Site Preparation Strategies to Manage Soil Disturbance

Interior Sites

Land Management Handbook
FIELD GUIDE INSERT **2**

September 1990
Revised June 1993

Ministry of Forests

ISBN 0-7726-7447-7

Site Preparation Strategies to Manage Soil Disturbance

Interior Sites

Land Management Handbook
FIELD GUIDE INSERT **2**

Revised edition

by

MIKE CURRAN, Nelson

BRUCE FRASER, Victoria

LORNE BEDFORD, Victoria

MARTY OSBERG, Prince George

BOB MITCHELL, Kamloops

in association with other members of the

SITE SENSITIVITY AND DEGRADATION INTERPRETATIONS WORKING SUBGROUP

BC Ministry of Forests

ISBN 0-7726-7447-7

ACKNOWLEDGEMENTS

This guidebook has been prepared under the auspices of the Site Sensitivity and Degradation Interpretations Working Group in response to a request from the Technical Advisory Committee of the Interior Forest Harvesting Council. It is expanded from original draft interpretations developed for Silviculture in the Nelson Forest Region and has been reviewed and improved upon by the Site Sensitivity and Degradation Interpretations Working Group.

With the exception of the Forest Floor Displacement Hazard Key, the standard site sensitivity keys and rainfall factor tables that appear in the Appendix are from the Field Guide Insert, "Developing Timber Harvesting Prescriptions to Minimize Soil Degradation - Interior Sites", by T. Lewis, W. Carr, and the Timber Harvesting Interpretations Working Subgroup of the B.C. Ministry of Forests. These keys were developed with the Basic Interpretations Working Subgroup that is now part of the Site Sensitivity and Degradation Interpretations Subgroup.

The authors would like to thank Dave Presslee and Dave Basaraba for their valuable input.

FOREWORD

The primary objective of this field guide is to provide a framework for determining site sensitivity and for developing site preparation strategies to minimize unacceptable soil disturbance.

When preparing a site for reforestation the following proverb provides an excellent working guideline –

"as much as necessary but as little as possible".

CONTENTS

SITE PREPARATION STRATEGIES TO MANAGE SOIL DISTURBANCE

Interior Sites

1 INTRODUCTION

The choice of a site preparation strategy is a critical decision in the reforestation process. The main steps in making the decision are outlined below. More detail is provided in later sections on site sensitivity and site preparation strategies.

What Are the Site Preparation Options?

The decision to prepare a site should be based on a number of considerations. Perhaps the most important consideration is which option is best for the site:

- no site preparation
- modified harvesting to create desired disturbance
- mechanical site preparation
- prescribed burning
- motor manual site preparation
- special planting (e.g., using jumbo stock)
- herbicide use

This guide deals primarily with mechanical site preparation, although interpretations are also provided for motor manual, prescribed burning and herbicides. More comprehensive guides and procedures exist in each Forest Region for other options, such as prescribed burning and herbicide application.

What Are the Resource Considerations?

Site preparation prescriptions should be developed only after the careful analysis of several resource-related factors, including:

- timber and non-timber resource management objectives
- regeneration objectives (method, species, standards)
- silvics of desired crop species
- characteristics of non-crop vegetation
- environmental growth-limiting factors for seedlings

Figure 1 shows the steps in the decision-making process required for site preparation prescriptions. This guide focuses on the environmental limiting factors, but users are reminded to consider the other factors also.

Form FS 117, the Site Preparation Guide, is used to determine treatment feasibility. This is normally used **after** harvesting to assess site conditions and fine-tune the site preparation prescription developed at the Pre-harvest Silviculture Prescription (PHSP) stage.

DECISION MAKING PROCESS FOR SITE PREPARATION PRESCRIPTIONS

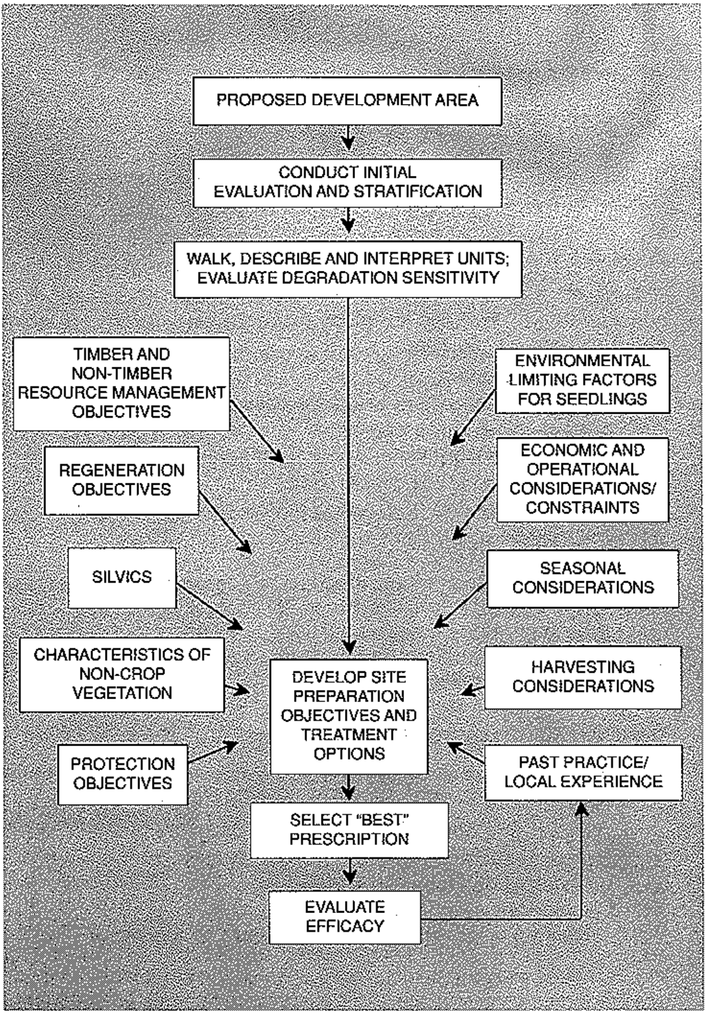

FIGURE 1

What Are the Site Preparation Objectives and Needs?

Site preparation may be needed for one or both of the following sets of objectives:

1. to minimize the effects of growth-limiting factors

   Direct growth factors:
   - cold soil temperature
   - dry soil conditions
   - insufficient light
   - wet soil conditions
   - poor nutrient availability
   - poor rooting substrate
   - high frost hazard

   Indirect growth factors (influence direct factors):
   - vegetation competition
   - others (e.g., rodents)

2. to achieve other silvicultural and protection goals:
   - fire hazard abatement
   - reduced mechanical damage to seedlings
   - elimination of residuals
   - seedbed establishment for germination
   - improve plantability
   - lodgepole pine cone distribution
   - forest health (insects, disease)
   - social and economic acceptability

What Is the Desired Type of Disturbance?

The desired disturbance should meet at least one of the above sets of objectives. One or more of the following types of disturbance may be used:

- burning
- scarification (drag, patch, trench, trail, blade)
- inverting (ploughing, mounding)
- mixing (discing, bedding, rototilling)
- windrowing (usually with minimal forest floor disturbance)
- subsoiling

What Is the Site Sensitivity to Disturbance?

When selecting the most appropriate treatment type, one must consider the site's sensitivity to long-term degradation. Site sensitivity falls into five categories and a high sensitivity in any of these means that the desired disturbance will likely have to be modified to prevent long-term soil degradation (strategies are discussed in Section 3). These five types of site sensitivity are:

1. forest floor displacement hazard
2. compaction and puddling (rutting) hazard
3. mineral soil displacement hazard
4. erosion hazard
5. mass wasting hazard

Keys for assessing these hazards are provided in the Appendix. The information should be collected for treatment units at the PHSP stage and may be further supplemented by data collected during a Silviculture Survey after logging.

What Are the Strategies and Equipment Options to Address Sensitivity?

By choosing the right piece of equipment and prime mover, and by following certain strategies, you can usually prepare the site (i.e., create the desired disturbance) while preventing negative long-term effects (i.e., addressing the site sensitivity).

You should have answers to the following questions before you begin:

Equipment	Site Conditions
• Is the ground pressure low? • Does the implement minimize unacceptable disturbance?	• Can operations be timed for the dry season, frozen ground or snow cover?

Operating Techniques

- Can operations running up/downhill be avoided?
- Should the operation be kept away from water?
- Does the operator know your objectives?
- Can the operator move to drier ground if it rains?
- Does the operator have sufficient experience?

2 SITE SENSITIVITY TO DISTURBANCE: EVALUATING THE SITE

Soil degradation is defined as being detrimental soil disturbance that causes long-term site productivity losses.

Potentially degrading site preparation usually involves compaction or puddling (rutting) and deep gouges. On more sensitive sites, gouges that simply displace the upper mineral soil or even just the forest floor can cause soil degradation.

2.1 Data Collection

Collecting data with which to evaluate site conditions is part of the PHSP process. Further information may be added in the subsequent Silviculture Survey. The data required for the hazard keys are summarized below. Collection of these data are described by keys and definitions in regional "Ecoguides", and for the Kamloops and Nelson Forest Regions in the upcoming soil data collection handbook.[1]

Climatic information required:
- Biogeoclimatic subzone variant
- occurrence/depth of dry soil, snow, frozen ground

Slope information required:
- slope gradient and continuity
- slope length/uniformity
- presence of slope failure indicators

Site hydrology information:
- gully spacing
- water course spacing
- soil moisture regime
- occurrence and depth of seepage

Soil information required:
- forest floor depth and dominant horizon
- Ah horizon depth
- soil texture and changes with depth
- coarse fragment % and changes with depth
- depth to carbonates
- depth to bedrock
- depth to unfavorable substrates
- depth to restricting layer

2.2 Site Sensitivity and Hazard Keys

The hazard keys for determining site sensitivity are appended to this field guide insert. The hazard ratings are discussed separately below, under strategies to manage soil disturbance.

3 INTERIM SITE PREPARATION STRATEGIES TO MANAGE SOIL DISTURBANCE

The strategies presented in this section should not be relied on to replace local experience. Several other options exist, such as raw planting through slash, planting large stock on brush prone sites, or using domestic livestock to control vegetation.

Use of the strategies presented in the following table requires integration of all applicable information, paying particular attention to the highest hazard rating for the site.

[1] Mitchell, R. And M. Curran. 1990. Site mapping and soil data collection for site sensitivity evaluation associated with preharvest silviculture prescriptions, Field Guide Insert, First Approximation. B.C. Min. For., Unpubl. draft.

Strategies Based on Site Sensitivity

Hazard	Rating	Strategies to Control Disturbance: Mechanical Site Preparation (incl. piling and burning)	Broadcast Burning[a]	Herbicide/ Motor-Manual
Forest Floor Displacement Hazard	VH	Avoid. May be OK[b] if forest floor disturbance is minimal and forest floor kept near seedling.	Avoid	May be OK[c]
	H	Questionable. May be OK if forest floor disturbance is minimal and forest floor kept near seedling.	Low impact burn may be OK. (i.e., forest floor loss minimized).	OK
	M	Avoid extensive scalping and keep forest floor near seedling.	May be OK	OK
	L	Avoid excessive scalping. Maintain LFH and enriched mineral soil.	May be OK	OK
Compaction & Puddling (basic hazard)	VH	Avoid when wet (unless frozen). Questionable when moist (use LGP[d]).	OK	OK
	H	Avoid when wet. LGP when moist. Normal equipment when dry.	OK	OK
	M	Avoid when wet.	OK	OK

Continued . . .

[a] Refer to Regional Guides for burning as well.

[b] In this table, "May be OK" means that the strategy may be acceptable on some sites.

[c] The plantable spot created by a motormanual scalp may be unacceptable if unfavorable subsoils are exposed.

[d] Low ground pressure equipment (i.e., ≤ 6.3 p.s.i.)

[e] Herbicides may be questionable if the potential for sediment delivery to water courses is high.

[f] Herbicides may be questionable, particularly if dry ravelling is a problem.

Strategies Based on Site Sensitivity (Continued)

Hazard	Rating	Strategies to Manage Disturbance: Mechanical Site Preparation (incl. piling and burning)	Broadcast Burning[a]	Herbicide/ Motor-Manual
Mineral Soil Displacement	VH	Questionable unless slopes are favorable. Avoid scalping and gouging that will expose unfavorable substrate.	Questionable? Check forest floor displacement hazard.	OK
	H	Minimize displacement.	May be OK	OK
	M	Minimize displacement.	May be OK	OK
Erosion	VH	Avoid	Questionable if mineral soil exposure becomes wide spread or common near water courses.	May be OK[e]
	H	Minimize continuous mineral soil exposure near water courses. Avoid mineral soil exposure that runs up and down hillslopes.	May be questionable as above.	May be OK[e]
	M	Avoid continuous mineral soil exposure that runs up and down hillslopes.	Acceptable	OK
Mass Wasting	VH	Avoid	Questionable, particularly if dry ravelling is a problem.	May be OK[f]
	H	OK on slopes > 30% if patch can be made from existing roads with excavator. Minimize gouge/deposits.	May be OK	OK
	M	Minimize gouges/ deposits.	May be OK	OK

Strategies Based on Other Site Conditions

Other Factors:	Strategies to Manage Disturbance
Slope Gradient	
> 60%	**Avoid MSP.** Burning may be acceptable if forest floor displacement hazard < VH (very high).
45 - 60%	Very high potential for degradation; generally avoid MSP. Great care must be taken in choosing equipment and operator.
30 - 45%	Displacement hazards are still high; use experienced operator and ensure equipment is properly matched to site conditions.
15 - 30%	Inappropriate equipment can still displace large amounts of soil. Caution required.
< 15%	Generally few constraints.
Slope Complexity	Sites with extensive gullying or hummocky terrain may not be suitable for MSP and are usually very sensitive (prone) to soil/forest floor displacement.
Slash Loading	Heavy slash loading can restrict MSP options and can result in suboptimal treatments. Consider the merits of yarding unmerchantable material to the landing for disposal. Or, is slashburning an option? Conversely, a mat of tops and branches can act as a protective blanket, reducing the amount of compaction.
Harvest System	Keep stumps low to facilitate subsequent mechanical treatments. Random skidding under low or moderate compaction hazard ratings may increase plantable spots and create effective site preparation (weigh against potential negative impacts). Destumping (for root disease control) harvesting systems should be considered in consultation with a soils specialist.
Vegetation Complex	Adequate control of rhizomatous complexes such as thimbleberry by traditional blading techniques often requires very severe soil disturbance which usually results in extensive degradation. Consider another form of mechanical site preparation, herbicides, broadcast burning, or consider local experience in planting grasses, etc., to minimize revegetation. High speed mixing can control competing vegetation because the plant parts are chopped up small enough

Continued . . .

	to inhibit resprouting. On the other hand, slow mixing in which plants are cut into large pieces may stimulate vegetation as a result of rapid resprouting. Inverting may be effective in controlling rhizomatous complexes, but effectiveness depends on factors such as depth of mineral soil capping and soil characteristics. Hardwood complexes such as alder, birch, and aspen can seed-in to exposed mineral soil or sucker from damaged roots. Minimize soil disturbance and exposure from site preparation.

Equipment Factors:	**Strategies to Manage Disturbance**
Equipment Operator	Operator training and supervision provide the greatest opportunities to manage disturbance and reduce the risk of soil degradation. It can take a long time for an equipment operator familiar with skidding or road construction to become "in tune" with the needs of site preparation. It is your responsibility to ensure the operator understands fully what is desirable and what is not. Daily supervision is essential when you are using an operator with no previous mechanical site preparation experience.
Equipment Size and Type	Larger crawler tractors have better traction and power for heavy slash conditions than smaller tractors, but have far greater potential for soil/forest floor displacement and compaction. Perhaps more important than size is ground pressure and the number of passes required. LGP equipment is often desirable and essential when you are dealing with High Compaction Hazards at the time of operation. On some sites, excavators or other specialized equipment is preferable.
Traction	Equipment should be set up for the maximum traction needed (e.g., with wide tires, chains), but in keeping with the soil conditions.
Site Preparation "Types"	Blading techniques (windrowing, bunching, planting trails) have a high potential for creating unacceptable soil disturbance, such as: excessive removal of soil/forest floor; exposure of undesirable substrates, or; compaction/puddling associated with repeated passes over the same area.

Continued . . .

Strategies Based on Other Site Conditions (Cont'd)

Equipment Factors:	Strategies to Manage Disturbance
Site Preparation "Types" *continued*	**Minimize displacement.** Brush blading techniques can be non-degrading provided soil/forest floor displacement is minimized and the prime mover is well matched to site and slash conditions. **Disc trenching and drag scarification** are usually less degrading for several reasons: they cause less overall displacement; harmful compaction is less likely as the treatments are usually achieved in a single pass; and the implements used often run in the equipment tracks. **Patch scarification and mounding** generally result in minimal soil disturbance, though excessive disturbance may result if pretreatment is necessary (e.g., if windrowing excessive slash on sensitive sites). **Mixing (cultivating) systems** may expose a large amount of mineral soil, which in turn may cause erosion problems in high and very high erosion hazard areas. Spot mixing techniques avoid this problem.

Getting the Most from Your Equipment Complement

There is more than one way to create most types of desired disturbance. Selecting the least degrading technique available can reduce a large proportion of the potential site degradation associated with site preparation.

Always select the technique which meets the treatment objectives and minimizes unacceptable soil disturbance.

Other reference handbooks provide guidance on relating equipment to disturbance types. For example, McMinn and Hedin, in *Regenerating British Columbia's Forests*, describe the types of equipment that are best suited to various sites, and that can best address various growth-limiting factors.[2] If the option you desire is not available, you might be able to pool your demand with other foresters to create enough demand to get the desired equipment into your area. Contact your District Silviculturist or Regional Site Preparation Forester.

---

[2] McMinn, R. and I. Hedin. 1990. Site preparation: mechanical and manual. *In* Regenerating British Columbia's Forests. University of B.C. Press, Vancouver, B.C., pp.150-163.

Also remember to schedule the operation to take advantage of the most favorable soil conditions if soil compaction and rutting are concerns. If the site has a high or very high sensitivity, be very careful to protect long-term productivity.

Remember, when preparing a site for reforestation, the following proverb provides an excellent working guideline –

"as much as necessary but as little as possible".

APPENDICES

COMPACTION AND PUDDLING

Compaction is the increase in soil density that results from the rearrangement of soil particles in response to applied external forces.

Puddling is the destruction of soil structure and the associated loss of macroporosity that results from working the soil when wet.

Site factors determining hazards:

texture
coarse fragments
moisture regime
forest floor H horizon ≥20cm
organic soil

Management considerations:[1]

applied forces
- equipment (ground pressure)
- number of passes

scheduling of operations
scalping
slope (adverse, favourable)
frozen soil >15cm deep
compressibility/depth of snow >1m
seasonal soil moisture content
(moist soil compacts, wet soil puddles)

Soil texture abbreviations:

S - sand
SL - sandy loam
L - loam
SiL - silt loam
SCL - sandy clay loam
SiCL - silty clay loam
LS - loamy sand
fSL - fine sandy loam
Si - silt
SC - sandy clay
SiC - silty clay
C - clay
CL - clay loam

The **COMPACTION AND PUDDLING HAZARD KEY** (facing page) derives a hazard rating from an assessment of the combined influences of soil texture, coarse fragment content, moisture regime, thickness of the forest floor H horizon and soil type (mineral or organic) on the load-bearing capacity of the soil.

Column 1 of the key is used for mineral soils with xeric to subhygric moisture regimes where the forest floor H horizon (the well-decomposed humic layer) is <20cm thick. Column 2 is used for mineral soils where the soil moisture regime is subhygric and the forest floor H horizon is ≥20cm thick; or the soil moisture regime is hygric or wetter. Organic soils with >40cm of wet, organic material or peaty forest floors >40 cm are rated as Very High Puddling Hazard.

[1] Management considerations are discussed further in field guide inserts 1 (for harvesting strategies) and 2 (for site preparation strategies).

COMPACTION AND PUDDLING HAZARD KEY

SOIL TEXTURE[1] (0–30 cm)		HAZARD RATING[2]	
		Xeric-subhygric[3] [3] (H horizons <20 cm)	Subhygric[4]-subhydric [4] (H horizons ≥20 cm)
Fragmental coarse fragments >70%		L	M
Coarse fragments <70%	Sandy S, LS	L	VH[5]
	Loamy SL, L	M	
	Silty fSL, SiL, Si	H	
	Clayey SCL, CL, SiCL, SC, SiC, C	VH	

[1] Use dominant soil texture and coarse fragment content of the upper 30 cm of mineral soil to assess compaction hazard. If a pronounced textural change occurs within the upper 30 cm (e.g., silty over sandy soil), then use the more limiting soil texture, providing it amounts to 5 cm of the top 30 cm.

[2] L = Low; M = Moderate; H = High; VH = Very High.

[3] Use this column for subhygric sites with forest floor H horizons <20 cm thick.

[4] Use this column for subhygric sites with forest floor H horizons ≥20 cm thick.

[5] Organic soils comprised of more than 40 cm of wet organic material, or peaty forest floors >40 cm, are susceptible to rutting and puddling by displacement of their very low load-bearing strength materials. Consequently, organic soils have a high displacement hazard and a very high puddling hazard.

DISPLACEMENT

Displacement is the mechanical movement of soil materials by equipment and movement of logs. It involves excavation, scalping, exposure of underlying materials and burial of surface soils.

Three aspects of displacement can produce soil degradation:

- **exposure of unfavourable subsoils**
- **redistribution and loss of nutrients**
- **alteration of slope hydrology**

Site factors determining hazards:

slope steepness
slope complexity
soil depth to:
- bedrock
- unfavourable subsoil
- seepage

soil chemistry
- carbonates

Management considerations:[1]

logging system
ground vs cable
- equipment size
- use of snow
- skid road spacing, pattern, gradient

site preparation
depth of scalping

Displacement Hazard Key Definitions:

Close gully spacing — 2 or more >2 m deep, sharp-edged gullies occur per 100 m along the contour. Gentler, rounder gullies are not a concern, since extra excavation would not be involved in crossing such gullies with a bladed structure.

Hummocky terrain — broken terrain with small, but steep-sided knolls or ridges, (e.g., eskers, rocky knobs and drumlins).

Unfavourable subsoils — includes subsoil conditions that produce unfavourable growing conditions when exposed by displacement. Does not include carbonates, seepage or bedrock, which are rated separately in the key. Unfavourable subsoils include:
- *dense parent materials* — compact glacial till, silt or clay glaciolacustrine materials that cannot be readily dug into with a shovel (i.e., a pick or pulaski is required to loosen before digging).
- *dense, clayey Bt horizons* — clay-enriched subsoils of Luvisols >5 cm thick and with clayey textures that cannot be readily dug with a shovel.
- *granular materials with sand or loamy sand texture* — granular materials with a low content of silt and clay, and low water-holding and nutrient-storing capacity.
- *fragmental materials* — subsoils comprised of >70% coarse fragments (i.e., fragments >2 mm diameter).

Carbonate — a soil layer containing appreciable calcium carbonate (lime) in which the soil particles <2 mm in diameter fizz when contacted with 10% HCl (muriatic acid); may have white coatings on coarse fragments; may have powdery white deposits in the soil.

Seepage — consider seepage only for subhygric, hygric and subhydric sites, as indicated by vegetation (site series). For these sites, estimate typical depth of seepage by direct observation of seepage or water table (make allowances for recent weather and spring break-up); or by inference, using soil colours, either mottling or gleying.

[1] Management considerations are discussed further in field guide inserts 1 (for harvesting strategies) and 2 (for site preparation strategies).

DISPLACEMENT HAZARD KEY[1]

Mineral Soil

1. Slope[2]

Slope gradient (%)	Points	Slope gradient (%)	Points
0	0	40	6
5	1	45	8
10	1	50	10
15	2	55	12
20	3	60	16
25	3	65	20
30	4	70	26
35	5	75	32

2. Slope complexity

Terrain feature	Slope	Points
Close gully spacing: two or more >2 m deep sharp edged gullies occur per 100m along the contour	<30%	2
	30–45%	4
	>45%	6
Hummocky terrain: broken terrain with small, but steep-sided knolls or ridges, (e.g., eskers, rocky knobs and drumlins)		+2

3. Subsoil conditions

USE THE MOST LIMITING FACTOR				
Depth from bottom of LFH to:	<30cm	30–60cm	61–90cm	>90 cm
	POINTS			
Unfavourable subsoil	8	4	2	0
Carbonate	12	8	4	0
Seepage	12	8	4	0
Bedrock	12	8	4	0

DISPLACEMENT HAZARD RATING: (point total)			
Low	Moderate	High	Very High
<7	7–14	15–24	>24

Organic Soil

Organic soils with >40cm of wet, organic materials or peaty forest floors >40 cm thick have a **High Displacement Hazard.**

[1] The Displacement Hazard Key involves adding the points for slope gradient, slope complexity (gullied and/or hummocky terrain), and substrate conditions; the total determines the rating.

[2] Use average slope to determine rating, but also consider the upper end of the slope range in formulating prescriptions.

FOREST FLOOR DISPLACEMENT

Forest floor displacement is the mechanical movement of the upper organic materials by equipment and movement of logs. It involves excavation, scalping, mineral soil exposure, and burial of the forest floor.

Effects range from beneficial to detrimental, depending on site factors (e.g., mineral soil characteristics) and degree of forest floor displacement (e.g., how far the displaced forest floor is from the seedlings).

Two aspects of forest floor displacement can produce soil degradation:

- redistribution and loss of nutrients
- exposure of unfavourable rooting medium

Site factors determining hazards:

forest floor
- type
- depth

soil texture
coarse fragment %
slope steepness
slope complexity
soil depth to:
- unfavourable subsoil
- bedrock
- seepage
- carbonates

Management considerations:[1]

harvesting system
silvicultural system
site preparation
- type
- pattern
- prime mover
- implement

operating gradient
depth of scalping
operator experience
instructions
seasonal soil moisture content
ground freezing
compressibility/depth of snow

Forest Floor Displacement Hazard Key Definitions:

Close gully spacing — 2 or more >2m deep, sharp-edged gullies occur per 100m along the contour. Gentler, rounder gullies are not a concern, since extra excavation would not be involved in crossing such gullies with a bladed structure.

Hummocky terrain — broken terrain with small, but steep-sided knolls or ridges, (e.g., eskers, rocky knobs and drumlins).

Unfavourable subsoils — includes subsoil conditions that produce unfavourable growing conditions when exposed by displacement. Does not include carbonates, seepage or bedrock, which are rated separately in the key. Unfavourable subsoils include:

- *dense parent materials* — compact glacial till, silt or clay glaciolacustrine materials that cannot be readily dug into with a shovel (i.e., a pick or pulaski is required to loosen before digging).
- *dense, clayey Bt horizons* — clay-enriched subsoils of Luvisols >5cm thick and with clayey textures that cannot be readily dug with a shovel.
- *granular materials with sand or loamy sand texture* — granular materials with a low content of silt and clay, and low water-holding and nutrient-storing capacity.
- *fragmental materials* — subsoils comprised of >70% coarse fragments (i.e., fragments >2mm diameter).

Carbonate — a soil layer containing appreciable calcium carbonate (lime) in which the soil particles <2mm in diameter fizz when contacted with 10% HCl (muriatic acid); may have white coatings on coarse fragments; may have powdery white deposits in the soil.

Seepage — consider seepage only for subhygric, hygric and subhydric sites, as indicated by vegetation (site series). For these sites, estimate typical depth of seepage by direct observation of seepage or water table (make allowances for recent weather and spring break-up); or by inference, using soil colours, either mottling or gleying.

1 Management considerations are discussed further in field guide inserts 1 (for harvesting strategies) and 2 (for site preparation strategies).

FOREST FLOOR DISPLACEMENT HAZARD KEY[1]

LFH[2]	<6cm	6–10cm	>10≤20cm	<10cm	≥10≤20 cm	>20cm	all
Ah	<3cm	<3cm	<3cm	3–10cm	3–10cm	<10cm	>10cm
(points)	12	8	6	6	4	4	0

Dominant Soil Matrix (top 30 cm)	Very Coarse	Coarse	Medium	Fine
(points)	8	4	2	8
Depth to unfavourable subsoil, bedrock, seepage, or carbonates	<15cm	15–30cm	30–60cm	>60cm
(points)	12	8	2	0
Slope[3]	>60% Gullied or hummocky terrain		30–60%	<30%
(points)	6		3	0
RATINGS:	>25 **Very High**	16–25 **High**	5–15 **Moderate**	<5 **Low**

[1] The Forest Floor Displacement Hazard rating is determined from the total of points added up for: forest floor LFH depth/Ah depth; soil "matrix" (texture/coarse fragments); depth to unfavourable subsoil, bedrock, seepage, or carbonates; and slope/hummocky terrain.

[2] Not including rotten wood.

[3] Use average slope to determine a rating, but in formulating precriptions also consider the upper end of the slope range.

SOIL MATRIX

TEXTURE	**COARSE FRAGMENT CONTENT**		
	<30%	**30–70%**	**>70%**
S, LS, SL	Coarse	Very Coarse	Very Coarse
fSL, Loam	Medium	Coarse	Very Coarse
SiL, Si	Medium	Medium	Coarse
SC, SiC, SCL, SiCL, CL, C	Fine	Medium	Medium

Soil texture abbreviations:

S - sand
SL - sandy loam
L - loam
SiL - silt loam
SCL - sandy clay loam
SiCL - silty clay loam

LS - loamy sand
fSL - fine sandy loam
Si - silt
SC - sandy clay
SiC - silty clay
C - clay
CL - clay loam

SURFACE EROSION

Surface erosion is the wearing away of the earth's surface by water and includes splash, rill and gully erosion. 'Accelerated' erosion is erosion that results from human activities, in excess of 'geologic' erosion. It causes **on-site** impacts (soil loss, nutrient loss, lower productivity) and **off-site** impacts (water quality, sedimentation, habitat impacts).

Site factors determining hazards:

climate (R factor)
- rain intensity/duration
- snowmelt

topography
- slope %
- slope length

soil properties
- texture
- structure
- coarse fragments
- restricting layers

Management considerations:[1]

logging system
ground vs cable
- soil exposure

extent of forest floor removal
road system
site preparation
erosion control
soil moisture during operations

The Surface Erosion Hazard Key rates the susceptibility of exposed soil to water erosion **(i.e., when protective vegetation and florest floor are removed).**

Surface erosion of forest soils remains low when surface organic layers are intact.

After exposure of mineral soil, rates of erosion are initially high and drop off after the first year. **To be effective, erosion control measures must be promptly applied.**

Surface Erosion Hazard Key Definitions:

Rainfall (R) factor — integrates precipitation type, frequency, intensity and duration and the biogeoclimatic subzone/variant. Extract appropriate value from tables on pages 24 to 28.

Short slopes — <150m unbroken slope length between level or adverse slopes that will impede the continued flow of water.

Long slopes — ≥150m unbroken slope length between level or adverse slopes that will impede the continued flow of water.

Broken slopes — variable, complex or benchy slopes.

Water-restricting layer — restricting to downward flow of water, but not necessarily to root growth. Includes impermeable, dense, compact or cemented layers; bedrock; or permanent water table.

[1] Management considerations are discussed further in field guide inserts 1 (for harvesting strategies) and 2 (for site preparation strategies).

SURFACE EROSION HAZARD KEY[1]

SITE FACTORS	DEGREE OF CONTRIBUTION OF FACTORS			
	LOW	MODERATE	HIGH	VERY HIGH
CLIMATE Rainfall factor (R) **(points)**	<25 **3**	25–49 **6**	50–100 **9**	>100 **12**
TOPOGRAPHY Slope gradient (%) **(points)**	0–15 **2**	16–30 **4**	31–60 **6**	>60 **8**
and Length/Uniformity **(points)**	short broken 1	short uniform 2	long broken 3	long uniform 4
DEPTH TO WATER-RESTRICTING LAYER (cm) **(points)**	>90 1	61–90 **2**	30–60 **3**	<30 **4**
SURFACE SOIL DETACHABILITY[2] (0–15 cm) Texture **(points)**	SC, C, SiC 1	SiCL,CL,SCL **2**	SL, L **4**	Si,SiL,fSL,LS,S **6**
SUBSOIL PERMEABILITY (16–60cm) Texture **(points)**	S,LS,SL,fSL 1	L,SiL,Si **2**	CL,SCL,SiCL **3**	C,SC,SiC **4**

SURFACE EROSION HAZARD RATING (point total)	LOW	MODERATE	HIGH	VERY HIGH
	<16	16–22	23–29	>29

1 The Surface Erosion Hazard Key involves adding the points for the six site factors; the total determines the rating.

2 If two contrasting textures occur in the depth, use the most limiting texture with the highest point rating.

MASS WASTING

Mass wasting is erosion due to gravity.

- **Dry ravelling** occurs on oversteepened slopes underlain by non-cohesive, granular and fragmental materials.
- Shallow, rapid failures — **debris slides and debris avalanches** — are of concern on slopes that have shallow soils overlying impermeable material (i.e., bedrock, till) above which zones of saturation are present or develop during periods of rainfall or snowmelt.
- Deep-seated, slow failures — **slumps and slump-earthflows** — occur on deeper cohesive materials (i.e., clayey till, lacustrine).

Site factors determining hazards:

climate (R factor)
- rain intensity/duration
- spring break-up

topography
- slope %
- slope length
- slope continuity

soil properties
- texture
- coarse fragments
- soil moisture regime
- restricting layers

Management considerations:[1]

logging system
- ground vs cable
- extent of cut and fill

roads
- width, cut height, sidecast
- drainage structures
- maintenance
- deactivation

Excavation-related slides may be triggered by removal of support, oversteepening of fill/sidecast slopes, overloading, and concentration of drainage waters. Clearcut-related mantle failures may be caused by loss of root strength and changes in slope hydrology.

Mass Wasting Hazard Key Definitions:

Rainfall (R) factor — integrates precipitation type, frequency, intensity and duration and the biogeoclimatic subzone/variant. Extract appropriate value from tables on pages 24 to 28.

Continuous slopes — ≥150 m slope length between slope segments at least 20 m wide and <30% slope gradient, or between ridge crests and valley bottoms.

Discontinuous slopes — <150 m slope length between slope segments at least 20 m wide and <30% slope gradient (i.e., variable, complex or benchy slopes), or between ridge crests and valley bottoms.

Gullied — two or more >2 m deep sharp-edged gullies occur per 100 m along the contour.

Water-restricting layer — restricting to downward flow of water, but not necessarily to root growth. Includes impermeable, dense, compact or cemented layers; bedrock.

Texture groupings — **Sandy** = S, LS; **Clayey** = SC, SiC, SCL, SiCL, CL, C. Use predominant textural group overlying the restricting layer or the most limiting soil texture in the profile.

[1] Management considerations are discussed further in field guide inserts 1 (for harvesting strategies) and 2 (for site preparation strategies).

MASS WASTING HAZARD KEY

A. If the site contains active slides or the initiation zone of historic slope failures[1], THEN mass wasting hazard =	**VERY HIGH**

B. If the site is underlain by non-cohesive materials – i.e., sands (S,LS), gravels, volcanic pumice or fragmental material with >70% coarse fragment content (e.g., rubbly talus), THEN dry ravelling is the process of concern.[2]

SLOPE (%):	<30	30–45	46–60	>60
MASS WASTING HAZARD RATING:	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**

C. OTHERWISE, the risk of slope failures and excavation-related cut and fill slope failures for the more cohesive materials is assessed by adding the points determined by the following site factors:[3]

R FACTOR	<25	25–49	50–100	>100
(points)	0	5	10	20
SITE MOISTURE	Very xeric-submesic	Mesic	Subhygric-hygric	Subhydric
(points)	0	5	10	20

SLOPE (%)	<30	30–40	41–50	51–60	61–70	>70
(points)	0	2	4	8	16	32

LENGTH/ CONTINUITY	Slopes <30%	Slopes ≥30%		
		Discontinuous	Continuous	Gullied
(points)	0	4	6	8
SOIL TEXTURE	Sandy[4]	SL, L, fSL	Si, SiL	Clayey
(points)	3	5	8	12
DEPTH TO WATER-RESTRICTING LAYER (cm)	>90	61–90	30–60	<30
(points)	0	2	4	6

MASS WASTING HAZARD RATING:[5]
LOW = <15 MODERATE = 15–30 HIGH = 31–45 VERY HIGH = >45

[1] Evidence of old slides includes contrasting strips of seral vegetation not associated with snow avalanching, tilted or jack-strawed trees, tension cracks, headscarps, rotational failures — *see Land Management Handbook 25.*

[2] Part B of the Key rates dry ravelling hazard directly from slope steepness.

[3] Part C of the Key involves adding points for the six site factors; the total determines the rating.

[4] Where sandy (especially finer sands) soils have moisture conditions that vary seasonally from wet (moist) to dry, it may be necessary to use Parts B and C of the Key.

[5] **Where evidence of potential slope instability exists**, such as accelerated soil creep, buried or absent soil profiles, curved trees, etc., **the hazard rating should be increased by one level** — *see Land Management Handbook 25.* **If Mass Wasting Hazard is Very High, seek further geotechnical advice before proceeding with development.**

Rainfall (R) Factors for the Cariboo Forest Region

<25	25–49	50–100	>100
all BG PPxh			
IDFxm IDFxw IDFdk	IDFmw		
MSxk	MSxc		
SBSdw SBSmc*	SBSmh SBSmc* SBSmw SBSwk		
SBPSxc SBPSdc	SBPSmc SBPSmk		
ESSFxv	ESSFwk*	ESSFwc ESSFwk*	
	ICHdk ICHmk ICHwk*	ICHwk*	

* These subzones encompass two R factor ranges. Use local experience in deciding the appropriate R factor to apply in the keys.

Rainfall (R) Factors for the Kamloops Forest Region

<25	25–49	50–100	>100
all BG PPxh			
IDFxh IDFxw IDFdk IDFdm	IDFmw IDFww		
MSxk	MSdc MSdm MSmm		
SBSdh SBSdw	SBSmm		
SBPSmk*	SBPSmk*		
ESSFxc	ESSFdc ESSFdv	ESSFwc ESSFwm	ESSFvc ESSFvv
	ICHmk ICHmw ICHwk*	ICHvk ICHwk*	
		CWHds CWHms	

* These subzones encompass two R factor ranges. Use local experience in deciding the appropriate R factor to apply in the keys.

Rainfall (R) Factors for the Nelson Forest Region

<25	25–49	50–100	>100
PPdh1 PPdh2			
IDFdm1 IDFdm2 IDFun IDFxh1			
	MSdk MSdm1		
	ESSFdc1 ESSFdk	ESSFwc1 ESSFwc2 ESSFwc4 ESSFwm	ESSFvc
	ICHdw ICHmk1 ICHmw1 ICHmw2 ICHmw3 ICHxw	ICHvk1 ICHwk1	

Rainfall (R) Factors for the Prince George Forest Region

<25	25–49	50–100	>100
SBSdh SBSdk SBSdw SBSmk1 SBSmc*	SBSmh SBSwk SBSmw SBSmk2 SBSmc*	SBSvk	
BWBSdk BWBSmw2 BWBSwc3	BWBSmw1 BWBSwc1&2		
	ESSFmm ESSFmv ESSFwk*	ESSFwc ESSFwk*	ESSFvc
	all SWB		
	ICHmc ICHmm ICHwk*	ICHvk ICHwk*	

* These subzones/variants encompass two R factor ranges. Use local experience in deciding the appropriate R factor to apply in the keys.

Rainfall (R) Factors for the Prince Rupert Forest Region

<25	25–49	50–100	>100
SBSdk SBSmc*	SBSmc*		
SBPSmc			
BWBSdk2 BWBSmw2			
	ESSFmc ESSFmk	ESSFwv	
	all SWB		
	ICHmc	ICHvc	
			CWHws1&2
			MHm

* These subzones/variants encompass two R factor ranges. Use local experience in deciding the appropriate R factor to apply in the keys.