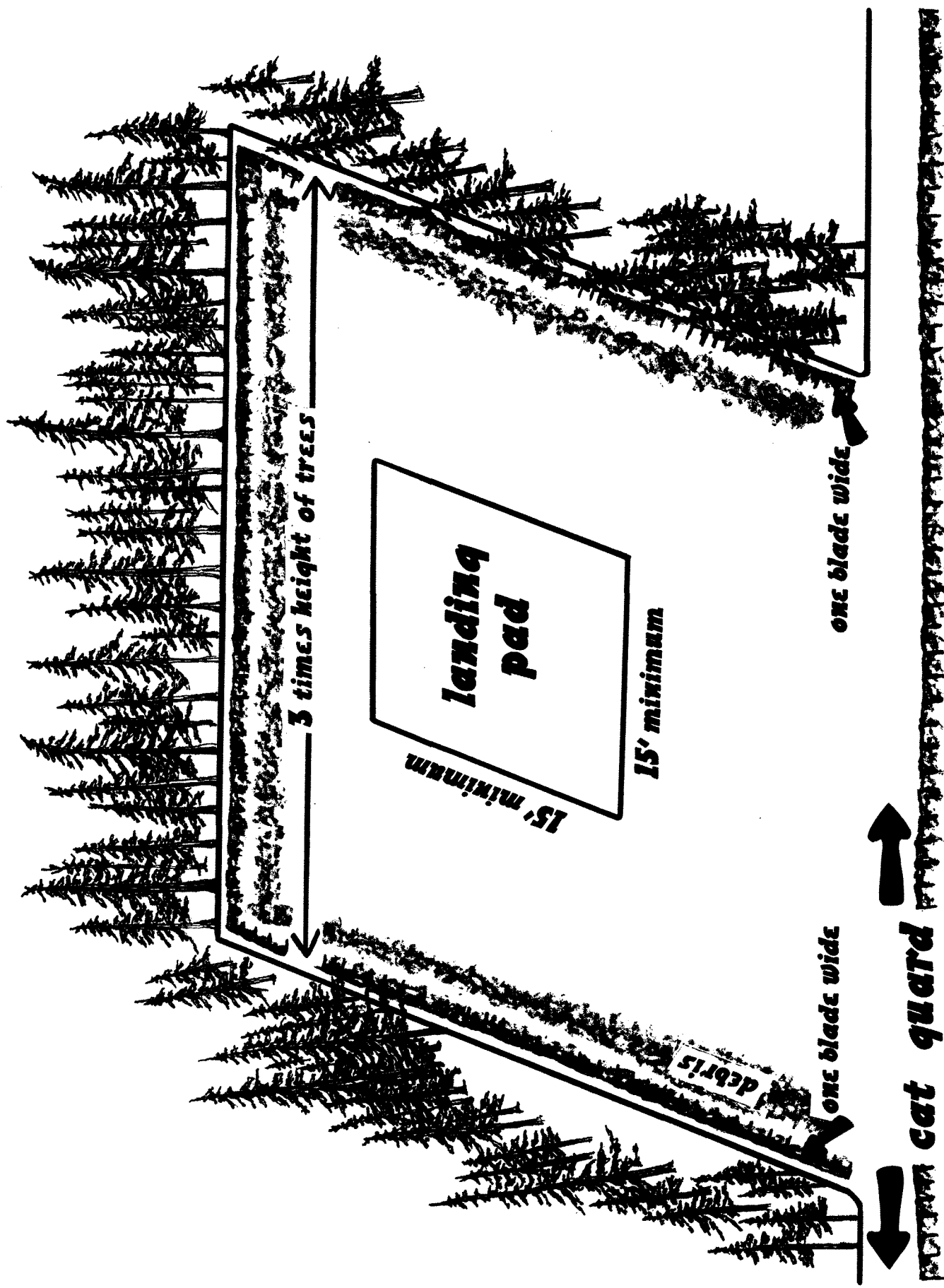
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4. Drier areas are preferable over wetter sites.

5. Consider the topography and locate the helispot on the site which will best facilitate landing and lift-off.

Certain specifications must be met to ensure safe usage by the helicopters. Some important factors include:

1. The size of the helispot should be relative to the size of helicopters which will be using it. If the timber is less than 10 metres in height, the helispot should be a minimum of 23 metres square. If the timber exceeds a height of 10 metres, the minimum acceptable diameter is 2.5 times the height of the trees.
2. When piling debris from the helispot, a minimum width of one dozer blade must be left between debris piles and standing timber. This practice will simplify reclamation work as all debris must then be scattered over the clearing.
3. Debris capable of becoming entangled in the helicopter skids or rotor blades should be removed from the site.
4. On uneven terrain, the pad should be located as high as possible and the slope should not exceed two per cent. The actual pad should be approximately 10 metres square.



Helispot Construction

CHAPTER VI - MAXIMIZING BULLDOZER PRODUCTIVITY

A. PRODUCTIVE TIME VERSUS NON-PRODUCTIVE TIME

During the Northern Forestry Centre bulldozer productivity study, non-productive time varied from fire to fire, depending on fire behavior, duration of fire, and dozer unit organization. Productive time averaged sixty percent of total time over all campaign fires. On smaller fires and initial attack situations, productive time was obviously much higher, although a reliable figure could not be established due to insufficient data. Non-productive time included the following:

1. Dozers waiting for other machines arrive prior to the unit being dispatched.
2. Stoppage of guard construction when unsafe to continue.
3. Stuck time.
4. Normal servicing.
5. Mechanical malfunctions.
6. Waiting for line to be located.
7. Any other stoppage in guard or helispot construction whether avoidable or unavoidable.

Most non-productive time was considered unavoidable as maintenance, servicing, line locating, stuck dozers, and mechanical malfunctions are inevitable. Safety of people must take precedence over all suppression objectives, regardless of the circumstance. Non-productive time can however, be reduced by complying with some very basic standards:

1. Hire dozers in good mechanical condition, owned and operated by reputable people or firms.
2. Hire the best dozer for the job. Low ground pressure dozers have proven very effective in most boreal forest types when horse power requirements have been met. If steep slopes are to be encountered and moisture and soil conditions permit, standard gauge tracks will provide better traction.
3. The number of dozers per unit should not exceed three, unless circumstances warrant. When dozer units become too large, operators have difficulty distributing the work load.
4. A qualified dozer foreman should be assigned to supervise the activities of each dozer unit. Line locators, swampers, cleanup and burnout crews are an integral part of most dozer guard operations. When one aspect of the unit is not properly supervised the entire operation may be jeopardized.
5. When running a night shift, it is preferable to walk down the line prior to darkness. However, if this is not possible, make sure the line is well marked so dozer operators do not become lost.
6. Directions must be related through the proper channels. Dozer operators are often confused by conflicting instructions from several different sources.
7. Integrate other techniques. Don't waste time on short sections of line which could be contained more efficiently by employing other methods.
8. The hiring of personnel from the private sector for positions such as dozer foreman and line locator has proven very beneficial.

However, it is recommended that such personnel not be assigned to dozer units with which they are employed.

9. During the transporting of dozers to the fire and mobilizing dozer units, there may be a time lag of several hours between the arrival of the first and last dozer within a particular unit. Under normal circumstances dozers should commence guard construction as soon as possible, and not wait for the entire unit to arrive. The late arrivals can catch up.
10. Operators refusing to follow directions and safety practices must be replaced.
11. A concentrated effort to preserve employee morale is essential if high productivity levels are to be maintained.

There are also instances when dozers are working, but to no avail. For example, lines may have been unnecessarily wide, too much mineral soil may have been removed, or guard may have been constructed around bays and fire fingers. These instances occur most frequently when dozer units become too large or are not properly supervise.

By following the preceding recommendations, productive time could probably be increased to a minimum of 70% and 90% respectively for campaign fires and initial attack situations.

B. Morale

Maintaining good employee morale may be the single most important factor in sustaining acceptable production levels, especially on a campaign fire. It is hoped that greater awareness of the concerns of all participants will translate into greater productivity. Related concerns include:

1. Dozer operators hired in late afternoon or evening should not be expected to work through the first night of a fire. This practice should take place only if the operator willingly agrees. It may be more practical to replace the day-shift operator 2-3 hours before dark so that night operators have adequate time to familiarize himself with the fire.
2. Dozer operators sometimes do not know when a shift will end. Worse than not knowing, is being told the time of shift-end, and then having the shift extended without being consulted.
3. Include dozer operators in any decision making, if possible.
4. Consider 2-ten or twelve-hour shifts on extra period fires, instead of one longer shift.
5. When running one shift, dozer operators are often the first to leave camp in the morning, and the last to return at night. Make sure supper has been prepared and is ready for them upon their arrival back at camp.
6. If over-hiring does occur, there must be reasonable compensation for those dozers with little or no operating time. It should not be too generous, but must cover the owner's expenses.
7. Under normal circumstances, dozer operators should not be worked for longer periods than they feel good about. Efficiency drops and accident frequency increases when shifts exceed 10 hours.
8. Consult dozer operators when scheduling a night shift. Some operators prefer working at night, while others do not some can not keep their directions straight and become disorientated in the dark.

CHAPTER VII - ENVIRONMENTAL IMPACT OF DOZER AND FIREGUARD RECLAMATION

A. RECLAMATION CONSIDERATIONS PRIOR TO DOZERGWARD CONSTRUCTION

Bulldozers should only be used only in areas that can be restored to their near natural state at a reasonable price. Overuse will result in restrictions being placed on the entire concept of dozers as an alternate suppression technique. Fortunately the boreal forest is generally not as susceptible to irreparable environmental damage as other forest regions.

Some of the old misconceptions, such as the wider the guard the better, have been laid to rest as a result of greater concern regarding the environment. In recent years, fire overhead teams have had to become more versatile and resourceful by integrating techniques that cope with modern ideology.

The construction of fireguards using bulldozers has generally been very effective in containing and controlling fires. However, massive reclamation may be required if environmental considerations do not play a major role in the initial decision making process. When attempting to bring a fire under control, decisions regarding line location and type of line may be primarily based on fire suppression effectiveness rather than potential erosion or reclamation problems and solutions.

Erosion and sedimentation as a result of dozerguard construction depends on soil particle size and shape of the surface. Fine-grained soils such as clay and silt are extremely unstable and very erodible. Coarse-grained gravelly soils are much more stable and less vulnerable to erosion. Specific efforts are therefore required to control erosion, prevent stream siltation, and encourage revegetation.

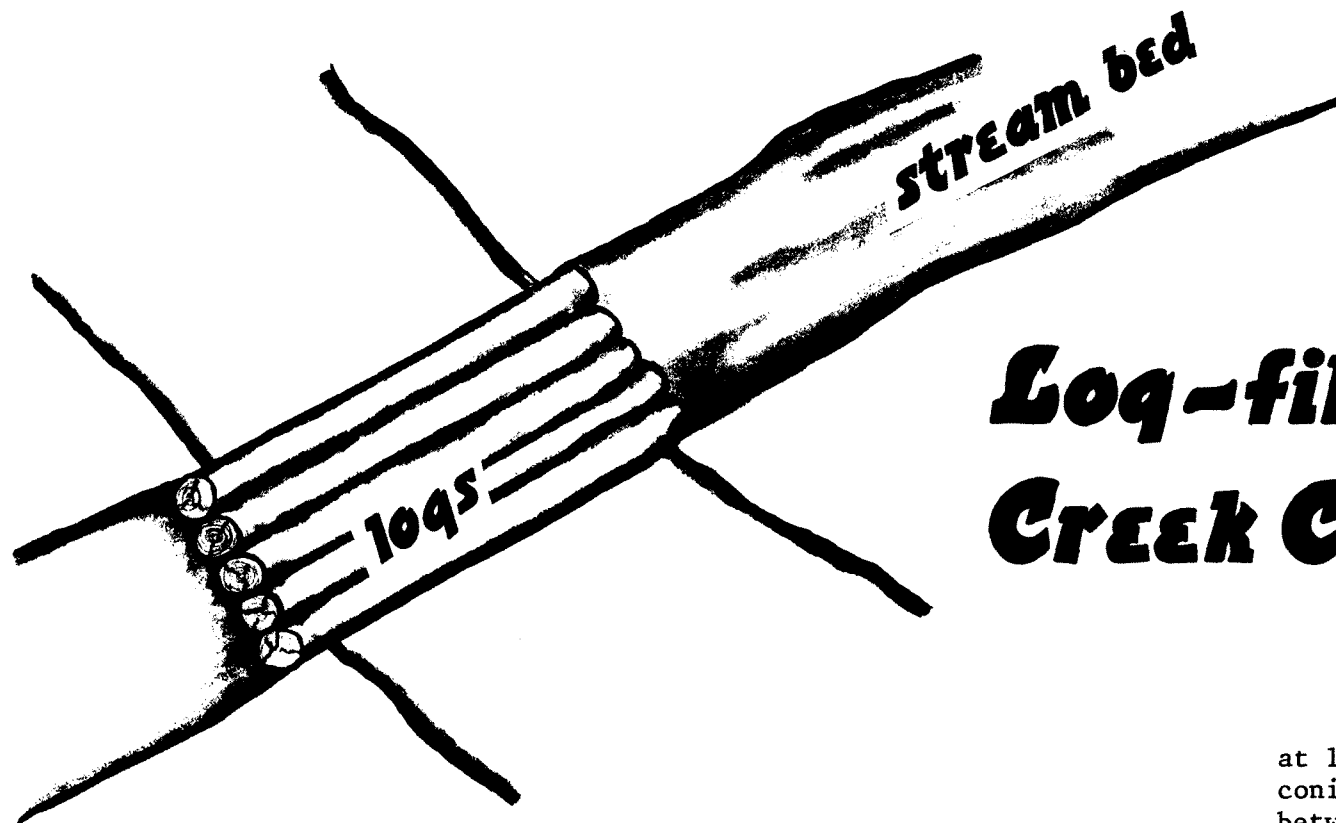
Reclamation considerations must be a contributing factor to any decision regarding fire suppression tactics from the onset of any fire. This decision will not only be crucial as to the time required and the cost of extinguishing the fire, but also to effort and expense of restoring the area.

Personnel must keep in mind the final objectives of post fire reclamation when locating and monitoring dozerguard construction. Adaptability and strict co-ordination of suppression activities will aid in achieving the following objectives:

- 1 Blend dozerguards into the original land form.
- 2 Restore the original drainage pattern.
- 3 Restore or improve the original level of productivity.
- 4 Re-established a self-sustaining cover of vegetation consistent with that of the surrounding area to stabilized the disturbed soil and minimize erosion.

By adhering to some basic ground rules and avoiding situations detrimental to restoring dozerguard, the above objectives can be achieved with less effort. Some basic considerations include:

1. Dozerguards should not be constructed straight up or down steep slopes. If soils are not susceptible to erosion, the guard may be angled up or down slope. On more sensitive areas alternative suppression techniques may have to be put in place.

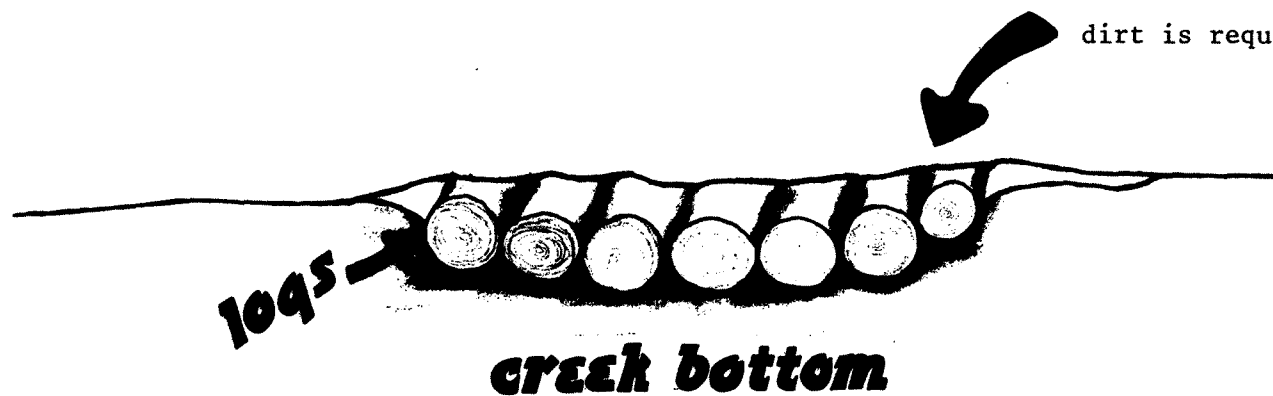


Log-fill

Creek Crossing

at least 0.4m of
coniferous boughs layed
between if logs and dirt

dirt is required over logs



2. Repeated vehicular traffic frequently results in depressions which can cause erosion gullies. Dozer operators should be advised of this potential damage. Alternate routes may have to be established if other measures prove ineffective.
3. When possible dozerguards should not be located on or near unstable areas, springs and seepages.
4. Stream crossings are best located:
 - a. at right angles to the stream,
 - b. at a narrow point along the watercourse,
 - c. at locations where channels are well defined, unobstructed and straight,
 - d. at stable approaches.
5. If alternative suppression methods can be used, avoid constructing dozerguards within:
 - a. 100 m of the highwater mark of any permanent watercourse
 - b. 30 m of any intermittent watercourse, and
 - c. ephemeral draws.
6. Log fills should be used when crossing streams rather than dirt fills only if the following guidelines are observed:
 - a. crossing intermittent and ephemeral streams when fish passage is not required or when the stream channel is dry.
 - b. The flow of water is not unduly obstructed and any back-flooding is restricted to the stream channel.
 - c. The logs can be bundled together to allow for easy placement and removal.
 - d. De-limbed and lopped logs, free of stumps should not exceed either side of the running surface by more than 1.5 meters.
 - e. if soil is placed on top of the log bundle to facilitate vehicle use it should be separated from the logs with a synthetic mat or 0.4 meters of coniferous boughs.
 - f. Log fills are to be removed upon crossing the stream if unforeseen problems arise such as flooding etc., or in any event, prior to dozers leaving the immediate area.
7. Fords are acceptable crossings provided the following guidelines are observed:
 - a. The stream bank has a firm rock or coarse gravel bottom and stable approaches capable of standing up to dozer traffic.
 - b. Fisheries or water users downstream are not critical factors.
 - c. Improvement to the crossing should be limited to removal of large boulders or debris from the stream within the right-of-way which would interfere with vehicle passage.
 - d. Access to the ford is not on the outside of any bend in the watercourse.
 - e. The number of crossings are kept to a minimum.

B. DOZERGUAARD RESTORATION

Upon the fire being brought to a "being held " status, timber management and land use personnel should be notified so that restoration work and salvage operations can be coordinated. A restoration plan should be put in place and an adequate number of dozers retained to carry out such plans. Abandonment of fire guard should include:

1. Removal of any log fills used for crossing streams.
2. Cross drains and diversion ditches installed where necessary to reduce erosion and stream sedimentation.
3. Restoration and stabilization of stream bank.
4. The roll back of organic material and slash.
5. Compaction of debris
6. Revegetation of all disturbed areas.
7. Recontouring may be necessary where fireguard was constructed across ridges etc., especially in highly visible areas.
8. Depressions resulting from repeated dozer traffic should be repaired whether on or off the guard.
9. Measures should be taken to prevent unnecessary vehicle traffic in the future.

1. Cross Drains and Diversion Ditches

The purpose of installing cross drains and diversion ditches is to intercept and divert surface runoff across the guards rather than having water flow along the fireline resulting in the creation of erosion ditches. Hand tools or the corner of a bulldozer blade are used to construct these channels.

2. Revegetation

The purpose of revegetating dozerguards is to establish a dense root system which will retard soil movement by water. The selection of grass mixtures to be used should be made on the basis of the particular soil involved and the factors affecting erosion for that site.

The indentations resulting from the track cleats of bulldozers will aid in creating a microsite capable of promoting vegetative establishment.

3. Recontouring

Recontouring is required in highly sensitive areas or recreational areas usually where dozerguards have been constructed across ridges which do not coincide with the original contour of the landscape.

4. Spreading Debris

All unmerchantable debris previously removed from the guard during construction, should be scattered over the guard and compacted with dozers. This will retard water movement and reduce the impact of rain and wind.

CHAPTER VIII - BULLDOZER SAFETY CONSIDERATIONS

A. Importance of Safety

The safety of the people, whether working on the fire or not, must always take precedence over all other matters. The sector boss and dozer foreman are directly responsible for the welfare of all personnel involved in the operation of dozers. They must demonstrate and ensure that all personnel within their jurisdiction are maintaining a safe work environment and are physically capable of conducting such duties.

A review of the U.S. Forest Service's records between 1926 and 1976 shows that 145 men died from fire-induced injuries on 41 fires. Some common denominators of fatal fires are:

1. Relatively small fires or deceptively quiet sectors of large fires.
2. Relatively light fuels, such as grass, herbs, and light brush.
3. An unexpected change in wind direction or speed.
4. Sudden flare-ups resulting from helicopter, air tankers or slope.

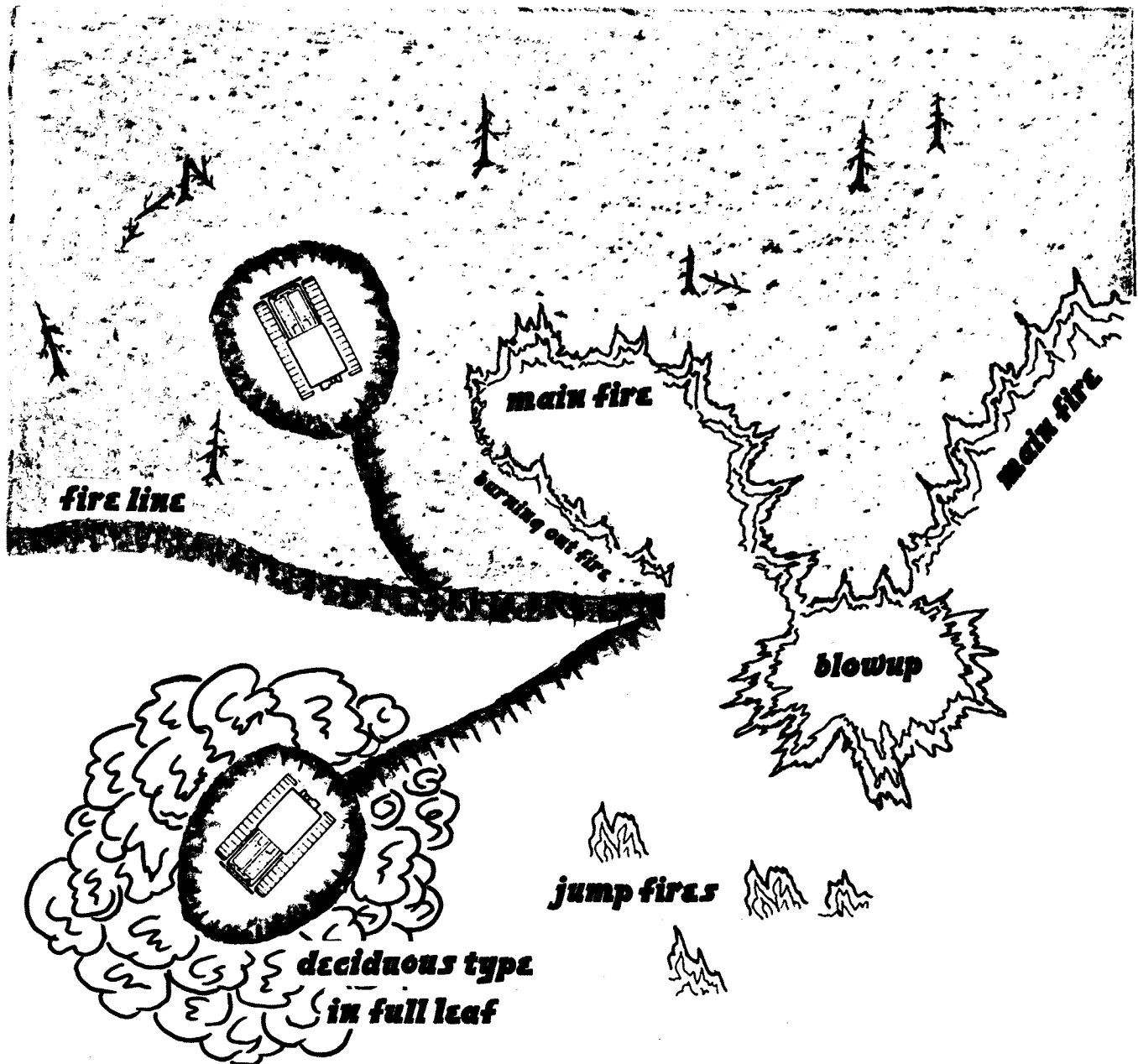
B. Dozer Foreman Responsibilities

Many of the safety responsibilities are delegated to crew bosses and dozer operators, but supervision and enforcement should be carried out by the dozer foreman.

A. The dozer foreman must:

1. Have adequate communications equipment for his personnel. It is essential that a line locator, lead dozer operator and sector boss can relay messages.
2. Keep current with any changes or expected changes in fire behavior.
3. Have two escape routes planned and ensure that all personnel are aware of these routes, should an evacuation be necessary. Commonly used escape routes include:
 - a. deciduous stands
 - b. the burned area when smoke and heat are not too intense
 - c. sparsely stocked wet areas.
4. Make sure crew members and operators work reasonable shifts and, do not become exhausted. Efficiency, safety and morale all suffer as a result of fatigue.
5. Inform operators of personnel working within the influence of their machines. Lead dozer operators should be warned to maintain a distance of at least two tree lengths behind the line locator.
6. Ensure that all machines are well maintained and free of any debris which could start a fire; frequently resulting from a buildup of leaves, in the belly pan or on the manifold.
7. Ensure that all fire dozers are equipped with fire extinguishers and track shovels.
8. Ensure that pumps and hoses are made available to operators wishing to wash their machines.
9. Discourage the use of one dozer working alone.
10. Be aware that dozers working on frost or rock can slide sideways unexpectedly.

Protection of a Bulldozer in a Burned Area or in a Deciduous Stand



11. Make sure that no one besides the operator is allowed on the dozer at any time.
12. See that all precautionary measures are taken when crossing pipelines. These include:
 - a. notify the oil company of the need to cross their pipeline; hopefully the pressure can be reduced prior to crossing.
 - b. notify dozer operator of the pipeline.
 - c. determine the exact location of the ditch and whether the pipe is visible
 - d. construct a pad over the beam; a dirt fill of 1 meter will be adequate for the machines to cross
 - e. make sure all machines cross at this point
13. Be sure that all crew members and dozer operators have been versed as to proper procedures during airtanker drops.
14. To inform operators and make sure that all extra precautionary safety measures are taken when running a night shift such as.
 - a. never attempt a night operation unless supervised by experienced, reliable personnel.
 - b. at least one person working the night shift should have a first aid certificate.
 - c. check on which helicopter pilots are licensed for night flights and make sure they are readily available should an accident occur.
 - d. make provisions for someone in camp to be contacted by radio should the need arise.
 - e. "walking down" trees is the most dangerous aspect of a night operation. Consideration should be given to walking down line, destined to be completed during the night shift, before dark, thus eliminating the need for walking down during the night.
 - f. if an accident should occur during the night a helispot should be constructed near the victim, or the victim should be moved to the nearest helispot if back injuries have not been sustained. If back injuries are suspected a paramedic team should be sent to the accident scene. In any case, two dozers should be stationed on opposite sides of the helispot with lights shining towards the helipad. The dozer foreman can direct the pilot on landing with the aid of a flashlight.
15. Make sure all persons travelling in, or using helicopters have been briefed on safety procedures. The main emphasis should be on the main and tail rotors and how to avoid being struck. Safety features include:
 - a. approach and leave the helicopter "in clear view of the pilot".
 - b. approach and depart from the helicopter on the downslope side, never upslope.
 - c. approach and depart from the helicopter in a crouched position.
 - d. never carry anything above shoulder level near the helicopter.

- e. use proper chin straps for securing hard hats otherwise one must hold on the hard hats or caps to avoid being swept off by the rotor wash.
 - f. remove unnecessary articles from around the helispot, especially light articles (tarps, pop cans, cardboard, etc.). Other light articles must be weighted down.
 - g. never throw articles or tools during loading or unloading.
 - h. use the proper procedures for closing doors and compartments.
 - i. seat belts are to worn at all times.
 - j. make sure seat belts are placed on the seat when leaving the helicopter and not left hanging out the door to damage the paint and skin of the machine during flight.
16. Make sure all personnel are moved to a safe area that is conspicuous from the air during aerial ignition operation, especially when using gel.

C. Dozer Operator Safety Responsibilities

Dozer operators must be made aware of their direct responsibilities regarding safety. Operators are responsible for:

- 1. personnel safety and safety of the machine
- 2. for the actions of his machine regarding other personnel and equipment, operators must make sure that no one is resting under or near his machine before commencing work.
- 3. the daily maintenance and upkeep of his dozer.
- 4. to ensure that winching and towing operations are conducted safely.
- 5. the safety of any passengers.

D. Air Tanker Drops

All fire personnel must be made aware that serious injury or death can result if hit by an air tanker load, or the debris and falling trees associated with a drop. Therefore, communications must be established before any drop can take place. Backup measures are mandatory in case of error or misunderstanding.

Upon arrival at the fire the "bird dog officer" will probably try some "dummy runs" during his reconnaissance. Dummy runs are trial runs to insure safe effective air tanker drops. This method is frequently used to demonstrate the target to tanker pilots by pulling up sharply at the proposed drop site.

The bird dog officer will advise ground crews of where and when the drop will take place, and where to take refuge. They are to remain there until notified to resume work, as further drops may be forthcoming. In addition to verbal communications, the bird dog will fly the proposed flight path with the siren on a continuous yelp mode. Caution is advised as several drops may be made without further dummy runs.

Just prior to making the drop it is said to be on "final". Although tanker groups have their own frequency, silence should be observed on all frequencies for reasons of safety and to allow the bird dog officer to concentrate on the drop for the purpose of analyzing accuracy and safety. On completion of the drops, the bird dog plane will make another pass with the siren on a noncontinuous wailing mode.

Ground crews and equipment should be moved well away from the drop site, in case of an inaccurate drop and to avoid retardant drift. Dozers operators should be instructed on the proper procedures to follow, if he fears being hit with a load while on his dozer. Such procedures include:

1. To avoid being hit from the side, the machine should be turned facing into the direction of the load, so the canopy will take the bulk of the impact and some of the flying debris.
2. The operator should crouch down on the floor of the dozer to avoid being struck directly by debris.

If ground personnel are endangered of being hit by a tanker drop, they should quickly determine where the load is likely to hit. They should move away and at right angles to the drop. If this is not possible:

1. Don't panic or run.
2. Lie face down, into the direction of the drop so the hard hat will take the brunt of the impact.
3. Hold on to avoid being thrown back.
4. Stay clear of snags and dead branches.
5. Keep clear of hand tools.
6. Don't move back to the fireline until all drops have been completed.
7. Watch your footing as most retardants are extremely slippery.

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