FOREST PRACTICES

CODE

of

BRITISH COLUMBIA

Hazard Assessment Keys for Evaluating Site Sensitivity to Soil Degrading Processes Guidebook

June 1995

BC Environment

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Authority:

Forest Practices Code of British Columbia Act

Operational Planning Regulation

Canadian Cataloguing in Publication Data
Main entry under title:
Hazard assessment keys for evaluating site sensitivity to soil degrading processes guidebook

(Forest practices code of British Columbia)

Co-published by BC Environment.
ISBN 0-7726-2532-8

1. Forest soils – British Columbia - Evaluation. 2. Soil erosion - British Columbia. 3. Soil conservation - British Columbia. I. British Columbia. Ministry of Forests. II. BC Environment. III. Series.

SD390.3.C3H39 1995 631.4'5 C95-960246-1

Preface

This guidebook has been prepared to help forest resource managers plan, prescribe, and implement sound forest practices that comply with the Forest Practices Code.

Guidebooks are one of the four components of the Forest Practice Code. The others are the *Forest Practices Code of British Columbia Act*, the regulations, and the standards. The ***Forest Practices Code of British Columbia Act*** is the legislative umbrella authorizing the Code's other components. It enables the Code, establishes mandatory requirements for planning and forest practices, sets enforcement and penalty provisions, and specifies administrative arrangements. The **regulations** lay out the forest practices that apply province-wide. **Standards** may be established by the chief forester, where required, to expand on a regulation. Both regulations and standards are mandatory requirements under the Code.

Forest Practices Code guidebooks have been developed to support the regulations, but are not part of the legislation. The recommendations in the guidebooks are not mandatory requirements, but once a recommended practice is included in a plan, prescription, or contract, it becomes legally enforceable. Guidebooks are not intended to provide a legal interpretation of the *Act* or regulations. In general, they describe procedures, practices and results that are consistent with the legislated requirements of the Code.

The information provided in each guidebook is used to help users exercise their professional judgement in developing site-specific management strategies and prescriptions designed to accommodate resource management objectives. Some guidebook recommendations provide a range of options or outcomes considered to be acceptable under varying circumstances.

Where ranges are not specified, flexibility in the application of guidebook recommendations may be required, to adequately achieve land use and resource management objectives specified in higher-level plans. A recommended practice may also be modified when an alternative could provide better results for forest resource stewardship. The examples provided in many guidebooks are not intended to be definitive and should not be interpreted as being the only acceptable options.

Contents

Introduction

The five keys provided in this guidebook have been developed for the assessment of the inherent sensitivity of a site to five major soil-degrading processes:

Soil compaction and puddling
Soil displacement (including exposure of unfavorable subsoil and slope hydrology changes)
Forest floor displacement
Surface soil erosion (exposed mineral soil)
Mass wasting

For each soil-degrading process a write-up provides definitions, controlling site factors, management considerations, and a hazard assessment key. Procedures for use are the same throughout the province.

Pre-harvest data collection needs

The quality of forest management decisions can only be as good as the quality of the data upon which they are based. Many decisions are based on the data collected for silviculture prescriptions and road reconnaissances. **Inadequate data collection can result in incorrect soil disturbance hazard assessments, excessive soil degradation and off-site impacts such as damage to streams, private property, and in extreme cases, human life.** Data must be collected by appropriately trained individuals.

Site and soil data must be collected to characterize variability in site sensitivity to soil disturbance before standards units for silviculture prescriptions are delineated. The data required to use the hazard assessment keys are summarized below. If additional information is required on methods for collecting and recording these data the Ministry of Forests' district earth scientist or regional soil scientist should be consulted.

Data required for soil disturbance hazard assessment:

Climatic information	biogeoclimatic subzone/variant reliable seasonal occurrence of: dry soil > 15-30 cm deep, or compressible snow > 1 m deep, or frozen ground > 15-30 cm deep
Slope information	slope gradient slope length/uniformity slope continuity presence of slope instability indicators
Site hydrology information	gully spacing water course spacing soil moisture regime occurrence/depth of seepage
Soil information	forest floor depth and dominant horizon Ah horizon depth soil texture and changes with depth coarse fragment content (%) and changes with depth depth to carbonates depth to bedrock depth to unfavorable subsoil depth to water restricting layer

Gully systems > 5 m deep should be typed out and assessed separately for soil disturbance hazard assessment during data collection in the Interior. On the

Coast, gullies must be assessed in accordance with the *Gully Assessment Procedure Guidebook.*

The evaluation of sensitivity of mineral soils to soil disturbance involves working through hazard assessment keys for compaction and puddling, soil displacement, forest floor displacement, surface soil erosion, and mass wasting.

Organic soils, composed of more than 40 cm of wet, organic material or peaty forest floors >40 cm thick, are susceptible to rutting and puddling by displacement of their very low load-bearing strength materials. Consequently, organic soils have a high soil displacement hazard and a very high soil compaction and puddling hazard. Organic soil ratings have not been developed for surface soil erosion and mass wasting hazards, but some interim direction is provided in the keys.

Soil compaction and puddling hazard

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

Soil 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 ≥20 cm
- organic soil.

Management considerations:
- applied forces
  - equipment (ground pressure)
  - number of passes
- scheduling of operations
- scalping
- slope (adverse, favorable)
- frozen soil >15 cm deep
- compressible snow >1 m
- seasonal soil moisture content.

The soil compaction and puddling hazard key 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.

Soil compaction and puddling hazard key

Soil texture[a] (0-30 cm)		Hazard rating[b] moisture regime: Xeric-subhygric[c] (H horizons <20 cm)	Hazard rating[b] moisture regime: Subhygric[d]-subhydric (H horizons ≥20 cm)
Fragmental (coarse fragments >70%)		**L**	**M**
Coarse fragments (<70%)	Sandy S, LS	**L**	**VH[e]**
	Sandy loam SL, fSL	**M**	
	Silty/loamy SiL, Si, L	**H**	
	Clayey SCL, CL, SiCL, SC, SiC, C	**VH**	

a 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.

b L=Low; M=Moderate; H=High; VH=Very High.

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

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

e **Organic soils** composed of more than 40 cm of wet organic material, or forest floors >40 cm (including Folisols < 40 cm), are susceptible to rutting by displacement of their very low load-bearing strength materials. Consequently, these organic materials have a high soil displacement hazard and a very high puddling hazard.

Soil texture abbreviations:

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

* for the purposes of this key fSL, "fine sandy loam" means the soil contains 30 per cent or more fine or very fine sand, or more than 40 per cent fine and very fine sand combined. Fine sand is 0.25 - 0.10 mm in diameter, very fine sand is 0.10 to 0.05 mm in diameter; these generally represent the limits of visible particles.

Soil displacement hazard

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

Three aspects of displacement can produce soil degradation:
- exposure of unfavorable subsoils
- redistribution and loss of nutrients
- alteration of slope hydrology.

Site factors determining hazards:
- slope gradient
- slope complexity
- soil depth to:
  - bedrock
  - unfavorable subsoil
  - seepage
- soil chemistry
- carbonates (free lime).

Management considerations:
- logging system
- ground versus cable
- equipment size
- use of snow
- skid road spacing, pattern and gradient
- site preparation
- depth of scalping.

Soil displacement hazard key definitions:

Close gully spacing - Two 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).

Unfavorable subsoils - includes subsoil conditions that produce unfavorable growing conditions when exposed by displacement. Unfavorable subsoils include:

- dense parent materials - compact glacial till, silt or clay textured glaciolacustrine, or other soil parent 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.
- sandy 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 effervesce (fizz) when contacted with 10% HCl (muriatic acid); these calcareous soils 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.

Soil displacement hazard key[a]

Table 1. Slope[b]

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**

Table 2. Slope complexity

Terrain feature	Slope	Points
Close gully spacing: two or more >2 m deep, sharp-edged gullies occur per 100 m 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**

Table 3. Subsoil conditions

Depth from bottom of LFH to unfavorable subsoil, bedrock, seepage, or carbonates	<30 cm	30-60 cm	61-90 cm	>90 cm
(points)	**12**	**8**	**4**	**0**

Soil displacement hazard rating: (point total)			
Low	**Moderate**	**High**	**Very high**
<7	7-14	15-24	>24

Organic soil

Organic soils composed of ≥40 cm of wet, organic materials:	**High**
Forest floors over bedrock or skeletal materials (e.g., folisols):	**Very high**

a The soil displacement hazard key involves adding the points for slope gradient, slope complexity (gullied and/or hummocky terrain), and subsoil conditions; the total determines the rating.

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

Forest floor displacement hazard

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 unfavorable rooting medium.

Site factors determining hazards:

- forest floor
  - type
  - depth
- soil texture
- coarse fragment per cent
- slope gradient
- slope complexity
- soil depth to:
  - unfavorable subsoil
  - bedrock
  - seepage
  - carbonates.

Management considerations:

- harvesting system
- silviculture 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 >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).

Unfavorable subsoils - includes subsoil conditions that produce unfavorable growing conditions when exposed by displacement. Unfavorable subsoils include:

- dense parent materials - compact glacial till, silt, or clay-textured glaciolacustrine, or other soil parent 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.
- sandy 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 effervesce (fizz) when contacted with 10% HCl (muriatic acid). These calcareous soils may have white coatings on coarse fragments; they 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 colors, either mottling or gleying.

Forest floor displacement hazard key[a]

Forest floor LFH[b]	< 6	6-10	11-20	>20	< 5	5-10	>10	<10	<10	all
Ah	< 1	< 1	< 1	< 1	1-2	1-2	1-2	3-5	6-10	>10
(points)	**12**	**8**	**6**	**4**	**9**	**6**	**4**	**4**	**2**	**0**
Dominant soil matrix (top 30 cm)[c]	Very coarse		Coarse		Medium			Fine		
(points)	**8**		**4**		**2**			**8**		
Depth to unfavorable subsoil, bedrock, seepage, or carbonates	<15 cm		15-30 cm		30-60 cm			>60 cm		
(points)	**12**		**8**		**2**			**0**		
Slope[d]	>60 %, gullied, or hummocky terrain				30-60%			<30%		
(points)	**6**				**3**			**0**		
Ratings	**Low**		**Moderate**		**High**			**Very high**		
	<9		**9-14**		**15-25**			**>25**		

a 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 unfavorable subsoil, bedrock, seepage, or carbonates; and slope/hummocky terrain.

b Not including rotten wood. The three boxes generally correspond to Mor, Moder, and Mull humus forms, respectively.

c If first or top soil horizon is 15 cm or more thick, use it, otherwise use thickest layer in the top 30 cm of mineral soil.

d Use average slope to determine a rating, but in formulating prescriptions 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, Si	Medium	Coarse	Very coarse
SiL, L	Medium	Medium	Coarse
SC, SiC, SCL	Fine	Medium	Medium
SiCL, CL, C	Fine	Medium	Medium

Soil texture abbreviations:

S	- sand	LS	- loamy sand	SiL	- silt loam
SL	- sandy loam	fSL	- fine sandy loam (defined in compaction hazard section)	SC	- sandy clay
L	- loam			SiC	- silty clay
Si	- silt	SCL	- sandy clay loam	SiCL	- silty clay loam
CL	- clay loam	C	- clay		

Surface soil erosion hazard (exposed mineral soil)

Surface soil 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 (precipitation factor)
  - rain intensity/duration
  - snowmelt
- topography
  - slope per cent
  - slope length
- soil properties
  - texture
  - structure
  - coarse fragments
  - restricting layers.

Management considerations:

- logging system
  - ground based, cable or helicopter
  - degree of log suspension, resulting disturbance
- extent of forest floor removal
- road system
- site preparation
- drainage control, erosion control measures
- soil moisture during operations.

The surface soil erosion hazard key rates the susceptibility of exposed soil to water erosion (i.e., when protective vegetation, forest floor, and slash 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.

A table presenting an example classification for rating the potential for sediment delivery from surface erosion sources is provided in Appendix 2. This rating system should be used where there is a requirement to evaluate the potential for sediment to be delivered to a stream. For example, the surface soil erosion hazard and the sediment delivery potential must both be evaluated when determining whether or not it is acceptable to construct an excavated trail within a community watershed.

Surface soil erosion hazard key definitions

Precipitation factor - integrates precipitation type, frequency, intensity and duration and the biogeoclimatic subzone/variant. Extract appropriate class from tables in Appendix 1.

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

Long slopes - >150 m 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.

Surface soil erosion hazard key[a] (exposed mineral soil)

Site factors	Degree of contribution of factors			
	Low	**Moderate**	**High**	**Very high**
Climate precipitation factor **(points)**	low **2**	moderate **4**	high **6**	very high **8**
Topography slope gradient (%) **(points)**	0-10 **1**	11-20 **3**	21-50 **6**	>50 **9**
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 (0-15 cm)[b] texture **(points)**	SC,C,SiC **1**	SiCL,CL,SCL **2**	SL,L **4**	Si,SiL,fSL,LS,S **8**
Surface coarse fragments (0-15 cm)[b] **(points)**	>60 **1**	31-60 **2**	16-30 **3**	<16 **4**
Subsoil permeability (16-60 cm)[b] texture **(points)**	S,LS,SL,fSL **1**	L,SiL,Si **2**	CL,SCL,SiCL **3**	C,SC,SiC **4**

Surface soil erosion hazard rating[c]	**Low**	**Moderate**	**High**	**Very high**
(point total)	**<16**	**16-22**	**23-31**	**>31**

a The surface soil erosion hazard key involves adding the points for the six site factors; the total determines the rating. Note: Surface soil erosion rating has not been developed for organic soils. **Organic soils** can be highly erodible when exposed, see directions in mass wasting hazard key and seek advice if in doubt.

b If two contrasting textures or coarse fragment contents occur in the depth, use the one with the highest point rating.

c Gently sloping areas with long, uniform slopes may rate as high surface soil erosion hazard. This is because substantial erosion can occur on these sites given the right conditions.

Mass wasting hazard

Mass wasting hazard assesses susceptibility to small, disturbance-related slope failures - ***it is not the same as landslide likelihood*** (landslide likelihood is determined in accordance with the procedures specified in the *Mapping and Assessing Terrain Stability Guidebook).* **Mass wasting hazard** refers primarily to small-scale failures which mainly cause on-site degradation, while landslide likelihood primarily refers to larger events, which are of concern because of possible off-site impacts. The two hazards are correlated; a very high mass wasting hazard may indicate a potentially unstable slope, and such sites must be checked by a person qualified to assess slope stability. In addition, small, disturbance-related slope failures can lead to larger landslides through drainage diversion or failure of "stacked" excavations up a hillside, such as in switchbacks.

Gully systems > 5 m deep should be typed out and assessed separately for soil disturbance hazard assessment during data collection in the Interior. On the Coast, gullies are subject to a separate gully assessment procedure.

The mass wasting hazard key has two parts. The first part has two keys that rate the hazard for dry ravelling in non-cohesive soils and the hazard for cutslope or full slope failures in more cohesive soils. The second part has a table of field indicators of potential slope instability to help field data collectors identify areas that require a detailed terrain stability site assessment.

Dry ravelling (use on dry Interior sites only) occurs on oversteepened slopes underlain by non-cohesive, granular and fragmental materials.

Cutslope or fill slope failure (use on Interior sites only) These excavation-related slumps may be triggered by removal of supporting slope segments, oversteepening of fill/sidecast slopes, overloading of fill slopes, and/or concentration of drainage waters. **These failures can lead to larger landslides if they cause drainage diversion - this is a common problem in the Interior.** This rating IS NOT used on the Coast

Site factors determining hazards:

- climate (precipitation factor)
  - rain intensity/duration
  - spring break-up
- topography
  - slope per cent
  - slope length
  - slope continuity

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

Management considerations:
- logging system
  - ground, cable or helicopter
  - extent of cut and fill
- roads
  - width, cut height, and sidecast
  - drainage structures
  - maintenance
  - deactivation.

Mass wasting hazard key definitions

Precipitation factor - integrates precipitation type, frequency, intensity and duration and the biogeoclimatic subzone/variant. Extract appropriate class from tables in Appendix 1.

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; or permanent water table.

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

Mass wasting hazard rating

Dry ravelling (use on dry Interior sites only) - is a concern 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).				
Non-cohesive or fragmental materials (sand or > 70% coarse fragments	**Slope %**			
Sands or coarse fragments that are rounded, subrounded, flat/platy, or fine gravelly angular	<30	30-45	46-60	>60
Angular, interlocking coarse fragments, or compacted/cemented/consolidated materials	<40	40-55	56-70	>70
Rating	**Low**	**Moderate**	**High**	**Very high**

Cutslope or fill slope failure (use on Interior sites only): add the points for each of the following site factors to determine the hazard for excavation-related cutslope and fill slope failures in more cohesive soil materials.

Precipitation factor **(points)**	low **0**		moderate **3**		high **6**	very high **9**
Soil moisture regime[1] **(points)**	very xeric-submesic **0**		mesic **10**		subhygric-hygric **18**	subhydric **22**
Slope % **(points)**	< 30 **0**	30 - 40 **3**	41 - 50 **6**	51 - 60 **12**	61 - 70 **24**	> 70 **36**
Slope gullying/ continuity[2] **(points)**	slopes < 30 % not gullied **0**	gullied **4**	slopes ≥ 30 % discontinuous **2**	continuous **5**	gullied **10**	
Soil texture[3] **(points)**	Sandy **0**		SL, fSL **5**		Si, SiL, L **10**	clayey **15**
Depth to water restricting layer[4] **(points)**	> 90 **0**		61 - 90 **2**		30 - 60 **3**	< 30 **4**
Point total	**< 22**		**22 - 38**		**39 - 53**	**> 53**
Rating	**Low**		**Moderate**		**High**	**Very high**

1 It is acceptable to assign moisture regime ratings part way between values, as long as your actions are defendable and the wetter conditions in the standards unit are the ones being rated.

2 The continuity of the underlying bedrock is also important on some sites.

3 Use the predominant soil texture grouping overlying the restricting layer or the most limiting texture in the profile (which ever is rated highest).

4 Deep materials can also pose a hazard, but this is somewhat compensated for by texture (deep deposits that are of concern on slopes are often finer textured).

Indicators of potential slope instability

The following list of slope instability indicators should be used during data collection for silviculture prescriptions, and road location surveys. The primary purpose of the list is to help the field data collector verify terrain hazard information presented in forest development plans. The information being verified may have been derived from reconnaissance terrain hazard mapping, detailed terrain hazard mapping or contour maps. The field verification is needed because, depending on the scale of the initial assessment, certain features may have been missed. For detailed terrain mapping, the number of field checks is usually no greater than one per square kilometre. In heavily forested terrain, some active slope instability features may be obscured on airphotos and not identified during field checking. In addition, because of the initial mapping scale, smaller unstable sections of land cannot be mapped. The smallest mappable unit is about 4 ha for detailed mapping and 10 to 20 ha for reconnaissance mapping. The field data collector must be looking for indicators of instability. Overlooking potential slope instability can result in unacceptable damage to productive forest land, water quality, property, and risk to human life.

Field indicators	Potential landslide type
• recent landslide scars • revegetated landslide scars	high likelihood of landslides of the same type and size
• partially revegetated strips (may also be snow avalanche tracks) • jack-strawed trees (trees tilted in various directions) • linear strips of even-aged timber • landslide debris piled on lower slopes • soil and rocks piled on the upslope side of trees • pistol butt (recurved) trees (may also indicate snow creep) • mixed or buried soil profiles • poorly developed soils relative to other comparable slopes • tension fractures • poorly drained or gullied*, fine-textured materials <3m deep on slopes >50% • poorly drained or gullied* coarse-textured materials on slopes >50% • wet site vegetation on slopes >50% • shallow, linear depressions • shallow, wet, organic soils on slopes >40%	• debris avalanches • debris flows (debris torrents) • debris slides
• recently scoured gullies* • exposed soil on gully sides* • debris piles at the mouths of gullies* • vegetation in gully much younger than the adjacent forest • poorly developed soils on gully sides relative to adjacent slopes (repeated shallow failures continually remove the developed soil profile)	• debris flows (debris torrents) • debris slides

* *Apply the* Gully Assessment Procedure Guidebook *(1995) to any gullied areas on the Coast.*

Field indicators	Potential landslide type
• tension fractures • curved depressions • numerous springs at toe of slope, sag ponds • step-like benches or small scarps • bulges in road • displaced stream channels • jack-strawed trees (trees tilted in various directions), split trees • poorly drained medium- to fine-textured materials (e.g., till, lacustrine, marine and some glaciofluvial deposits) >3m deep • mixed or buried soil profiles • ridged marine deposits	• slumps • earthflows
• talus or scattered boulders at base of slope • rock faces with freshly exposed rock • steeply dipping, bedrock discontinuities (bedding planes, joints or fracture surfaces, faults) that parallel the slope • bedrock joint or fracture surface intersections that dip steeply out of the slope	rock slides or rock fall (can be induced by excavation and blasting for roads)

Modified from: Land Management Handbook 18 (1994). Chatwin, S.C., D.E. Howes, J.W. Schwab, and D.N. Swantson. Crown Publications Inc. 546 Yates Street, Victoria, B.C. V8N 1K8. *Consult LMH 18 for background information.*
* *Apply the* Gully Assessment Procedure Guidebook *(1995) to any gullied areas on the Coast.*

Appendix 1. Precipitation factors for biogeoclimatic subzones by forest region

Precipitation factors for the Cariboo forest region

low	moderate	high	very high
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 precipitation factor ranges. Use local experience in deciding the appropriate precipitation factor to apply in the keys.

Precipitation factors for the Kamloops forest region

low	moderate	high	very high
all BG PPxh			
IDFxh IDFxw IDFdk IDFdm	IDFmw IDFww		
MSxk	MSdc MSdm MSmm		
SBSdh SBSdw	SBSmm		
SBPSmk			
ESSFxc	ESSFdc ESSFdv	ESSFwc ESSFmw	ESSFvc ESSFvv
	ICHmk ICHmw	ICHwk	ICHvk
		CWHds CWHms	

Precipitation factors of the Nelson forest region

low	moderate	high	very high
PPdh1 PPdh2			
IDFdm1 IDFdm2 IDFun IDFxh1			
	MSdk MSdm1		
	ESSFdc1 ESSFdk	ESSFwc1 ESSFwc2 ESSFwc4 ESSFwm	ESSFvc
	ICHdw ICHmk1 ICHmw1 ICHmw2 ICHmw3 ICHxw	ICHwk1	ICHvk1

Precipitation factors for the Prince George forest region

low	moderate	high	very high
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 precipitation factor ranges. Use local experience in deciding the appropriate precipitation factor to apply in the keys.

Precipitation factors for the Prince Rupert forest region

low	moderate	high	very high
SBSdk SBSmc*	SBSmc*		
SBPSmc			
BWBSdk2 BWBSmw2			
	ESSFmc ESSFmk	ESSFwv	
	all SWB		
	ICHmc	ICHvc	
			CWHws1&2
			MHm

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

Precipitation factors for the Vancouver forest region

low	moderate	high	very high
all CDF			
	IDFww		
		CWHxm CWHds1 CWHms1 CWHwh1	
		ESSFmw	
			CWHdm CWHds2
			MHmm1,2
			CWHvh1, vh2 CWHvm1,vm2

Appendix 2. Potential for sediment delivery from surface erosion sources

Class	Rating	Road, logging trail and ditch line erosion	Non-specific surface erosion sources*
VL	Very low potential	Roads, logging trails or ditch lines crossing this unit will not provide a direct avenue for sediment input into any ephemeral or permanent stream.	The terrain unit is separated from any ephemeral or permanent stream by at least 20 metres of gently sloping, well-vegetated ground.
L	Low potential	Roads, logging trails or ditch lines crossing this unit will provide a direct avenue for sediment input into an ephemeral stream, which crosses ≥ 200 metres of gently sloping terrain before it reaches a permanent stream.	Sediment source on a gully sidewall or stream escarpment leads directly into an ephemeral stream, which crosses ≥ 200 metres of gently sloping terrain before it reaches a permanent stream.
M	Moderate potential	Roads, logging trails or ditch lines crossing this unit will provide a direct avenue for sediment input into an ephemeral stream, which crosses 100-200 metres of gently sloping terrain before it reaches a permanent stream.	Sediment source on a gully sidewall or stream escarpment leads directly into an ephemeral stream, which crosses 100-200 metres of gently sloping terrain before it reaches a permanent stream.
H	High potential	Roads, logging trails or ditch lines crossing this unit will provide a direct avenue for sediment input into an ephemeral stream, which crosses <100 metres of gently sloping terrain before it reaches a permanent stream.	Sediment source on a gully sidewall or stream escarpment leads directly into an ephemeral stream, which crosses <100 metres of gently sloping terrain before it reaches a permanent stream.
VH	Very high potential	Roads, logging trails or ditch lines crossing this unit will provide a direct avenue for sediment input into a permanent stream.	Sediment source on a gully sidewall or stream escarpment leads directly into a permanent stream.

* *Non-specific sediment sources include yarding disturbance, road fills and very small landslides (0.05 ha).*

Note: This is an example classification. Modifications may be necessary to suit local conditions.