FOREST INVENTORY

ENVIRONMENTAL PROTECTION GUIDELINES

British Columbia Forest Service
Forest Inventory Division

October, 1978
JAN 30 1979
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Chapter 13.
(From Forest Classification and Sampling Manual)

TABLE OF CONTENTS

13.0 General
13.01 Introduction
13.02 Objectives
13.03 Implementation
13.1 E.P.A. Guidelines by Category
13.11 Es - Soil problems
13.12 Ep - Regeneration problems
13.13 Ei - Operability problems
13.14 Ea - Snow avalanche problems
13.15 Er - Recreation values
13.16 Ew - Wildlife values
13.17 Eh - Water values
13.18 Ef - Fish values
13.2 Field Procedures
13.21 Flight Planning
13.22 E.P.A. Assessment Form
13.3 Mapping Procedures
13.4 E.P.A. Report

Appendices

A.8 Soil Protection
A.81 Movement of Surficial Material by Gravity
A.82 Methodology for Designation of Es Category for 82F
     - Cranbrook P.S.Y.U.
A.9 Snow Avalanche Protection Zones
A.10 Water Source - Watershed Protection
A.11 Habitat Characteristics of Major Wildlife Species
A.12 Slope Conversion Chart
13.0 General

13.01 Introduction

The extent of the forest resource is determined by the forest inventory process.

Cumulative experience in forest land management indicates that all productive forest sites are not necessarily available for timber production. There are stands growing on steep hillsides or on unstable soils where slides or excessive soil erosion may occur following logging; there are forested areas where society may place a higher value on other resources, such as wildlife, recreation and water; there are fragile sites where the establishment of a second crop may prove to be unsuccessful or much delayed following present logging practices; and there are isolated patches of forest which are physically inaccessible and would not justify an economic operation. All these sites should be identified and delineated during the inventory process. These suspected problem areas are called Environmental Protection Areas.

13.02 Objectives

13.021 Broad Objectives of Program

a) To provide data on a site-specific basis to assist in the calculation of Allowable Annual Cuts.

b) To identify and indicate the main potential conflict and problem areas to forest managers in order to prevent mistakes as a result of oversight or lack of information.
Specific Objectives of Program

a) To identify sensitive sites in order to prevent the destruction of or serious damage to the productive base. Trees are renewable - the soil resource is not.

b) To identify and afford site-specific protection to other highly sensitive resources (wildlife, recreation, water, etc.).

c) To identify and defer fragile and/or inoperable areas from development until justified by advances in research and technology.

Environmental Protection Areas reflect the environmental, technological, social, and economic constraints in force at the time of inventory. All E.P.A. boundaries are subject to revision during subsequent field surveys.

E.P.A.'s are designated only where there is evidence that the area's contribution to the timber harvest may be severely limited over the length of rotation. Two classes of limitations are recognized: inventory constraints and management constraints. Inventory constraints are those which make an area unavailable for harvesting. Inventory constraints include physical elements, ecological considerations, or priority use. Criteria such as product potential, timber quality, species desirability and site productivity, either alone or combined, do not qualify an area for E.P.A. designation. Management constraints in the current context refer to those portions of the land base that will be managed for more than one resource and where there will be a substantial loss to the A.A.C. because of other uses.
Environmental Protection Areas may still contribute to the allowable cut. In the case of management constraint areas, their contribution is depreciated by a factor determined by consultation.

For P.S.Y.U.s or management units where problem sites or conflict areas are not covered by normal E.P.A. categories, the Resource Planning Division of the Forest Service may consider special reduction factors.

13.03 Implementation

To meet the objectives as stated, the E.P.A. classification system recognizes three broad forest land use zones and a minimum of eight basic categories. Table 1 summarizes the categories covered by these guidelines. A percentage factor is assigned to each category to indicate the degree of sensitivity in terms of potential exclusion from the A.A.C. However, it is important to understand that these reduction factors are to provide guidance for classification only. They are intended to assist field crews in applying uniform standards on a Province-wide scale. Consequently, all E.P.A. lines must be mapped according to these standards.

By way of illustration, under Er2 in Table 1 the basic reduction factor is 50%. This means that if an important recreation area is evaluated on its sensitivity to timber harvesting but fails to meet the minimum requirement of 50% estimated constraint, then that area is not an E.P.A. This applies to actual and potential areas anywhere in the Province. Similarly, an area labelled as Er1 must be judged to meet a 90% constraint.
E.P.A.'s are delineated on forest cover maps and marked by a capital "E" followed by a lower case letter to denote the specific category. This label may also be used with a dual or multiple designation - for example, Esr or Epw - to indicate more than one kind of problem, preferably in decreasing order of permanence and importance.

Field identification of the various E.P.A. categories must be based on the best information available at the time of inventory. Of necessity, the data comes from a variety of sources and these are listed in further detail in each section. The cooperation and support of all agencies is required to reach a consensus on area designation.

To sum up, the E.P.A. classification system is a necessary and expanding part of the forest inventory process. It provides a framework for forest land stratification considering basic environmental concepts, other land use needs and potentials, and recognizable physical limitations to harvesting. The programme does not limit or displace the planning function. On the contrary, the programme supplements an essential resource data base necessary for integrated land management at several levels of planning intensity.
<table>
<thead>
<tr>
<th>Zone I</th>
<th>Constraint</th>
<th>E.P.A. Category</th>
<th>% Constraint</th>
<th>E.P.A. Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unharvestable</td>
<td></td>
<td>Es 1</td>
<td>90%</td>
<td>severe soil and steepness related problem areas.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ep 1</td>
<td>90%</td>
<td>severe regeneration (plantation) problem areas.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>El 1</td>
<td>90%</td>
<td>inoperable forest land because of severe access limitations.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ea 1</td>
<td>90%</td>
<td>severe snow chute and avalanche problem areas.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Er 1</td>
<td>90%</td>
<td>areas where recreational values are paramount.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ew 1</td>
<td>90%</td>
<td>areas of critical importance to wildlife.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eh 1</td>
<td>90%</td>
<td>water supply areas requiring exceptional protective measures to maintain water quantity and quality.</td>
</tr>
<tr>
<td>Zone II</td>
<td></td>
<td>Er 2</td>
<td>50%</td>
<td>areas where recreational values are significant but less critical than Er1.</td>
</tr>
<tr>
<td>Multiple Use</td>
<td></td>
<td>Ew 2</td>
<td>VARIED</td>
<td>areas where wildlife values are significant but less critical than Ew1.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eh 2</td>
<td>50%</td>
<td>areas of water supply that are not as critical as Eh1, but still merit some form of protection.</td>
</tr>
<tr>
<td></td>
<td>fisheries</td>
<td>VARIED</td>
<td></td>
<td>varying constraints indicated by map symbols rather than &quot;E&quot; notation. &quot;Blank - unknown values; ▲ no constraint required; ▼ little constraint; ○ moderate constraint; ◆ high constraint.</td>
</tr>
</tbody>
</table>

| Zone III       | NIL        |                |              | Management practices on these lands are subject only to operational constraints consistent with the topography and policies of the region. |

Table 1. Table to show E.P.A. categories and constraint values.
13.1 E.P.A. Guidelines by Category

13.11 Es - Guidelines for Identifying Soil Problem Areas

13.111 Objective

The objective of the Es category is to identify ecosystems having extremely fragile or unstable soils that are likely to be subject to unacceptable deterioration following forest harvesting activities.

13.112 Information Sources

Identifying highly sensitive soils requires a basic understanding of soil and landform characteristics. Knowledge of various harvesting techniques and their potential impact is also important. The task of Es site recognition will be made easier by seeking input from the following agencies and by checking a number of references. These include:

a) Forest Service district staff - especially pedologists, engineers, individuals with local knowledge.

b) Resource Analysis Branch, Ministry of the Environment - especially specialists in soils and terrain analysis.

c) Resource Analysis Branch, Ministry of the Environment - maps are available depicting soil/landform, landform (only), soil erosion and mass movement potential.

d) Interpretation of Landforms from Aerial Photographs (Keser, 1976).

e) Air photos.

f) Series of background articles related to basic soil characteristics and soil instability (Appendix A.8).
13.113 Procedure
13.113.1 General

It must be clearly understood that only sites that may be highly sensitive to forest harvesting are to be identified with an Es. Sensitive sites that may significantly affect or constrain forest management are not delineated as an Es unless feasible forest harvesting options are expected to lead to unacceptable site deterioration from excessive soil movement. Unacceptable deterioration includes:

a) A severe lowering of site productivity by removing soil material and nutrient capital necessary for plant growth.
b) Extreme difficulty in re-establishing protective vegetation and forest cover.
c) Long-term loss of the productive land base.
d) Severe lowering of downstream water quality and degradation of fish habitat.

Before an Es label is used there must be clear evidence of either actual or potentially severe erosional problems. Sites are selected by air photo interpretation, and supplemented by ground and air examination where possible. In general, sites selected for Es fall into either of two categories:

1) Sites with visible evidence of either natural or man-made instability.

Evidence includes slumps, scars, debris avalanches, severe erosion, etc. It is necessary, however, to analyse the cause, size and frequency of the erosional process to ensure that an Es designation is warranted. For example, a soil that has failed because of a management error may not justify an Es if the problem is preventable.
2) Landforms or landform features with a consistent history of severe instability.

In some regions or units there are specific landforms such as lacustrines, or the edges of fluvial terraces that have a record of severe instability. With the assistance of the district pedologist, local expertise, and landform maps, develop guidelines for identifying landform features specific to each P.S.Y.U. that may deserve an Es.

Forest managers and planners are urged to refer to any existing soil and landform information to determine other sensitive soil conditions, not handled by the E.P.A. program, that may still affect their harvesting plans.

13.1132 Constraint Factor

A high constraint factor will be assigned to Es sites.

13.1133 Recognition of Es Problems

To identify Es problems it is necessary to recognize sites with the potential for excessive erosion.

The erosional process includes both surface and mass soil movement.

13.1133.1 Surface Erosion

Surface erosion is essentially a two-stage process—detachment of soil particles and their subsequent transport by either water or wind. The principal types of erosion are:

a) rilling and gullying which involve channelized erosion by water.
b) sheet erosion by water which occurs in areas of bare mineral soil.
c) movement of fine sand, silts and organic particles by wind.

Surface or photo features most likely to indicate extreme surface erosion potential are:
a) steep sided gullies - suggestive of relatively cohesionless material.
b) sand dunes.

13.113312 Landforms with a high potential for degradation from surface erosion following timber removal:
a) sites on some dry, shallow soils <30 cm with frequent bedrock exposure (50%+), e.g. hilltops, ridges (these sites are subject to the loss of organic and mineral soil by gravity, water, and wind action).
b) sites occurring on steep topography (70%+, 35°+) with thin to negligible soils, e.g.
- very steep, broken sites - cliffs, bluffs, narrow ledges,
- colluvial, fragmental soils (large boulders, few fines),
- lower margin of talus slopes,
(these sites are prone to persistent erosion of soil by gravity and water).
c) sites occurring on soils developed on highly stratified and/or cohesionless materials, e.g.
(1) erosion hazard from water
   - faces and edges of outwash terraces.
   - lacustrine deposits of silts and sand adjacent to established drainage patterns.
(2) erosion hazard from wind
   - some aeolian, alluvial or lacustrine deposits of fine sand, and silt.
Mass soil movement is the downslope movement of the land surface under the direct influence of gravitational forces. The majority of mass movements are associated with high soil moisture and steep slopes. Local bedrock type, climate and basic soil characteristics determine the individual failure mechanism. There are two major types of mass soil movements:

a) Slides

A slide refers to a mass of surface material that breaks loose from its bed and moves downhill as either a cohesive or a non-cohesive mass. It slides over the substratum along a definite slippage plane. Examples include slumps, debris-slides, debris-falls, rockslides, and rock falls (talus).

b) Flows

Wet. Wet flow refers to surface materials saturated with water where continuous deformation takes place and no slip plane is present. Examples include earthflows, mudflows, debris flows, creep, and solifluction.

Dry. Dry flow involves downslope movement of single particles and thin sheets of coarse, cohesionless material on steep, sparsely vegetated slopes. Example include dry ravel, dry creep, and sliding.

Conditions favouring a high incidence of mass movement (particularly on steep slopes with a high moisture content):

a) non-cohesive soils, i.e. those soils with a low clay content and a corresponding low frictional resistance.
b) permeable, shallow soils overlying an impermeable till or bedrock.
c) topography which collects surface and subsurface drainage such as deeply incised and V-notched ravines.
d) soils comprised mainly of silts, uplifted marine clays.
e) soils derived from shales, serpentine, siltstones, claystones, nonsiliceous sandstones, and pyroclastics.
f) bedrock joint planes parallel to slope.

13.113322 Air photo features indicating potential for mass movement:

a) scars from debris avalanches, debris flows, slumps or earthflows (severity of problem is reflected by size and frequency of past disturbances).
b) active undercutting of stream banks.
c) escarpments, often crescent shaped, sometimes a series of parallel breaks in the slope
d) hummocky surface at toe of slope.

13.113323 Ground features indicating potential for mass movement:

a) tilted trees.
b) certain plant associations, i.e. cedar-skunk cabbage association on a steep slope.
c) certain features of soil morphology, i.e. buried horizons, discontinuity of humus layer, etc.
d) escape of muddy water from springs at base of potential slide.
13.113324 Landforms with a high potential for mass movement:

a) steep, colluvial slopes (70%+ or 35°+). The main problem is associated with continuous movement of surficial material. This includes dry ravel, dry creep and sliding, all of which involve downslope movement of single particles and/or thin sheets of coarse, cohesionless material on sparsely vegetated slopes. The more extreme cases occur on south to southwest exposures which produce early successional stages.

b) steep slopes (70%+ or 35°+) having a thin blanket of loose till over an impermeable layer of compacted till or bedrock with a smooth sliding plane parallel to the surface.

c) faces of outwash terraces with layers of fine-grained clay beds that restrict drainage.

d) steep stream banks consisting of lacustrine deposits (silts, clays).

e) steep stream edges and ravines associated with unconsolidated material (till, colluvium).

13.1134 Use of Landform and Soil Association Maps

The Resource Analysis Branch of the Environmental and Engineering Services (Ministry of the Environment) produces landform and soil association maps for parts of the province. When available, these maps provide a good basis for outlining potentially sensitive sites. Such maps may be used in the following manner:

a) study the forestry interpretation table.

b) determine the surficial materials for each soil association.
c) determine the soil textural and drainage classes for each soil association to determine the potential hazard rating.

d) establish actual hazard rating classes for each soil association by slope and depth to bedrock (Appendix A.82).

e) colour code by hazard classes on the soil/landform map.

f) transfer the most sensitive areas to 1:63,360 (80 chain) or equivalent photographs when available.

g) transfer the boundaries of such areas to the 1:20,000 or 1:15,840 (20 chain) air photos for field examination.
13.12 Ep - Guidelines for Forest Regeneration (Plantation) Problems

13.121 Objective

To identify actual and potential reforestation problem areas irrespective of age and species composition of the existing cover. All productive forest sites having an anticipated regeneration delay of 20 years or more following major disturbance, such as clearcut harvesting or wildfire, should be considered.

13.122 Information Sources

Contacts and data sources, particularly high elevation research programs, may be obtained from the District Research Officer and the District Reforestation Officer. In Victoria, contact the Research Division and the Silviculture Officer in the Reforestation Division. Other sources include:

a) Forest Ranger and staff.
b) Resource Analysis Branch, Ministry of Environment, Victoria.
c) Canadian Forestry Service, Victoria.
d) University of British Columbia, Vancouver.

13.123 Procedure

13.1231 General

At the outset, recognition of Ep areas will be largely a matter of subjective judgement based on the major components of the environment - biological, physical, chemical - together with added reliance on local knowledge.
13.1232 Constraint Factor

Only those areas considered to be critical are designated Ep. Accordingly, the constraint factor is high.

13.1233 Recognition of Ep Category

Delayed forest regeneration is a natural occurrence and is not necessarily induced or aggravated by logging. Therefore, areas where past management practices have resulted in delays in natural reforestation or, more recently, plantation failures, should be used as a guide only. In other words, the site itself rather than site reaction to treatment, or degree of disturbance, should be the chief criterion for Ep designation.

Recognizing the complexity of an ecosystem and that any given environmental variable rarely acts alone, the delineation of Ep areas involves consideration of all known elements of macro-climate, soils and living organisms - a difficult task. For ease of reference, the major variables can be grouped under the headings of (1) ASPECT: (2) LANDFORM: (3) UNDERLYING BEDROCK AND SURFICIAL MATERIAL: (4) ALTITUDE AND LATITUDE: and (5) BIOTIC INFLUENCES.

13.12331 Aspect

The influence of aspect varies markedly by latitude, regional climate, altitude and slope angle. Critical exposures are generally south, southwest and west. In the dry southern Interior, for example, the elevation of the timberline is often lower on southern exposures. In northern British Columbia, however (about latitude 57°N),
the situation may be reversed. That is, north-facing slopes are critical because of prolonged deep snow or intense cold on sites unprotected by snow cover. Here timberline elevation is generally higher on southern exposures.

In many cases, aspect will be a major factor determining whether or not an Ep label is warranted. Temperature and drought, both influenced by aspect, may seriously affect regeneration.

13.123311 Temperature

Soil surface temperatures can reach lethal levels during the growing season. Seedling die-off in sun-exposed habitats may occur as low as 49°C. Also, frost-heaving of germinants and seedlings commonly occurs on exposed, heavy, wet soils, especially clays and silts (refer to section 13.123334). The effects of temperature are modified by soil moisture content and the thermal conductivity of surface layers (organic versus bare mineral soil).

13.123312 Drought Conditions and Soil Moisture Relationships

Wind is the dominant factor in determining evaporation. Evaporation may be greater on shaded windward slopes than on sunny lee slopes. The prevailing wind may also determine snow accumulation and distribution. See diagram Appendix A-40. Other evaporation factors are relative humidity, temperature, soil type and soil moisture content.
Drought severity is modified by the hydrologic behaviour of the soil. Water from melting snow can either percolate into the soil or run off the surface, depending on the amount of frost in the ground. In relation to aspect, solar radiation and rapid snowmelt on southerly exposures contributes to drought conditions. Also, water run-off of summer rains is faster because of sparse ground vegetation.

Under drought conditions there is reduced biological activity in the soil (less nitrogen transformation; lower rate of soil development; soil is generally less productive).

Site deterioration is usually the outcome when thin organic layers overlying bedrock are disturbed by logging, leaving barren, rocky conditions.

13.12332 Landform

Consider the following landforms as critical areas where Ep designation is probable.

13.123321 Knolls and Ridges; Eskers

Very dry and thin soils are common along the tops of ridges. Seepage waters, vital for nutrient supply as well as moisture itself, are generally minimal or absent.

Wind can also be a critical factor as evaporation is much higher on wind-exposed ridges. At higher elevations transfer of snow by wind can result in significant side effects: - a wind-blown ridge, bare or with a thin unprotective snow cover, is subject to deep ground frost penetration.
- snow deposition on ridges is minimal and hence a moisture deficiency usually exists.
- leeward slopes with persistent deep snow accumulation may be prone to seedling snow-blight (parasitic fungi).

13.123322 Exposed Bluffs, Headlands and Island

Prevailing onshore winds alone may not cause regeneration delay, but added to other factors (soil depth, rockiness, windblast, dessication, salt spray, seed source) it could become critical to certain tree species. Sitka spruce benefits from the supply of magnesium in ocean spray.

13.123323 Talus Slopes Below Outcroppings; Loose Colluvial Material

Once logged or burned, these sites may revert to a non-productive state for a recovery period of 50 or more years. In extreme cases, recovery and re-establishment of forest growth may not be possible. Labelling is optional as either Es, Ep or Esp, but not Eps.

13.123324 Lowland Swampy Areas; Moist Depressions

Removal of the forest cover and resultant reduction in evapo-transpiration (not offset by exposure) may lead to local soil saturation on these sites. A higher water table generally compounds an already unfavourable growing situation.

13.123325 Sand Dunes

As with some factors already mentioned, sand is basically a soils-related problem. Though occurring only rarely in B.C., sand
dunes are sensitive areas and must be treated accordingly. The removal of forest cover, or indeed any cover, is often irreversible. The protective mat of vegetation should not be disturbed.

13.123326 Slope

Consider slope only in conjunction with other factors such as amount of snowfall, elevation, aspect, etc. For example, in regions of heavy snowfall, the removal of forest cover adjacent to brushed-in subalpine areas tends to predispose the site to snow creep and further downslope encroachment by brush. The invasion by brush can inhibit the establishment of commercial species, and snow creep can shear off or uproot seedlings if freeze-thaw events are common.

Avalanches - refer to Ea section.
Soil creep, talus creep and ravelling - refer to Es section.

13.123327 Valley Bottom Depressions

Rely on local knowledge for areas of poor air drainage and frost pockets.

13.123328 Floodplain

River-flat stands subject to violent annual or periodic flooding often exhibit long regeneration delays following disturbance. The early seral stage of succession is usually brush cover. Consider a choice of species for planting - Sitka spruce, red cedar, hardwoods - before Er designation.
13.12333 Underlying Bedrock and Surficial Material

13.123331 Drought

Drought conditions are sometimes caused by the porous nature of the bedrock, such as sandstone or inclined bedding planes. Sub-surface seepage waters may be entirely absent. Non-climatic drought is accentuated where unfavourable bedrock coincides with southerly aspect or extreme coarseness of surficial material.

13.123332 Nutrient Deficiency and Depletion

Certain soils are low in major nutrients and high in elements toxic to organisms, as in serpentine outcroppings. If possible, rely on local knowledge or research.

Also consider high elevation folisols, sandy soils and coarse well-drained river-terrace soils of glacio-fluvial origin. Harvesting on such sites may result in nutrient depletion. Similarly an intensive burn, particularly in mountainous terrain, where all the organic matter is consumed, could result in severe nutrient volatilization, especially nitrogen, which is confined to a very thin layer.

13.123333 Soil pH

Most forest trees will grow over a considerable range of pH, and it is only the extremes that are critical. For instance, over the pH range of 7.5 to 4.0. Douglas fir could grow quite well, but at 3.0 the hydrogen ion itself may damage the plant. Above 7.5, the change in the availability of elements may
be the critical factor in limiting growth. For other tree species, the preferences are as follows:
- White spruce - exists over a wide range of acid conditions.
- Sitka spruce - optimum growth on near neutral sites.
- Western red cedar - prefers neutral (7.0) to slightly acidic soils.
- Yellow cedar - prefers neutral (7.0) to slightly acidic soils.
- Western hemlock - grows well on rather acid soils of pH less than 5.8 (regenerates best on very acid decaying coniferous wood).
- Grand fir - intolerant of very acid sites.
- Lodgepole pine - tolerant of a wide range of acid conditions.
- Tamarack - grows only on near neutral or slightly alkaline soils of pH 6.6 to 7.6.
- Western white pine - intolerant of very acid sites.

Highly alkaline soils (pH 9+) occur in areas of limestone bedrock or similar parent material where evaporation exceeds summer rainfall causing groundwater to be drawn to the surface. The result is a concentration of calcium and carbonates in the upper soil layers.

13.123334 Frost Heaving

This occurs in all regions of the Province in soils having a high clay content, and in silty loams. Frost heaving results in shearing of rootlets or "throwing" of container seedlings. Rely on local knowledge.
Altitude and Latitude

Altitude alone is not a factor in designating Ep areas. However, many environmental influences are fixed by the regional climate and increase adversely with increasing elevation. The cumulative effect of adverse factors is significant.

The length of the growing season (frost-free period) determines, to a large extent, the establishment, success and rate of growth of new forests. At higher elevations a short growing season may not allow seedling root systems to develop sufficiently to withstand drought stresses and temperature extremes.

Ultra-violet radiation at higher elevations may be significant in reducing regeneration success. In addition, snow cover on adjacent terrain can reflect enough sunlight to double radiation intensity. Also, freeze-thaw cycles are more prevalent, especially during the growing season.

Windblown snow and ice particles may inflict physical damage to the buds and branchlets of seedlings projecting above the snow.

Seed crop periodicity is partly influenced by elevation and latitude. An average of more than 10 years between heavy cone/seed crops is unfavourable to natural regeneration. Zones in which seed crops are likely to be infrequent are:

- Southern Interior: 1,515 m+
- South Coast: 600 m+
- Northern Interior: 55°N and more; cool, moist summers as above
13.12335 Biotic Influences
13.123351 Wildlife

High ungulate populations as evidenced by overbrowsed brush or a well-defined browse line can seriously affect the growth of young trees. Also consider winter ranges where the availability of forage is limited by snow cover. Seedlings projecting above the snow may be browsed until killed. Rely on local knowledge.

13.123352 Integrated Use

A normally productive area may be static or deteriorating due to heavy grazing or trampling by domestic cattle. Consider (1) areas adjacent to sub-alpine livestock summer ranges; and (2) open grown climax forests of ponderosa pine and Douglas-fir and in semi-arid climates. Basically these are management problems of the past and may not hold true for the future.

13.123353 Vegetative Ground Cover

Extensive areas of brush, mostly of fire origin, are a common occurrence in parts of the Province, especially the northern portion. Much of this potentially productive land is currently classified as NCBr (non-commercial brush) and will require time or treatment before forest growth is resumed. Ep designation, if warranted, could be applied to neighbouring forest stands as well as the brushed-in areas. This is a very difficult situation to assess and designation as Ep should be made only after consideration of all factors. The District Silviculturist should be consulted whenever possible. Ep must be used with caution in these situations.
Ep Summary

Following is a summary of factors and stand characteristics most likely to indicate an Ep problem.

Remember - it is the site itself rather than the site's reaction to treatment or degree of disturbance that is the chief criterion for Ep designation.

a) Aspect

(i) Critical aspect is related to latitude and degree of slope. In southern B.C. most problems are found on dry, hot, south to southwest exposures. Good problem indicators include mature, open grown Py, PyF, FPy, F stands growing on convex slopes with little or no advance regeneration.

In northern latitudes, north to east aspects are most suspect because of long periods of frozen ground and a short vegetative season.

b) Landform

(i) knolls, ridges and some site specific landform features with coarse outwash material.

(ii) exposed coastal bluffs, headlands and islands.

(iii) some talus slopes with coarse, rapidly drained textures.

(iv) areas with high water tables, e.g. outer coastal lowlands, swampy areas, etc.

(v) sand dunes.

(vi) steep, sub-alpine, high snowfall slopes prone to excessive snow movement. Problem indicated by a crown canopy with multiple steps or scars from recurring snow slides, i.e. resembles a reverse shingle effect.
c) Underlying bedrock and surficial material
   (i) non climatic drought caused by porous rock.
   (ii) highly alkaline soils.

d) Altitude
   (i) high elevation sub-alpine forests. Problems due to excessive radiation, prolonged snow-packs, short growing seasons, infrequent seed crops. Problem indicated by sparse, clumpy stocking and little advance regeneration.

e) Biotic
   (i) areas deteriorating because of domestic cattle e.g. open grown climax forests of ponderosa pine and Douglas-fir bordering open range in semi-arid climates.
   (ii) areas classified as non-commercial brush and adjacent forested areas with a high potential for reverting to brush, i.e. open timber with heavy underbrush. (Handle these areas with caution).
13.13 Ei - Guidelines for Inoperable Problem Areas

13.131 Objective

To identify and delineate merchantable timber or potentially merchantable timber which is inoperable because of some obvious physical barrier or other limitation.

13.132 Sources of Information

Advance preparation and close liaison during the field season are essential for this category. The following people should be consulted:

a) Forest Service district personnel - Zone Forester, District Engineer, Forest Rangers.

b) Industrial foresters, engineers, wood managers, etc.

13.133 Procedure

13.1331 General

The assessment for Ei should only be undertaken following consideration of all other environmental factors. While many factors restrict the development and harvesting of timber the Ei constraint is only applied to timber that will not be harvested over the rotation because of some physical barrier or restriction. The whole emphasis, then, must be placed on physical rather than on economic parameters.

Such areas are identified using a combination of air photographs, aerial reconnaissance and local expertise.

13.1332 Constraint Factor

A high reduction factor is used for this category as the timber is not likely to be logged within the rotation.
13.1333 Recognition of Ei Category

Merchantable or potentially merchantable timber that should be considered for the Ei designation includes:

a) Stands behind "blocked" access, e.g. hanging valleys, canyons, highways, railroads, parks, etc. (larger areas, cut-off by parks in particular, should be handled by Planning through N.R.L.'s (non-recoverable losses).

b) Narrow ribbons of timber, e.g. that extend up narrow valleys, or that are found between avalanche tracks.

c) Patches (isolated)
   (1) as fringes of mature timber on rough ground above logged areas.
   (2) as islands of mature timber within younger immature or any productive stand surrounded by non-productive or non-forest areas.
   (3) in the upper ends of long valleys, behind or above rock bluffs, slides, or younger immature forests.
   (4) isolated by rivers or other bodies of water.
13.14 Ea - Guidelines for Snow Avalanche Protection Areas

13.141 Objective

To protect man-made structures and other resource values from snow avalanches.

13.142 Information Sources

For a basic understanding of the mechanics of avalanches and avalanche prediction refer to Appendix A-9 or to the U.S.D.A. "Handbook on Avalanches". Additional sources of information include:

b) National Research Council (Peter Schaerer), 3940 West 4th Ave., Vancouver, B.C. V6R 1P5, Telephone 732-6619.
c) Snow Surveys - Water Resources - Victoria, Local 3432.

13.143 Procedure

13.1431 General

British Columbia's mountainous terrain has many avalanche zones. Snow avalanches have a potential for destroying man-made features and natural resources, and for disrupting transportation links.

The threat from most avalanches is confined to well-defined avalanche tracks or chutes. Potentially destructive snow movement zones can also be created by removing forest cover from steep slopes in high accumulation snow belts.

While it is difficult to control the effects from major avalanches it is possible to reduce the frequency and effects of smaller avalanches by using forest protection zones. Protection zones, however,
should only be considered for threatened values that can be effectively protected.

Candidate sites for Ea designation are selected using the following procedure:

a) Decide if the values being threatened warrant special avalanche protection.

b) If avalanche controls are necessary, determine the potential effectiveness of a protection forest as not every avalanche zone can be controlled in this way.

c) Where applicable, determine the type and design of the avalanche protection forests required.

13.14311 Values to be Considered for Ea Protection

Because an avalanche protection forest may remove commercial timber values for a long period, make certain that the values being protected warrant protection. Some values to consider include:

a) industrial development, urban and rural settlements.

b) major and secondary highways.

c) railways.

d) high use recreational sites.

e) power line towers.

f) medium to high site forest land.

g) steep, high-elevation sites subject to potentially lengthy regeneration delays from snow creep and slabbing, following harvesting (may also be handled under Ep).
Assessment of Avalanche Hazard

The science of predicting the frequency and magnitude of avalanches is not that well developed. Predictions should be based on several important factors that can either be interpreted from aerial photographs or extrapolated from climatic records.

The most important factors are:

a) climatic data: snowdepth, frequency and magnitude of snowfalls, direction of prevailing winds.
b) slope angle of starting zone.
c) profile characteristics of avalanche track.
d) evidence of avalanche activity.
e) characteristics of forest and non-forest cover within and adjacent to the snow track.

Design of Avalanche Protection Forests

Once there is a perceived need for avalanche protection, protection zones should be established where practicable, i.e. where forest stands are available to control snow movement. Control measures are possible:

a) within and adjacent to the starting zone.
b) on the windward side of the starting zone.
c) at the end of the runout zone.
d) using a combination of (a), (b) and (c).

Figure 13-1. Avalanche path. An avalanche path has three parts: starting zone, track and runout zone. Some paths also have an airblast zone near the runout zone.
13.143131 Starting Zone

The starting zone is the critical area of snow accumulation and this is where avalanche control is most important. As a general rule, all high elevation forests within or adjacent to the starting zone should be considered for protection. An example is given to illustrate.

![Diagram](image)

**Figure 13-2.** Protection forest in avalanche starting zone.

13.143132 End Zone or Runout Zone

In most instances, buffer zones in the runout zone will only be of benefit for controlling the smaller, low speed avalanches. There is little that will stop a major, high speed avalanche - but these are relatively rare.

The shape and size of the buffer zone should reflect the microtopography, the wind firmness of the residual forest cover and the configuration of the runout zone. A number of examples are shown (Fig's. 13-3, 13-4, 13-5, 13-6).
Avalanche Protection Forests

Figure 13-3. Road and Site Protection

Figure 13-4. No Protection

Figure 13-5. Railroad Protection

Figure 13-6. High Site Protection
13.1432 Constraint Factor

A high constraint factor will be assigned as the timber is not likely to be harvested within the rotation.

13.1433 Recognition of Ea Areas

Ea designations should be considered for the following situations:

a) Where man-made values can be protected from snow avalanches.

Damage from snow may occur at the ends of avalanche chutes or on steep slopes. For avalanche chutes the best protection is to leave forest cover within and/or adjacent to the steeper starting zones and at the end of runout zones. Highways and railways that traverse steep slopes can be protected by leaving belts of protective timber above the road or railway.

(Refer also to Appendix A-9 for a comprehensive treatment on the recognition of avalanche hazards).

b) Where timber removal will lead to site regression.

Under certain conditions and/or combination of steepness, elevation, heavy snowfall, aspect, local terrain, etc. sheet or slab avalanches can seriously delay reforestation efforts. In regions of heavy snowfall, in particular, the removal of forest cover adjacent to sub-alpine brushed-in areas tends to predispose the site to snow creep and further downslope encroachment by brush. Susceptible sites on timbered slopes are also known to occur below rock exposures.

Some of the above problems can also be considered for Ep.
c) Where there are patches or stands of younger immature timber growing in active avalanche tracks.

In many of the larger avalanche tracks, stands or patches of timber are established only to be periodically destroyed by major avalanches. Where there is evidence of this occurring, designate the forest cover with an Ea as timber harvesting is unlikely over the rotation.
13.15  Er - Guidelines for Recreation Values

13.151  Objective

To designate areas having significant recreation values which are sensitive to environmental modification, particularly from timber harvesting.

13.152  Information Sources

A general appreciation of the recreation values in a unit is desirable before starting to consider those which may warrant Er designation.

For this overview, consult the Zone Forester, the District Recreation section, and the Ranger staff, since in many units recreation values will already have been identified. However, if more information is desirable, seek District advice as to which of the following agencies might best supply the data required:

a) Resource Analysis Branch, Victoria.
b) Parks Branch, Regional or Victoria office.
c) Archaeological Sites Advisory Board, Victoria.
d) Historic Sites Advisory Board, Victoria.
e) Outdoor Recreation Council of British Columbia, Vancouver.
f) Local interest groups.

13.153  Procedure

13.1531  General

Recreational features for Er should be identified and classified using the following procedure:

a) With the aid of the Forest District recreational planning maps, C.L.I. recreational capability maps, local knowledge, and air photos, pre-select all important recreational features for the unit. Features will include areas with present as well as future recreational potential.
b) With district guidance, assess the impact that management constraints will have on the contribution of each recreational area to the A.A.C. Protective features or constraints against logging will likely vary from nil to total exclusion.

c) From (b) above, determine the appropriate E.P.A. classification for each candidate area, i.e. Er₁, Er₂, or nil.

d) Miscellaneous guidelines:
1) The Er₁ designation is intended for small areas where there are no harvesting options.
2) Ignore ownership and land status when defining and classifying Er areas, especially the boundaries of proposed parks and other reserves.
3) Where possible, have Er boundaries follow logical topographic features or other E.P.A. boundaries and type lines.

13.1532 Constraint Factors

Two classes of protection are used to preserve recreational values.

Er₁* - High constraint. Used for areas with exceptionally high recreational values and where harvesting would be severely limited or excluded over the rotation.

Er₂ - Moderate constraint. Recreational values are less than for Er₁ but still sufficient to warrant a significant measure of protection. Harvesting of wood products would be permitted, but only on a limited scale over the rotation.

* Note: see Section 13.3214
13.1533 Recognition of Er Areas

Recreational areas fall into two broad categories, FEATURES and VISUAL AREAS.

13.15331 Features

13.153311 Locations with High Actual and/or Potential Use for Public Recreation

a) Concentrated, present use:

(1) Include recreation sites developed by the Forest Service (include both developed and potentially developable areas at each site).

(2) Include undeveloped locations, such as:

(i) unorganized picnic/camp area
(ii) roadhead ending at lakeshore
(iii) stops along trails
(iv) viewpoints

These are situations which could be, but have not yet been, developed under the F.S. recreation program.

b) Concentrated, future use:

Include those potential recreation use locations where it is reasonable to assume that public use will occur in the future.

c) Dispersed use areas:

(1) Include recreationally significant sections of the following:

(i) river banks
(ii) lake shores
(iii) trails
(iv) road margins

(2) Include areas that encompass a number of significant recreation features which are inter-dependent in providing a whole recreation experience (often found at higher elevations).
13.153312 Locations Carrying Natural or Historic Features

When reviewing the natural or historic features in a unit, examples of each item in the following list will likely be found. It is important to remember that NOT all of them will require an Er designation. Normally only those features of exceptional or outstanding quality (in the Unit context) will be given an Er rating. However, some examples of lesser quality in areas which are very sensitive to environmental disturbance (e.g. harvesting) may also be included.

a) Beach - sand, gravel or clay; having significant public use potential (regardless of length or width).
b) Sheltered waters - scenic bay or cover offering sheltered anchorage.
c) Islands - some islands situated in freshwater lakes and rivers, and saltwater.
d) Waterfalls (including major rapids) - significant for recreation, particularly viewing.
e) Small surface waters - pond(s), swamp(s), lake(s); not suitable for boating.
f) Thermal springs.
g) Geological formation - localized feature such as rock column, cliff, cave, hoodoo, talus slope, volcanic extrusion.
h) Vegetation - unique flora not found elsewhere in the unit or region.
i) Archeological site - location of pictographs, artifacts, middens, fossils.
j) Historic site - location of old (pre 1900) camps, settlements, structures, original sections of historic trails.
13.15332 Visual Areas
  13.153321 For Er Designation

  a) Visually sensitive areas (to recreationists), immediately adjacent to or surrounding specific features and public use areas, should be identified.

  b) Visually sensitive sectors of the following situations should also receive consideration for Er designation:
      - significant upland slopes bordering lakes.
      - significant margins of streams, major highways, recreation access roads, or major trails.

  c) Areas which are directly visible from settlements and which are considered visually significant should be designated as Er.

13.153322 Not for Er Designation

  Normally, visual values in middleground and background will not be included in Er designation. In steep terrain, these could include such large areas that the critical selection intent of the E.P.A. concept might be defeated. In flat terrain, middleground and background are not visually sensitive. A separate recreation inventory will be performed for these features.

  The exception to this is where a portion of middleground or background is extremely sensitive and very important visually to a particular public use site (i.e. a viewpoint).
13.15333 Classification of Recreation Values - Er₁ and Er₂

Er₁: 1. Recreation Sites
   2. Islands*
   3. Archaeology Sites
   4. Historic Sites
   5. Rare or unique features as directed by district

Er₂: 1. Beaches
   2. Sheltered Waters
   3. Waterfalls
   4. Small Surface Waters
   5. Thermal Springs
   6. Geological Formations
   7. Vegetation
   8. River Bank
   9. Lakeshore
  10. Trail
  11. Road Margin
  12. Visual Area

* Note: Normally, the recreationally significant smaller islands will be classified as Er₁. For larger islands the treatment is open and will depend on size, location, user pressures, etc.
13.16 Ew - Guidelines for Wildlife Values

13.161 Objective

To identify high value wildlife habitat areas that warrant special management consideration and/or protection.

13.162 Information Sources

The designation of Ew areas requires a great deal of cooperation with the Fish and Wildlife Branch of the Ministry of Recreation and Conservation. Their "Inventory Co-ordinator" in Victoria should be contacted before seeing the regional personnel. Other individuals or agencies to contact for further information are:


b) Canadian Wildlife Service, Delta.

c) Wildlife Biologist, Parks Branch, Ministry of Recreation and Conservation, Victoria.

d) Curator of Birds and Mammals, Provincial Museum, Victoria.

e) Forest Service district staff: i/c Planning, Zone Foresters, Rangers.

13.163 Procedure

13.1631 General

The wildlife resource is dynamic and resilient, yet sensitive to its environment and to environmental alteration. For optimal development and survival each species of animal requires a unique balance of environmental conditions, i.e. topography, climate, shelter, vegetation, etc. Any disruption of this balance can lead to a spectrum of responses, i.e. while an action might cause some animal species to
flourish, the same action might threaten the survival of others. Thus, it is not only important to understand the more critical relationships but also to identify habitats that must be managed or protected for individual wildlife species. While all species are important, the E.P.A. program is primarily designed to protect the critical habitat of the larger animals.

Unfortunately, very little base-line information is available for delineating critical habitats for much of the Province. Consequently, critical wildlife areas must be selected using a combination of quantifiable data from the Fish and Wildlife Branch, on-site examination, and by photo interpretation.

The following approach is used to identify Ew areas:

a) Localize the known important habitat areas using composite forest cover maps at a scale of 1:50 000. The information should come from: topographic maps, C.L.I. capability maps for ungulates, regional biologists, conservation officers, forest officers. The resulting information is a blend of capabilities, and occurrences, but it gives an initial identification of important wildlife areas by species.

b) Establish a set of guidelines for identifying priority wildlife areas that will meet the Inventory constraint categories of Ew₁ (high constraint) and Ew₂ (moderate constraint). These guidelines should be worked out on a regional basis in co-operation with the Fish and Wildlife Branch and Forest Service district personnel. Guidelines should be designed for use with air photography, forest cover maps and topographic maps.
c) Using the guidelines from (b) in combination with the habitat maps from (a) and air photographs, map the locations of probable important wildlife habitats, then define and label them on the air photographs.

d) Where time and access permit, ground check representative areas designated in (c) to test validity of the mapped areas. If necessary, consult the Fish and Wildlife Branch district personnel to modify the guidelines (b) to increase the accuracy of such mapping.

e) Miscellaneous:

(1) Ew1 areas in particular should be based on site-specific, quantifiable, and supportable information provided either by Fish and Wildlife or other agencies.

(2) Ew areas may be identified on non-productive sites.

(3) To facilitate mapping and summary, Ew boundaries should correspond to regular forest type boundaries and/or to other E.P.A. boundaries whenever possible.

13.1632 Constraint Factors

Two constraints are used. The choice depends upon the importance of the habitat being protected.

Ew1 - High Constraint

Areas of critical importance to wildlife. Timber removal would be seriously detrimental to the wildlife resource. This special category is intended for rare or endangered species or for extremely important habitat areas where wildlife require climax (old growth) forests.
Ew₂ - Moderate Constraint

Areas of high importance to wildlife where timber removal is possible but subject to management constraints. The Ew₂ is only to be used when a significant proportion of the wood within the important wildlife area will not be available for harvesting over the rotation.

13.1633 Recognition of Ew

13.16331 For Consideration as Ew₁

a) Small shelter stands which provide short-term but essential shelter from adverse conditions, i.e. thermal cover.

b) Areas which are required as mature or over-mature forest to supply an essential food source (e.g. to supply lichens and other blow-down food to sustain such species as mountain caribou and black-tailed deer in high snow areas during the winter).

c) Areas of variable size to protect rare and/or endangered species from disturbance (e.g. peregrine falcon nesting sites).

d) Areas of variable size to protect localized essential areas from disturbance (e.g. reproductive sites, mineral licks, migration corridors, bird colonies).

13.16332 For Consideration as Ew₂

a) Important habitat for regionally common species. These habitats, while not critical to wildlife survival, are still extremely important and

1. It should be noted that these categories are examples only. A regionally common species may require Ew₁ designations in some areas, whereas some rare species may benefit from an Ew₂ pattern.
require protection. An example would be a mature forest used by moose as a winter shelter area where timber extraction is permissible, but a certain amount of cover is needed to meet minimal requirements of the animal in question.

b) Only designate those Ew₂ habitats where the full Ew₂ constraint factor can be justified.
c) See Appendix A-11 for some habitat characteristics of major wildlife species.

13.1634 Map and Photograph Labels

13.16341 Species
The species are identified in the labels by lower case letters:

m - moose (e.g. Ew₁m or Ew₂m)
g - goat
d - deer
e - elk
s - sheep
c - caribou
o - birds

13.16342 Grizzly Bear
The E.P.A. areas for grizzly bear will be designated in symbolic form along salmon producing streams. These symbols will appear in the following manner:

\[ \text{Ew}_b \]
\[ \text{Ew}_b \]

The area enclosed by the symbols has a negotiable strip width and constraint percent.
13.17 Eh - Guidelines for Water Source and Watershed Protection

13.171 Objective

To identify watersheds or portions of drainages requiring special management considerations and/or protection to maintain water quality and quantity.

13.172 Information Sources

The Zone Forester and the Planning section of the Forest District should be the initial contacts when identifying watersheds requiring protection. Other sources of information should include:

a) The local Forest Ranger and his staff.
b) The Water Rights Branch, especially the Regional District Office which can provide specific detail regarding water licence commitments.
c) Appendix A.10.

13.173 Procedure

13.1731 General

Forest management activities in a watershed influence the quantity, quality and timing of water flow. Timber harvesting in general increases the quantity, changes the timing of flow, and, in many cases, impairs the quality of water in a watershed.

Degradation of water quality is minimized by using good logging practices and by limiting harvesting activities in sensitive areas. When the controls in these areas are expected to severely reduce the wood available over a rotation such areas are designated as an Eh.

Two methods are used in defining Eh areas: (1) buffer strips, and (2) whole or partial watersheds.
13.17311 Buffer Strips on Streams

A buffer or filter strip on each side of the stream may be used to protect a sensitive water-course from the impacts of road construction and logging adjacent to the stream and to aid as a filter for sediment washed down from disturbed areas.

Either a fixed buffer of 100 m on either side of the stream or a variable buffer may be used. The choice will depend on topography, soil texture, etc. The buffer strip is the most common method for protecting water values.

13.17312 Whole or Partial Watersheds

In rare or unusual circumstances either the whole of or part of a watershed may be "identified". However, this is generally only used for smaller watersheds which are officially designated on Management Atlas' and are heavily used, e.g. community watersheds.

13.1732 Constraint Factor

Two classes of watershed protection are used. They reflect the degree of protection needed for the candidate area.

Eh₁ - High constraint. Localized areas of critical importance to water production and where timber harvesting could have a serious adverse effect on the hydrologic regime.

Eh₂ - Moderate constraint. Areas less critical than in Eh₁, but where a significant form of protection is still necessary. Timber harvesting will be permitted in this area.
13.1733 Recognition of Eh Areas

The need for watershed protection is a function of the watershed's sensitivity to disturbance, and of the demand for water relative to supply.

13.17331 Watershed Sensitivity

Logging practices can have a major impact on water quality in terms of increased run-off and sedimentation. Run-off increases with the removal of ground cover and with soil compaction. Sedimentation is related to soil texture and stability, to the amount of ground disturbance, and to the frequency and severity of peak flows.

A watershed's sensitivity is also inversely proportional to its size, e.g. comparing two watersheds of equal sensitivity, a 100 h clearcut in a 200 h watershed will have greater impact on peak flows and sediment load than a 100 h clearcut in a 500 h watershed.

There are two types of sensitivity in particular that may justify an Eh:

1) Where an important water source is bordered by sensitive soils that do not justify an Es label but still require measures to protect water quality.

2) Where there is a consistent history of unacceptable water degradation from harvesting practices and where no practical harvesting alternatives exist.

13.17332 Demand Relative to Supply

The value of the water relative to that of the timber in a watershed is set by the market forces of supply and demand. Thus, if
there is high demand for quality water from a small, sensitive watershed the value of the water may justify severe logging constraints. Conversely, where demands are low for quality water an Eh is seldom justified. Most demand/supply situations will fall somewhere in between the two extremes.
13.18 Guidelines for Stream Protection for Fisheries Category

13.181 Objective

The objective of this category is to identify stream systems or reaches that are important for fish populations and which warrant special management considerations and/or protection.

13.182 Sources of Information

Document supported information is most reliable and should be used wherever possible. However, this information is not available from a single source, and therefore, a combination of sources must be consulted.

a) Ministry of Recreation and Conservation, Department of Conservation, Fish and Wildlife Branch (Victoria).
b) Regional Fisheries Biologist.
c) Regional Fish and Wildlife Habitat Protection Biologist.
d) Habitat Protection Unit, Fisheries Service, Environment Canada, Vancouver.
e) Regional Fisheries Officers, Fisheries Service, Environment Canada.
f) Local Conservation Officers, Fish and Wildlife Branch.
g) Water/Fish section, Resource Analysis Branch, Ministry of the Environment (Victoria).
h) Licensed guides and outfitters.

13.183 Procedure

13.1831 General

Environmental Protection Areas for fisheries protection should be designated in symbolic form as follows:
Watercourse line unaltered on maps unclassified, no information.

\(\Delta\) on watercourse (no constraint required)

\(\Box\) on watercourse (low constraint required)

\(\circlearrowright\) on watercourse (moderate constraint required)

\(\bullet\) on watercourse (high constraint required)

There are at least two reasons for this approach:

(i) Misinterpretation of "non-site specific" lines will be impossible.

(ii) Regional flexibility in defining the implication of the symbols for the A.A.C. will be possible.

- When constraint change along a watercourse the reaches will be shown as:

- Fish barriers will continue to be shown as the standard symbol for "falls" on forest cover maps. (\textit{Falls} \(\times\))

- Suspected values are to be omitted except when provided by fisheries experts.

(for further examples of mapping procedures refer to Section 13.3216).

13.1832 Constraint Factor

The method for calculating the impact of management constraints for fish protection against an A.A.C. is unique.
a) At the area summary stage each stream with stream values of • or better is measured for length and summarized by class exclusive of alienations, non-forest land, and other E.P.A. categories,
e.g. The total stream lengths, by class, for a unit might be equal to • = 11 000 m,
• = 14 000 m ◇ = 3 400 m
b) The total net length of each stream class is then multiplied by a constraint width. The higher the value the greater the width. • = 20 m,
• = 100 m, ◇ = 200 m
e.g. a unit with 11 000 m of class • and a constraint width of 20 m would have a constraint area of: 11 000 m x 20 m = 22 ha.
This area represents fisheries constraint areas to be used at some time, some where in the unit, to protect the fisheries resource. That is, although the constraint area is calculated as a strip along certain streams the timber values to which a management constraint will be applied will not necessarily be in those strips. This approach gives the biologists long-term management flexibility.

c) To account for reductions that fisheries constraints will have against the A.A.C. the contribution of the timber values within the constraint area is reduced by a fisheries constraint impact factor. The factor used will be negotiated between Planning in Victoria and the respective Forest Districts.

13.1833 Recognition of Ef Constraints

The need for protective measures is a function of both stream value for fisheries and stream system sensitivity to disturbance by forest harvesting.
Stream value is relative to several factors. Normally, a system occupied by any fish will be supporting a population adjusted to the productivity of that system. Commercial and sport fishery management, however, is designed to maximize the desired product, and hence minimize the "excess" fish within a system so that simple abundance is not always a reliable index of productivity. Additionally, emphasis is increasing toward enhancement of fisheries values (through removal of barriers to fish passage), so that absence of fish in an area with good enhancement potential should not necessarily be considered to eliminate fisheries values.

In the absence of stream inventory data, it will be necessary to evaluate the potential of a system on the basis of known habitat characteristics.

The habitat characteristics that best reflect potential productivity or value for fisheries can be generalized as follows:

nil = a stream reach with a gradient of more than 10%
low = a reach used primarily for migration of fish (usually sea-run species) to or between higher value areas where spawning or rearing occurs
moderate = a reach used primarily for rearing of juvenile fish. Such areas in streams are often characterized by the presence of back-channels, side-channels, a meandering stream bed, or occur as small tributaries with good protective cover from overhanging vegetation or cut-banks.
high = spawning areas and highly productive rearing areas. In lakes, the inlet and outlet areas are likely spawning areas. In streams, factors determining spawning value (e.g. gravel size, degree of compaction, rates of flow at certain times of the year) are very difficult to identify without extensive on-site inspection.

13.18332 Sensitivity

The sensitivity of a stream system is inversely proportional to its size. Hence forest harvesting will have an increasingly greater impact on smaller streams. With respect to system hydrology, the impact of harvesting will be directly proportional to the area of the watershed under forest cover above the point under consideration. Watersheds with complete forest cover will be more sensitive to harvesting than those with large areas in alpine or glacier. System sensitivity varies with:

a) streamside soil stability and erodability. (this factor may be reflected by Es designations. see 13.1131 d).

b) water volume. A deep and/or wide stream is less subject to disturbance than smaller, shallower systems.

c) stream flow regime. A large watershed exhibits a less "flashy" flow pattern than a short, steep system. Such fluctuations are usually amplified after forest harvesting. Also, lake-headed systems are usually more stable than comparable non-lake systems.

For more specific information pertaining to watershed management refer to the section on Eh (13.17).
13.1834 Selection of Symbol

The final selection of an appropriate symbol should consider both system sensitivity and value of the fisheries resource.

Stream Sensitivity

<table>
<thead>
<tr>
<th>Value to Fish</th>
<th>little sensitivity to disturbance</th>
<th>medium</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td>nil</td>
<td>△</td>
<td>△</td>
<td>■</td>
</tr>
<tr>
<td>low</td>
<td>■</td>
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<td>○</td>
</tr>
<tr>
<td>medium</td>
<td>○</td>
<td>○</td>
<td>◆</td>
</tr>
<tr>
<td>high</td>
<td>○</td>
<td>◆</td>
<td>◆</td>
</tr>
</tbody>
</table>

Figure 13-7. Selection of Symbol.
13.2 Field Procedures

13.21 E.P.A. Flight Planning and Aerial Reconnaissance

13.211 Objective

To identify, describe and delineate E.P.A.'s from the air.

13.212 Introduction

Once the obvious and marginal E.P.A.'s are delineated on the air photos they must be confirmed, modified or rejected either by ground or air examination. Most of this work is done by low-level helicopter reconnaissance.

A combination of formal air calls and informal observations is used for checking potential E.P.A.'s. Formal air calls are selected to give a representative cross-section of major problems and are summarized on E.P.A. assessment forms. Observations are quick checks and are recorded on the photos only.

13.213 Preparation

13.2131 Selecting Photo Scale

Most E.P.A. project areas will have a combination of photo scales available for E.P.A. flying - usually 20 chain (1:15,840), 40 chain (1:31,680), or 80 chain (63,360). Each scale has specific advantages. The best photo scale(s) for the project will depend on an assessment of: (1) the frequency, complexity and distribution of the problems, (2) the size of the area and (3) the quality of the photos available.
Advantages and disadvantages of available photo scales:

20 chain photos (1:15,840) and/or more recently 1:20,000

This scale is particularly good for an accurate, detailed study of E.P.A. problems. However, since most E.P.A. flights cover large areas this scale will necessitate a large number of photos, at least 100 or more for a normal three hour flight. Assembly time is high and navigation is more difficult because of extra photo shuffling and the small area covered by each photo.

80 chain photos (1:63,360)

Most of British Columbia is now covered by 80 chain photography. This scale is fast to assemble into a flight plan as few photos are required - perhaps eight to ten; there is less in-flight photo handling, which frees more time for observing; and the classifier can make aerial observations over a large area. However, some 80 chain photography is of very poor quality and the pin-pointing of E.P.A. boundaries is less precise than for 20 chain photos.

40 chain photos (1:31,680)

This scale was used for classifying much of the northern half of British Columbia. It is an excellent compromise for E.P.A. flying as it combines the advantages of both the 20 chain and 80 chain scales and is highly recommended when available.
13.2132 Flight Planning

There are three basic techniques for checking proposed E.P.A.'s from the air.

1) Formal flight plan using the pre-typed classification photos (1:15,840, 1:20,000, 1:31,680).

Using the typed set of photos with the preselected E.P.A. boundaries, assemble a conventional forest classification flight plan, i.e., select and denote a cross-section of E.P.A. problems as per forest classification air calls on the typed photos and connect them into a formal flight plan. E.P.A. assessment forms will be filled out for each air call.

2) Informal flight plan using typed photos.

This is basically an observation flight with an occasional formal air call. A flight path is selected and drawn on the photos to observe and describe as many problems as possible. Observations will be brief, entered into a tape recorder and summarized on the photos only. The formal air calls will be fully described and entered on E.P.A. assessment forms.

3) E.P.A. flight using 80 chain photos.

This technique may incorporate both informal observations and formal air calls. There are several options.

(a) Select a tentative flight route on the 80 chain photos, then transfer the boundaries of the proposed E.P.A.'s for checking to the 80 chain photos along the flight path chosen. These will be
checked either as formal air calls or as informal observations.

(b) Use the same approach as in (a) above but plan to insert a pre-typed 20 chain photo for each formal air call to be checked. This will permit a more precise identification and description of the problem area.

13.2133 Flight Plan Preparation

The actual flight patterns to be used will depend on E.P.A. characteristics, topography, type of helicopter and flying time available. Flight plans must be designed to maximize productive flying time and to ensure rapid, yet accurate observations.

The following steps are suggested for flight plan assembly.

(a) Flight plan units

First, select operational bases and possible refuelling depots for the helicopter. Next, using a good topographic map, divide the work unit into logical flight plan units. Units should have natural boundaries, be shaped to minimize ferry time and should not require more than 3½ hours flying time to complete (including ferry).

(b) Flight plan design

Design the plans as closed loops. This gives operational flexibility in that the plan can start at any point on the circuit. Design each flight path to check out various problems through a full range of elevations. When only one flight or pass is planned
through a drainage, at least attempt to
check the lower slopes and sensitive stream
borders that are likely to be affected by
development plans. When two or more flights
are anticipated, select routes on each side
of the drainage through a full range of
elevational problems.

(c) Navigation

Fast, accurate navigation is the key to
successful air classification. Navigational
accuracy is assisted by highlighting
specific topographic features on the
photograph in yellow. Mark only those
features visible from the flight path that
are not readily seen without a stereoscope,
e.g., knolls, small ridges. Use clear,
consistent symbols. Indiscriminate marking
of features is not advised as it clutters
the photo and obscures the E.P.A. problems.

(d) Communications

Establish a communication check-point for
each 10 to 15 minutes of flying, e.g., □, △,
□, △ etc.
*For examples of items d-g, refer to Fig.
13-11.

(e) Flight plan numbers

Give each flight plan a number and record
the number on each flight plan photo beside
the photo number.

(f) Photo numbers

Number each flight plan photo consecutively
at the top left hand corner.

(g) Photo ties

Establish good photo ties or connections
between photos along the flight path.
a. plan view

b. cross-sectional view

Figure 13-8. Single flight, one pass, variable elevation.
a. plan view

b. cross-sectional view

Figure 13-9. One flight, two passes, two elevations.
(h) Flight plan record

Prepare an operational base map to show flight plan routes, flight plan numbers, and radio check-points.

13.214 Flight Plan Procedure

Flight plan procedures should maximize the collection of meaningful information. This means adjusting the flying position and speed to place the classifier in the best position for observing and navigating. For optimum positions see Figures 13-8, 13-9, 13-10. While flying heights and speeds will vary greatly, speeds between 80 km/hr to 110 km/hr (50 mph to 70 mph) are most effective.

Except where safety is a factor the classifier has full control over the speed and position of the aircraft. The classifier should direct the pilot to alter course, speed, etc. if it will improve the quality of the work.

13.2141 Information to Collect and Features to Look for

The intent is to describe and confirm the presence or absence of marginal as well as definite E.P.A. candidates. The classifier should also be confirming photo features that can be used to recognize E.P.A. problems in areas not checked from the air. Remember - the more data obtained, the more reliable and defensible will be the maps.

Following is a summary of the most important features to look for by E.P.A. category.

(a) Soils
   - concentrate on areas of instability along streams and rivers.
   - note presence of talus slopes (especially
below rock bluffs), ravelling soils, excessive amounts of bedrock exposures.
- note steep slopes - measure the angles of a range of slopes in each drainage by suunto. Measurements of slopes should only be done with the helicopter flying straight and level. See Appendix A.12 which has a conversion table for degrees and percent.
- note and describe landform features with possible E.P.A. significance, i.e., fluvial terraces, lacustrine deposits adjacent to water courses.

(b) Regeneration
- concentrate on sites with a high probability for excessive regeneration delay such as open stocked semi-alpine areas; south to west aspects in the southern interior; open stocked brushed-in sites on moderate to steep slopes in the Prince George area; sites with high water tables; recent burns at high elevation; and steep slopes subject to snow movement.

(c) Operability
- note presence of rock bluffs, canyons, coarse colluvium. On steeper slopes over 40° rock bluff barriers are often difficult to see under old growth canopies. Check with a low pass close to the timber.
- in steep terrain look for deeply incised creek ravines that will limit road access.
- identify stands or patches too isolated to be recovered during the rotation.
- note presence of snags and decadence in marginally operable stands.

(d) Recreation
- assess and describe potentially valuable recreational features.
e) Fish
   - note fish barriers over 2 m.

f) Miscellaneous
   - note recent avalanche activity.
   - note and record the elevation for a number of
     points throughout each drainage.
   - take a series of 35 mm pictures of representative
     E.P.A.s during each flight.

13.2143 Recording In-Flight Information

a) E.P.A. Information
   The most efficient method for recording and
   storing information is with a tape recorder.
   Observation points should be cross-referenced to
   the photo using "a stabilo" pencil and a series
   of consecutive numbers or appropriate symbols.

b) 35 mm Photos
   For 35 mm pictures, record the frame number,
   the photo location, and direction taken, on the
   air photo. Store the descriptive details on tape.

c) Two Observers
   If two observers are flying, use the training
   board and headsets as an intercom and for recording.

13.215   Post Flight Plan Procedure

13.2151 Transferring Information from Tape

Information collected includes both tape
recorded observations and non-recorded visual
impressions. To optimize information retrieval
try to transcribe the information immediately
following the flight plan while details and
impressions are still fresh. The ideal method
is to remove the tape while studying the flight
route in stereo. This approach improves recall
and permits a comparison of photo characteristics
of confirmed E.P.A. sites against suspected but
unconfirmed E.P.A. sites.
Figure 13-12. Example of a photo (80 chain) with details of E.P.A. flight transferred from tape recording.

Key:
(i) E.P.A. designations
(ii) landform feature
(iii) slope in %
(iv) elevation
(v) natural feature description
(vi) recreation feature
(vii) direction and number of 35 mm photograph
(viii) date flown
Information may be summarized and stored in several ways:

a) E.P.A. Air-Calls
For each potential E.P.A. site treated as an air-call fill out an E.P.A. assessment form. This information is then summarized and stored on the typed photographs.

b) Observations
When using an informal reconnaissance flight most observations will be brief. This information can be transferred directly from the tape to the photo location and recorded in ink, (recommend a "Dart II" pen for 80-chain photos). Store details neatly and logically, with emphasis on the following: (see Fig. 13-12).

(i) Problems relating to soils, regeneration delay and operability. Note also marginal E.P.A.s that were confirmed as being operable.

(ii) Significant landform features. Use standard landform symbols to describe.

(iii) Slopes.

(iv) Elevations.

(v) Fish barriers.

(vi) Note important recreational features.

(vii) Record the location, direction and reference number of each photo taken. A separate, more detailed summary is also necessary.

(viii) Record date of flight on photos used if 80-chain.

c) Written Summary
It is useful for E.P.A. reports and follow-up meetings to have a brief, written summary of each E.P.A. flight. This should include a discussion of the major E.P.A. problems or values, either by E.P.A. flight plan unit or sub-drainage.
13.2152 Checking Pre-Typed E.P.A.s

The first E.P.A.s selected are at best an approximation, based on experience and intuition, but not much local knowledge. As local knowledge is acquired via flight plans or ground work the original E.P.A.s should either be confirmed, rejected or modified.
The following discussion describes why and how the area assessment form is to be used in the field. The form is intended for use by E.P.A. projects and standard inventory projects. In many cases the value of the form may be more apparent in standard projects as the classifier will have more time for ground inspection and a detailed analysis of the area. E.P.A. crews will have limited field time and therefore may not have the time to complete the detailed analysis. The form appears quite complex at first glance but after a few attempts the form will be quite self explanatory.

This form is intended to provide a record as to why a particular area was designated as an E.P.A. area or why the area was not given an E.P.A. designation. The forms are not meant to be completed at every site within the unit. It is intended that the areas for assessment will be selected through pre-typing or photo interpretation. The form would then be completed on these areas to determine whether they should have an E.P.A. designation. (In some cases the pre-typed area will show on ground inspection that an E.P.A. is not required and this form will be a record of why an E.P.A. was not designated). These forms will give a written record for classifiers to justify why and how areas were designated. These forms have been requested by District staff as they will have a record of areas assessed. Please complete the forms with as much detail and remarks as possible as they may be used by personnel outside of the Inventory Division.

The form has been designed so that the first page only, need be completed for an air assessment or a general ground assessment. The reverse side is intended primarily for ground assessment (although most details may be assessed from the air, e.g. - air call information as presently collected for timber types)
and is meant to substantiate the designation determined on the first page. The first page should be completed on all assessments.

In completing either page, it is not necessary to complete all sections, but it is desirable to complete as many of the sections as possible (i.e., on an Es site the soil features should all be assessed. At the same time, comments on the timber types, etc. (Ep), recreation potential, wildlife potential, etc. can be described as these may provide a secondary E.P.A. factor or give indications to substantiate your primary E.P.A. designation. For example: a stand exhibiting mixed age classes on a slumping soil area may indicate past disturbances).

The form was incorporated from several sources. The major portions were obtained from the present E.P.A. Guidelines (May 1978) and the Terrain Classification Manual (E.L.U.C., May 1976). Other sections were obtained from the Canada Soil Survey system and existing ground call sheets.

The following demonstrates how each section should be completed:

1) forest inventory zone (A-L)
2) region number
3) compartment number
4) special cruise number
5) name of P.S.Y.U.
6) method of assessment (check one)
7) list the appropriate river as shown by a topographic map of the area (e.g. Tamihi Creek - which is a tributary of Chilliwack River and part of the Fraser System - space should show Tamihi Creek only).
8) qualified the location of the assessment area - e.g.
   (1) unnamed creek at one km to west of Tamihí, B.C. 7807:186
   (2) km 0.7 - 1.3 on Tamihí Creek
   (3) upper 1/3 of Tamihí Creek
   (4) lower right quadrant of B.C. 7806:038
9) write the scale and photo number of photo used for E.P.A. assessment (1:10,000).
10) the area of assessment refers to the entire area enclosed by the E.P.A. line. (When an E.P.A. is not
designated the "XE" or "XGE" will be located at the centre of the area assessed). The assessment is
made on a representative portion of the E.P.A. area and this information is extrapolated to the
remaining area as is currently done for air-calls and ground calls.
11) assessment number
   - air assessments will be numbered XE 1-1, XE 1-2, XE 1-3, etc.
   - ground assessments will be numbered XGE-1, XGE-2, XGE-3
12) date of assessment.
13) classifiers name.
14) write the E.P.A. category, e.g. Es, Esp, Esi, etc.
   - if area does not warrant an E.P.A. write nil
   - if two or more categories are involved in one
   assessment area, list the order of importance,
   e.g. Es (70%) Ep (30%)
15) check whether 35 mm photo taken.
16) some people desired a space in which they could write their own photo code system - this space is available.
Aerial and/or General Assessment

17) elevation - actual specific point or range within assessment area - in metres if possible.

18) indicate area covered by each slope category, e.g.
   - steady slope of 50% would be shown
   - rolling topography or area with varying slope
     may be shown
   - the table is from the E.P.A. guidelines

19) check position(s) on slope.

20) surficial materials from E.P.A. Guidelines (Appendix A.821).

21) soil depth from E.P.A. Guidelines (Appendix A.821).

22) soil moisture
   - refers to the normal water content of the soil
     not to the drainage characteristics of the soil
     (Xeric-dry, Mesic-moist, Hygic-wet).

23) the mass movement indicators were taken from the
    E.P.A. Guidelines (13.11332) - the actual type of
    creep (e.g. soil creep) can be shown in the remarks
    section - the number/kilometre was devised to get
    a quantitative figure to obtain consistency between
    different classifiers (check off appropriate space).

24) erosion indicators - taken from E.P.A. Guidelines
    (13.11331) - check the indicator noted.

25) soil movement hazard (E.P.A. Guidelines - Appendix
    A.82).

26) remarks - this section can be used to describe the
    specific mass movement, other indicators of erosion,
    etc.

27) list the dominant forest types within the assessment
    area.

28) estimate the area coverage by the types listed in
    (27).

29) general remarks regarding stand vigour, etc. - this
    section will be especially important in a "Ep"
    designation.
30) Recreation - the guidelines for determining recreation values is shown in the E.P.A. Guidelines - check the appropriate feature(s).

31) Remarks - the most important information needed in this section is a description of the Recreation Values marked in (30) and their location on the ground.

32) check whether the site should be Er₁ or Er₂ and support your decision in the remarks section.

33) list the species to be protected.

34) indicate whether the species was sighted.

35) if species was sighted give numbers in this space; if game was not sighted list indicators such as browsing, pellets, etc.

36) describe the critical habitat - e.g. semi-open aspen stand surrounding lowland willow areas, southern aspect, spring calving area.

37) check (✓) if a browse survey was completed on this area.

38) check (✓) if a stream survey was completed on this area.

39) check which reduction factor is appropriate for the area.

40) indicate the values to be protected, e.g. highway, buildings, high value timber, etc.

41) check which reduction factor is appropriate for the area.

42) name the community this water source supplies.

Ground and/or Detailed Assessment

43) give actual slope measurements.

44) genetic materials - taken from the Terrain Classification Manual - E.L.U.C. (pages 6-12) - check appropriate material.

46) soil drainage - taken from "The System of Soil Classification for Canada" (pages 220-221). The definitions of soil drainage characteristics are as follows:

(a) rapidly drained - the soil moisture content seldom exceeds field capacity in any horizon except immediately after water additions

(b) well drained - the soil moisture content does not normally exceed field capacity in any horizon (except possibly the C) for a significant part of the year

(c) moderately well drained - the soil moisture in excess of field capacity remains for a small but significant period of the year

(d) imperfectly drained - the soil moisture in excess of field capacity remains in subsurface horizons for moderately long periods during the year

(e) poorly drained - the soil moisture in excess of field capacity remains in all horizons for a large part of the year

(f) very poorly drained - free water remains at or within 30 cm (12 inches) of the surface most of the year

- check the appropriate drainage

47) descriptive terminology - taken from the Terrain Classification Manual - E.L.U.C. (pages 13-20)

check appropriate description.

48) specific clastic - taken from the Terrain Classification Manual - E.L.U.C. (pages 1-5) - check appropriate class - see page 39-40 for field determination of texture for sand, silt and clay.


50) sample tree details from sample sheet - e.g. these sample tree details may verify why a specific site
warrants an Ep designation.

51) forest stand classification - basic format from forest classification sheet in present day use. This section is included to permit a more detailed assessment of the forest area being assessed, especially in designating "Ep" areas.

52) in a standard inventory project a ground call may be made at the same location in which case the number should be recorded.

53) this space is available for additional comments for any section and also provides space for a diagram of the assessment area.

54) if a diagram is drawn note the scale in this space.

55) check whether the classification of forest type was from the ground or air.
AREA ASSESSMENT FORM

F.I.Z. No. 1
R. No. 2
S.C. No. 4
METHOD OF ASSESSMENT:

☐ Air
☐ Ground

LOCATION: DRAINAGE 7
COMP. No. 3
SUB-DRAINAGE, ETC. 8
PS.YU. 5

AREA OF ASSESSMENT: (avg. width X length) _______ m X _______ m. 10

ASSESSMENT No. 11
DATE: 12
CLASSIFIER: 13
E.P.A. DESIGNATION: 14
35mm. PHOTO ☐ YES ☐ NO 15

AERIAL PHOTO:

Scale ______________________
Photo No. ______________________

AREA OF ASSESSMENT FORM

AERIAL AND/OR GENERAL ASSESSMENT

Es: % SLOPE % AREA

<table>
<thead>
<tr>
<th>% SLOPE</th>
<th>% AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-14</td>
<td></td>
</tr>
<tr>
<td>15-30</td>
<td></td>
</tr>
<tr>
<td>31-60</td>
<td></td>
</tr>
<tr>
<td>&gt;60</td>
<td></td>
</tr>
</tbody>
</table>

MEASURED

POSITION ON SLOPE: 19
☐ Upper
☐ Middle
☐ Lower
☐ Flat

SURFICIAL MATERIAL: 20
☐ Morainal
☐ Sedimentary
☐ Organic
☐ Rock

SOIL DEPTH: 21
☐ Thin 0-50 cm.
☐ Shallow 50-200 cm.
☐ Deep >200 cm.

SOIL MOISTURE: 22
☐ Xeric
☐ Mesic
☐ Hygic

ELEVATION: 17

ACTUAL OR RANGE.

% ROCK OUTCROP

ASPECT:

MASS MOVEMENT INDICATORS:

FEW MODERATE MANY

SLIDES

<table>
<thead>
<tr>
<th>No./km.</th>
<th>1-5</th>
<th>6-10</th>
<th>&gt;10</th>
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<tbody>
<tr>
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</tbody>
</table>

FLOURS

CREEPS

EROSION INDICATORS:

☐ Gullying 24
☐ Rilling
☐ Sedimentation

SOIL MOVEMENT HAZARD: 25

ACTUAL  POTENTIAL

FOREST TYPE(S) % AREA

REMARKS: STOCKING, STAND VIGOUR, ETC.: 28 29

FORE: 27

REMARKS: 31

RECREATION SITES 30
☐ Waterfalls/Rapids
☐ Lakeshore

ISLANDS
☐ Small Surface Waters
☐ Trail

ARCHEOLOGICAL SITES
☐ Thermal Springs
☐ Road Margin

HISTORIC SITES
☐ Geologic Formations
☐ Visual Area

BEACHES
☐ Vegetation

SHELTERED WATERS
☐ Riverbank

REMARKS:

SPECIES: 33

SIGHTED: ☐ YES ☐ NO 55

CRITICAL HABITAT DESCRIPTION: 56

VALUES PROTECTED: 40

COMMUNITY WATER SOURCE

BROWSE SURVEY 37
STREAM SURVEY ☐

Figure 13-13.
# GROUND AND/OR DETAILED ASSESSMENT

## GENETIC MATERIALS:
- [ ] Anthropogenic
- [ ] Organic
- [ ] Colluvial
- [ ] Bedrock
- [ ] Eolian
- [ ] Saprolite
- [ ] Fluvial
- [ ] Volcanic
- [ ] Lacustrine
- [ ] Marine
- [ ] Morainal
- [ ] Undifferentiated

## MODIFYING PROCESSES:
- [ ] Avalanched
- [ ] Karst Modified
- [ ] Bevelled
- [ ] Nivated
- [ ] Cryoturbated
- [ ] Piping
- [ ] Deflated
- [ ] Soliflucted
- [ ] Channelled
- [ ] Gulled
- [ ] Failing
- [ ] Washed
- [ ] Kettled

## SOIL DRAINAGE:
- [ ] Rapidly Drained
- [ ] Well Drained
- [ ] Moderately Well Drained
- [ ] Imperfectly Drained
- [ ] Poorly Drained
- [ ] Very Poorly Drained

## TEXTURE:
- [ ] Bouldery >64mm.
- [ ] Rubbly >2mm.
- [ ] Gravelly 2mm.-64mm.
- [ ] Sandy 0.4mm.-2mm.
- [ ] Fine Sandy 0.06mm.-0.4mm.
- [ ] Silty 0.004mm.-0.06mm.
- [ ] Clayey <0.004mm.
- [ ] Blocky
- [ ] Gravelly
- [ ] Rubbly
- [ ] Fines

## SAMPLE TREE DETAILS

<table>
<thead>
<tr>
<th></th>
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</table>

## COVER CLASS

<table>
<thead>
<tr>
<th>MAIN STAND(S)</th>
<th>Minor Species (10-19%)</th>
<th>Stocking</th>
<th>N.S.R. AREAS</th>
<th>REMARKS</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sp. %</td>
<td>Age Yrs.</td>
<td>Height</td>
<td>Diam. (G)</td>
<td>Sp. %</td>
<td>Inner</td>
</tr>
<tr>
<td>D.R.</td>
<td>L</td>
<td>L</td>
<td>PP</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>M</td>
<td>PR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S.D.</td>
<td>H</td>
<td>H</td>
<td>SF</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

## ADDITIONAL REMARKS AND/OR DIAGRAM:

Figure 13-14.
**AREA ASSESSMENT FORM**

**F.I.Z. No.** H  
**LOCATION:** DRAINAGE MUCANA CREEK  
**ASSessment No.** XGE-19  
**R.No.** 59  
**COMP. No.** 51  
**SUB-DRAINAGE, ETC.** ---  
**Kilometres Above** ---  
**WILLISTON LAKE**  
**E.P.A. DESIGNATION: E3**

**METHOD OF ASSESSMENT:**  
☐ Air  
☒ Ground

**AREA OF ASSESSMENT:** (avg. width x length) 100 m x 1000 m

---

### AERIAL AND/OR GENERAL ASSESSMENT

<table>
<thead>
<tr>
<th>% SLOPE</th>
<th>% AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-14</td>
<td></td>
</tr>
<tr>
<td>15-30</td>
<td></td>
</tr>
<tr>
<td>31-60</td>
<td>30</td>
</tr>
<tr>
<td>&gt;60</td>
<td>70</td>
</tr>
</tbody>
</table>

**MEASURED:** 65%

**POSITION ON SLOPE:**
- Upper
- Middle
- Lower
- Flat

**SURFICIAL MATERIAL:**
- Upper
- Middle
- Lower

**SOIL DEPTH:**
- Thin 0-50 cm.
- Shallow 50-200 cm.

**SOIL MOISTURE:**
- Xeric
- Mesic
- Hygic

**EROSION INDICATORS:**
- Gully
- Rilling
- Sedimentation

**SOIL MOVEMENT HAZARD:**

**ASPECT:**

**% ROCK OUTCROP:**

**REMARKS:** FREQUENT UNDERCUTTING OF SLOPE BY MEANDERIN

---

### MASS MOVEMENT INDICATORS:

<table>
<thead>
<tr>
<th>SLIDES</th>
<th>FLOWS</th>
<th>CREEPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEW</td>
<td>MODERATE</td>
<td>MANY</td>
</tr>
<tr>
<td>No./km</td>
<td>1-5</td>
<td>6-10</td>
</tr>
</tbody>
</table>

---

### ELEVATION:

**ACTUAL OR RANGE:**

---

### FOREST TYPE(S):

<table>
<thead>
<tr>
<th>SB 89-M</th>
<th>GS 53-P</th>
</tr>
</thead>
<tbody>
<tr>
<td>40%</td>
<td>60%</td>
</tr>
</tbody>
</table>

**REMARKS:** STOCKING, STAND VIJOUR, ETC.

---

### SOIL PROPERTIES:

**REMARKS:** NEGLIGIBLE RECREATION VALUES - SOMMER RESIDENT TROUT NEAR CREEK MOUTH

---

### CRITICAL HABITAT DESCRIPTION:

**REMARKS:** FOR MOOSE ALONG STREAM

---

### SPECIES:

**SPECIES:** N/A  
**SIGHTED:** ☐ YES ☐ NO

---

### VALUES PROTECTED:

**VALUES PROTECTED:** N/A

---

### COMMUNITY WATER SOURCE:

**VALUES PROTECTED:** N/A

---

Figure 13-15.
**GROUND AND/OR DETAILED ASSESSMENT**

**Es:**
- Genetic Materials:
  - Boxed: Anthropogenic
  - Boxed: Organic
  - Checked: Colluvial
  - Checked: Bedrock
  - Checked: Eolian
  - Checked: Saprolite
  - Checked: Fluvial
  - Checked: Volcanic
  - Checked: Lacustrine
  - Checked: Marine
  - Boxed: Morainal
  - Boxed: Undifferentiated

**Soil Drainage:**
- Checked: Rapidly Drained
- Checked: Well Drained
- Checked: Moderately Well Drained
- Checked: Imperfectly Drained
- Checked: Poorly Drained
- Checked: Very Poorly Drained

**Texture:**
- Checked: Bouldery >64mm.
- Checked: Rubbly >2mm.
- Checked: Gravelly 2mm.-64mm.
- Checked: Sandy 0.4mm.-2mm.
- Checked: Fine Sandy 0.06mm.-0.4mm.
- Checked: Silty 0.004mm.-0.06mm.
- Checked: Clayey <0.004mm.

**Specific Clastic:**
- Checked: Blocky
- Checked: Gravelly
- Boxed: Rubbly
- Boxed: Fines

**Modifying Processes:**
- Checked: Avalanching
- Checked: Karst Modified
- Checked: Bevelled
- Checked: Nivated
- Checked: Cryoturbated
- Checked: Piping
- Checked: Deflated
- Checked: Soliflucted
- Checked: Channelled
- Checked: Gullied
- Boxed: Failing
- Boxed: Washed
- Boxed: Kettled

**Remarks:** Active erosion occurring where river undercutting fluvial terraces and spewage from upper slope causing gullying.

---

**SAMPLE TREE DETAILS**

<table>
<thead>
<tr>
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</tr>
</tbody>
</table>

**FILL IN SAMPLE TREE DETAILS AS PER CLASSIFICATION SHEET**

---

**COVER CLASS**

**MAIN STAND(S)**

<table>
<thead>
<tr>
<th>Sp.</th>
<th>% Age Yrs.</th>
<th>Height</th>
<th>Ave. Diam. (g)</th>
<th>Sp.</th>
<th>% Im.</th>
<th>Stocking</th>
<th>OR(L-20 yr. mm.</th>
<th>N.S.R. Areas</th>
<th>Remarks</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 and all N.S.R only</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sp.</th>
<th>%</th>
<th>Age Yrs.</th>
<th>Height</th>
<th>Ave. Diam. (g)</th>
<th>Sp.</th>
<th>%</th>
<th>Im.</th>
<th>Stocking</th>
<th>OR(L-20 yr.</th>
<th>N.S.R. Areas</th>
<th>Remarks</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7</td>
<td>160</td>
<td>L/1</td>
<td></td>
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<td>1</td>
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</tr>
<tr>
<td></td>
<td>5</td>
<td>160</td>
<td>L/1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**COMPOSITION**

Stand Variations:
- Mixed stands, secondary stands, stands, regeneration (N.S.R. especially), disturbances, stand vigour.

**FOREST TYPE**

B5 831-P

**ADD ANY ADDITIONAL REMARKS**

---

Figure 13-16.
Figure 13-17. Air call therefore no information compiled for second page.
13.3 E.P.A. Mapping Procedures

13.31 Objective

To clearly delineate and classify those areas under an E.P.A. constraint.

13.32 Procedure

13.321 Typing Standards

13.3211 Clarity

The first and most important point when deciding how or where to draw an E.P.A. line is ease of interpretation. The line should be drawn in such a manner that it will be immediately apparent to the map user which areas are under constraint and which of the remaining areas are operable forest. This is not to say that all non-productive and other non-forest areas are to be typed out with E.P.A. lines. However, if including such areas with adjacent E.P.A.s might make the final map easier to interpret, then this should be done. (see Fig. 13-18).

Figure 13-18. High elevation non-forest areas.
High elevation non-forest areas (non-productive, alpine, alpine forest) will almost exclusively be separated from operable forest by an E.P.A. line. These areas will be keypunched as Eu (unclassified) at the summary stage.

Low elevation non-forest areas adjacent to E.P.A.s often involve complex type boundaries and the problems can only be solved by individual judgement. Large swamps or non-productive areas (non-productive burn, non-productive cover, non-productive brush) may be separated from operable forest if it adds to map clarity. However, on very complicated forest cover maps involving low elevation operable forest, non-forest and E.P.A. constraint areas, too many E.P.A. lines may ultimately detract from map clarity. Therefore, the area under E.P.A. constraint must first be clearly identified. Only as a secondary objective should non-forest areas be delineated. As it is impossible to describe all situations, the project supervisor, in consultation with the person drawing the lines, will have to decide which mapping procedure best achieves the mapping objective.

13.3212 Efficiency of Line

Although this issue is quite subjective, it should be kept in mind that the length of line used to designate E.P.A.s should be minimized wherever possible (but not at the expense of clarity). This means that in some cases, it is desirable to encompass Eu areas adjacent to specific E.P.A.'s. The following examples may be helpful. (See Fig's. 13-19, 13-20, 13-21).
a) Example 1.

Figure 13-19.
- easy to interpret
- almost same length of line and shorter in extreme cases

b) Example 2.

Figure 13-20.
- immediate clarity
- less line

c) Example 3.

Figure 13-21.
- immediate clarity
- less line
13.1213 Line Closure

a) Lines used to separate E.P.A.'s from operable forest are normally "complete" or "closed". They may or may not follow type lines as required. Exceptions to where the E.P.A. lines do not close on themselves, as with type lines, or where they touch or join natural topographic boundaries, such as shorelines or double-line rivers. (Fig. 13-22). Another exception is where they join adjacent projects which have not yet been mapped by current procedures. In this case the line may be left "hanging" at the project boundary. An attempt must be made to join from one completed unit to the next. (Fig. 13-23).

b) E.P.A. lines can be used to separate two or more kinds of E.P.A. within a single type. Lines used in this way need not be "complete" or "closed" but will end at type lines. (Fig. 13-24).
Figure 13-22. Line closure on natural boundary.

Figure 13-23. Line closure on adjoining unit.

Figure 13-24. E.P.A. line separating two or more E.P.A. categories within a single type.
13.3214 Labels

a) In all categories where a 90% constraint is used the subscript 1 will be assumed but not written, except for Eh₁, Er₁, Ew₁.
b) The subscript 2 will always be written when it occurs.

13.3215 Multiple Subscripts

Areas will be encountered where it is necessary to designate more than one E.P.A. category due to several interrelated resource values or problems. Expressing all relevant "E constraints" is done through the use of multiple subscripts.

13.32151 Guidelines for Establishing the Order of Multiple Subscripts

a) The subscript with the highest constraint factor always appears first. If reduction factors are equal, the classifier will have to place the permanent label first followed by importance, e.g. Esr, Epr, Esp, Epw.
b) Multiple subscripts should not be used as a "catchall" category. A second subscript should be added only when the values are worthy of protection. In exceptional cases of multiple values, up to three subscripts are allowable.
c) When using the inoperable label (Ei1), the "i" should always come second to another subscript of equal constraint. For example, Esi is permissible, while Eis is not. Also, Eir₂ is permissible as the "i" constraint is higher than the "r₂" constraint.
d) The reduction factor applied to the type is only that of the first subscript (i.e. not the sum of reduction factors implied by all subscripts).

13.3216 Use of Fisheries Symbols

Fisheries symbols are used to identify high value fisheries areas and to indicate the sensitivity of the habitat to disturbance. Therefore, a high value fish stream will not necessarily have a high constraint symbol (◆) applied to it. The stream may have very stable streamside soil and have a constant water flow over a wide, well-defined channel. In this case only a moderate constraint symbol (●) may be required.

Fishery symbols:  

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>▲</td>
<td>no constraint</td>
</tr>
<tr>
<td>■</td>
<td>low constraint</td>
</tr>
<tr>
<td>●</td>
<td>moderate constraint</td>
</tr>
<tr>
<td>◆</td>
<td>high constraint</td>
</tr>
</tbody>
</table>

Figure 13-25. Example of fish stream classification.
13.32161 Mapping Procedures

Only the area between symbols has a constraint factor applied to it. If the entire length of the river has a constant constraint, then it will be necessary to show symbols only at the edge of the map or photo. (Fig. 13-26).

![Diagram of creek or river with little constraint](image)

Figure 13-26. Constant constraint.

If constraints change across the map or photo, they will be mapped accordingly. (Fig. 13-27).

for example:

![Diagram of whole section of creek under constraint](image)

![Diagram of part of creek under constraint](image)

![Diagram with no symbol, values unknown](image)

Figure 13-27. Changing Constraints.
All symbols must be the same size and drawn on a horizontal plane only.

If the constraint is being carried across from the previous map, then there must be corresponding symbols at the edge of both map sheets where they tie. (Fig. 13-28).

Figure 13-28. Fisheries symbols tied together on adjoining maps.

13.32162 Special Mapping Problems

Situations will arise that do not fit into the standard mapping procedure. Some of the anticipated problems, and their solutions, are outlined below.

a) stream-lakes

A symbol must show where stream protection ends at a lakeshore (Fig. 13-29).

Figure 13-29. Fisheries symbols where streams enter and leave lakes.
b) stream widenings

If a stream widening is encountered which is not shown as a lake on the forest cover or base maps, and if protection is necessary, it may be mapped as in Fig. 13-30. This applies to all stream widenings such as natural ponds, beaver ponds and abnormal widenings that still have a steady flow of water through them.

![Figure 13-30. Stream widenings.]

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c) islands in streams

Constraint symbols will apply to multi-channels. If a back channel or side channel warrants a different fisheries symbol, it can be applied as necessary. (Fig. 13-31).

![Figure 13-31. Fisheries symbols for islands in streams and back channels.]

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13.322 Mapping Examples

a) Example 1

A hypothetical example (Fig. 13-32) best illustrates some of the major problems likely to be encountered in mapping. The encircled map reference numbers correspond to following remarks and considerations:

Figure 13-32. Example - Valley Side Slopes in Mountainous Terrain.
The following table summarizes the E.P.A. symbols used in mapping and the associated brief category descriptions.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Brief Category Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Es</td>
<td>Soils</td>
</tr>
<tr>
<td>Ep</td>
<td>Regeneration (plantation) problems</td>
</tr>
<tr>
<td>Ei</td>
<td>Inoperable problem areas</td>
</tr>
<tr>
<td>Ea</td>
<td>Snow chutes, avalanches</td>
</tr>
<tr>
<td>Er</td>
<td>Recreation Values</td>
</tr>
<tr>
<td>Ew</td>
<td>Wildlife</td>
</tr>
<tr>
<td>Eh</td>
<td>Water sources, watersheds</td>
</tr>
<tr>
<td>△,□,○,◆</td>
<td>None, low, moderate, high constraint to protect fisheries values</td>
</tr>
</tbody>
</table>

Two or more E categories are classified by multiple symbols, e.g. Esa or Epr, etc.

Map reference numbers

1 All hatched boundaries, whether Park, Park Reserve, Indian Reserve, etc., may be ignored for mapping purposes. This means that (a) E.P.A. lines do not stop at or follow a hatched boundary, and (b) E.P.A. labelling inside a hatched boundary remains unchanged. Thus Er for recreation is still shown even when the type is inside an established Provincial Park.

2 E.P.A. line usually conforms to shape of large avalanche track and follows type line.

3 In mountainous terrain, characterized by numerous finger-like avalanche tracks and/or small fragmented types, E.P.A. lines should be "smoothed out" or "shortcut" between type lines, to facilitate draughting, area summary and map user clarity.

4 E.P.A. line separating Es and Ea in the absence of a type line.
5. E.P.A. line separating Es from operable forest (punched as Eo at keypunching stage of summary) in the absence of a type line.

6. E.P.A. line in a non-forest area. An example is shown at 6A. Such designations should be made sparingly and only when justified by high value actual or potential resource use. Note that a dotted line is not necessary at 6b as a type line serves the same purpose. E.P.A. lines are not shown alongside a type line when other E.P.A. categories (also at 6c and 6d) occur within larger E.P.A. designations.

Collectively, the various E categories form a single zone, but only the outer E.P.A. line is continuous, passing through forest and non-forest areas alike, eventually closing on itself.

7. E symbols are not shown in unclassified non-forest areas.

8. Unless required, E symbols are not shown in non-productive or alpine forest E.P.A.s (such areas, again will be punched as Eu at keypunching stage of summary).

9. As with type lines, E.P.A. lines are not shown alongside natural type boundaries.

10. Multiple subscripts - a single label identifying two or more E categories. The category with the highest reduction factor is shown first. If reduction factors are equal, priority use is shown first.

11. Use of diamond fisheries symbol (♦) requiring high degree of constraint. Other fisheries category symbols include (▲) no constraint, (●) moderate constraint and (■) low constraint.
b) Example 2

Problem: To include rock and non-productive in leave strip?
Answer: No.

Problem: To include C in leave strip?
Answer: Only if a small area involved.

Figure 13-33. Leave strips along highways.

c) Example 3

Two alternatives are possible. Both are permissible.

Figure 13-34. Alpine, Alpine forest, productive forest complex.
d) Example 4

Problem: To include the non-productive?
Answer: You may if it adds to map clarity. In this case, yes, add the burn to the inoperable area.

Figure 13-35. Non-productive.

e) Example 5

No problem here. Remember E.P.A. line is a closed line around Alpine and Alpine Forest types, even if several map sheets are involved.

Figure 13-36. Alpine complex.
13.323 Transferring E.P.A.s to sepia maps from air photos (see also Fig's. 13-37, 13-38)

13.3231 General

a) All $E_1$ or $E_1 E_2$ areas are enclosed by a green line.
b) All $E_2$ areas are enclosed by a red line.
c) $E_1$ labels are in green, $E_2$ labels are in red.

13.3232 Specific

a) Where an $E_2$ area is adjacent to an $E_1$ a red line will be shown beside the green line on the $E_2$ side.
b) Where an $E_2$ area borders on an operable area, only a red line is necessary.
c) Where two different $E_1$ categories border in the same forest type they will be separated by a green line; bordering $E_2$ categories within the same type will be separated by a red line.
d) Where an E.P.A. line is following a type line care must be taken to follow the line closely.
e) Where a red and green line border, keep the lines close together.
Figure 13-37. Section from sepia map to show separation of $E_1$ and $E_2$ areas.

1. $E_1$ enclosed by green line
2. $E_2$ enclosed by red line
3. $E_1$ and $E_2$ areas bordering
4. Two $E_1$ categories being separated within the same type
5. Two $E_2$ categories being separated within the same type
Figure 13-38. *Section from sepia map to illustrate separation of combinations of E1 and E2.*
13.4  E.P.A. Report

13.41  Objectives

The E.P.A. report is designed for both regular and E.P.A. inventories. The objectives of the report are:

a) to standardize the information to be reported for each E.P.A. project
b) to provide a record of
   - procedures used
   - input received from outside agencies
   - major results from the survey


13.421  General Information

a) Name of unit (P.S.Y.U. or sub-unit)
b) Year of survey
c) Personnel responsible for survey (supervisors, classifiers, biologists, other)
d) Area description
   i) location and size of unit
   ii) biogeoclimatic zone(s)
   iii) other features or particular interest
   iv) include a topographic map of area

13.422  Outline of Procedures Used

a) Office Preparation
   i) photos (note last inventory from which photos uses, including photo scales(s) and year(s) of photograph)
   ii) procedures used for selecting E.P.A.s; i.e., refer to year of latest E.P.A. guideline
   iii) reference material, i.e. district E.P.A. maps, soils, landform maps, etc.
b) Field Procedures
   i) ground work
      - man-days expended
      - number of area assessment forms filled out
   ii) air classification
      - methods used (types of flight plan, photos used)
      - number of flight plans
      - hours flown, machine used, number of air-calls
      - information collected and method for recording
      - include flight plan map, when available
   iii) summary of input provided by outside individuals or agencies by E.P.A. category

c) Finalization
   i) nature of and number of finalization meeting(s) held
   ii) procedure used to finalize photos
   iii) procedure used to finalize maps

13.423 Summary of Problems and/or Values Found by E.P.A. Category (Could be done either by drainage or by unit)

a) Es - soil
   i) General - slopes 70%+, potential landform problems, thin soils, percent rock exposure, talus slopes, slumping, etc.
   ii) Specific - identify site-specific problem areas
b) Ep - regeneration problems
   Discuss in terms of:
   - regeneration delay, actual or potential, separate low elevation, mid-slope and high elevation problems
   - include a brief description of local climate if significant to the problem(s)
   - special problems

c) Ei - operability
   - could discuss general and specific operability problems
   - note special terrain problems: canyons, rock bluffs, hanging valleys, steepness, snow chutes

d) Ea - snow chutes
   Note specific areas where snow movement could be a problem to either man-made structures or to plantations.
   - note details of snowfall, snowpack, etc., if significant

e) Er - recreation
   Note - sources of information
   - importance of Er in unit and values most commonly recognized

f) Eh - watershed
   Note - sources of information
   - magnitude of problem and method for delineating Eh areas

g) Ew - wildlife
   Note - sources of information
   - importance of wildlife values, main species, etc. and method for delineating Ew areas

h) Ef - fish
   Note - sources of information
   - general importance of fish values
   - method for showing values on map
13.424 E.P.A. Constraints

List the E.P.A. constraints used for each category.

- \( E_s \) 90%  \( E_{r1} \) 90%  \( E_{r2} \) 50%, but can be negotiable between District and Planning
- \( E_p \) 90%  \( E_{w1} \) 90%  \( E_{w2} \) negotiable between District and Planning & F & W.
- \( E_i \) 90%  \( E_{h1} \) 90%  \( E_{h2} \) 50%, but can be negotiable between District and Planning
- \( E_a \) 90%  \( E_f \) negotiable between District and Planning & F & W.

13.425 Input from other Agencies

List the names of agencies and individuals contributing to the program; e.g.,

a) Forest Service
   - other division
   - Forest District staff
b) Other government agencies (Federal, Provincial)
c) Forest companies
d) Private citizens groups

13.426 Miscellaneous information and reports that might be added to the main E.P.A. report:

a) Enclose a small selection of appropriate 35 mm photographs to illustrate typical E.P.A. problems or values
b) Fish and Wildlife maps
c) Biologist's report
d) List of resource maps available for unit
e) List of reports or special studies that have significance to the E.P.A. study
f) Unit E.P.A. designation map

It will be useful to have a reduced forest cover map showing a color-coded distribution of the E.P.A.'s within the management unit. The scale should be either 1:63,360 or 1:125,000
depending on unit size and complexity.

Since the map coding should be standardized it is recommended that all projects use the following color code for showing E.P.A.s (Use "Mongol" pencils made by Eberhard and Faber).

<table>
<thead>
<tr>
<th>Category</th>
<th>Symbol</th>
<th>Color Code</th>
<th>&quot;Mongol&quot; Pencil Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>Es</td>
<td>Brown</td>
<td>936</td>
</tr>
<tr>
<td>Regeneration</td>
<td>Ep</td>
<td>Yellow-green</td>
<td>948</td>
</tr>
<tr>
<td>Operability</td>
<td>Ei</td>
<td>Purple</td>
<td>944</td>
</tr>
<tr>
<td>Avalanche</td>
<td>Ea</td>
<td>Yellow</td>
<td>967</td>
</tr>
<tr>
<td>*Recreation</td>
<td>Er</td>
<td>Light Blue</td>
<td>945</td>
</tr>
<tr>
<td>*Wildlife</td>
<td>Ew</td>
<td>Green</td>
<td>968</td>
</tr>
<tr>
<td>*Watersheds</td>
<td>Eh</td>
<td>Dark Blue</td>
<td>965</td>
</tr>
</tbody>
</table>

* To separate E1 areas from E2 areas write in "E2", where applicable.
Inventory

A.8  Soil Protection

A.81  Movement Of Surficial Material By Gravity*

A.811  Introduction

Downhill movement of rock and soil caused by the force of gravity is the most universal of all processes of erosion. Such mass movement mechanisms as landslides, slumps, earth flows, sheet wash, soil creep, and subsidence in combination with transportation by running water, glaciers, wave action, wind, ground water, and sea currents are responsible for most erosion. No matter where you are, you do not have to look far to find evidence of mass movement. Principles governing it are simple, but the variety of combinations of types of movement, of materials moved, and of geomorphic forms assumed by these masses is great.

The driving force behind all mass movement is the force of gravity. This force is directed toward the center of the earth, but components of it act along any inclined plane. The steeper the inclination, the greater will be the component of force acting down the slope. This force is most effective in moving materials that are unstable in their existing position, such as on surfaces over which they might slide, for example, fractures or bedding planes.

Downslope movements are of major importance locally and in combination with streams that are responsible for much long distance transportation. Downslope movements occur under all climatic conditions—in the air and under the waters of the oceans. Mass movement is even significant on the moon where there is neither atmosphere nor water.

Not only natural mass movements and resultant dangers are important to man; instability may be induced in rock and earth masses by our own modifications of the natural environment. As use of land is intensified, it becomes increasingly difficult to avoid areas where potential natural mass instability exists—areas where floods, wave actions, or earthquakes may trigger

* Reference obtained from Dr. N. Keser — original source unknown.

March '78
disastrous mass movements. Engineers must take great care to circumvent costly mass movements in planning and constructing building foundations, dams, reservoirs, bridge abutments, tunnels, and in designing cuts and fills along highways and canals. Costly and sometimes even disastrous results have followed where the dangers of potential mass movement have not been fully recognized or efforts to meet the danger have been too limited.

Classifications of Mass Movement

Numerous classifications of mass movements have been proposed. These are based on the type of material moved, the rate of movement, the presence or absence of water, or the mechanisms of movement.

In referring to materials moved, the terms rock, earth, soil debris, and mud are commonly used.

Rock. Applied to solid rocks and consolidated fragmental rocks.

Earth. General term used to describe disintegrated rocks and loosely consolidated sediments.

Soil. Product of rock disintegration and decomposition by weathering modified by biological agents; capable of supporting plant life.

Debris. General term applied to mixtures of rock, soil, plant matter, or mud.

Mud. Mixture of water and the finer particles of earth and soil.

Movements may take place through sliding along some surface or through an internal rotation of constituent particles, resulting in general flowage of the entire mass. Sliding is promoted by the existence of faults, fractures, bedding planes, and other planes of weakness. When these are inclined downslope, the material above can move along them. Flowage is a much more complicated process, involving rotation, slippage, or sliding of the materials inside the moving mass. Flowage of masses may take place slowly in nearly imperceptible movements called creep or at velocities of up to 96 kilometers an hour, as in debris avalanches. Flowage is possible in dry masses, but high water or ice

March '78
Inventory

Contents have pronounced affects on the nature and velocity of the flow.

The following classification devised by Sharpe (1938) is widely used. It separates the major categories on the basis of rate and type of movement, and subdivisions are made on the basis of the type of material moved.

Slow flowage

Rock creep
Talus creep
Soil creep
Rock-glacier creep
Solifluxion

Rapid flowage

Earth flow
Mudflow
Debris avalanche

Sliding

Slump
Debris slide
Debris fall
Rock slide
Rock fall

Subsidence

A.8121 Creep

Evidence of the slow downhill movement of soil or unconsolidated sediment is apparent on close inspection of almost every hillside. Weathered remnants of rocks and boulders may be drawn out into long, lens-shaped masses by creep. The small, parallel rows (Fig A-20), originally paths used by grazing animals, that circle many hillsides are signs of this creeping downslope movement. Fences and telephone poles set on slopes give indication of these surface movements as they slowly become inclined downhill. Observations of creep phenomena like the ones cited above indicate that creep takes place as a result of combinations of rotation of particles in the soil, drawing out of plastic materials, and probably other types of

March '78
Figure A-20. Soil creep causes these wrinkles on the ground surface.
Figure A-21. Talus cones. These cones line the side of this high mountain cliff in the Madison Mountains of Montana.

Figure A-22. A rock glacier seen from the trail pass near the head of Horseshoe Basin. Silverton quadrangle, Colorado.
Inventory

A.8122 Rock Fall and Talus Accumulation

Cliffs are formed along recent fault scarps, where resistant beds are eroded by stream action, and many of the most spectacular bare-rock cliffs, some thousands of meters high, have been formed where valley glaciers have eroded and deepened stream valleys in high mountains. Freezing and thawing are very effective in loosening rock fragments from cliffs, and other weathering processes are also responsible for inducing rock falls. Rocks usually dislodge other rocks as they fall, sometimes starting landslides. As this rock debris, called talus, reaches a lower slope, it piles up to form a cone-shaped feature called a talus cone (Fig. A-21). The cones may coalesce or, if rock fragments are not channeled into cones, a nearly continuous sheet of talus may form at the base of the cliff. Talus cones or sheets are composed of whatever rocks make up the face of the source cliffs. Mechanical weathering on such steep slopes, particularly freezing and thawing, is so much more rapid than chemical decay that the talus rocks on top of the piles usually appear freshly broken. These broken blocks are of all sizes, but seldom have dimensions smaller than several centimeters. Talus may form anywhere rock outcrops are subjected to weathering and erosion over long periods of time, where there is a cliff above a lower slope from which removal of materials lags behind the rate of accumulation.

A.8123 Rock Glaciers

On the floors of mountain valleys, talus may lie where it falls, moving at very slow rates and then only because it is disturbed by freezing and thawing, by animals, or by impact of new rocks falling on it. But if the valley floor is inclined, converging piles of talus may form a tongue-shaped projection down the valley. These lobes of talus move so slowly that their motion can be detected only by checking the position of the end of the lobe over a period of years. Such is the movement of the rock glacier (Fig. A-22). As a rock glacier advances it assumes garland-shaped loops, giving the appearance of a very viscous liquid. Some of these sheets have

March '78
<table>
<thead>
<tr>
<th>TYPE OF MOVEMENT</th>
<th>TYPE OF MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BEDROCK</td>
</tr>
<tr>
<td>FALLS</td>
<td>Rockfall</td>
</tr>
<tr>
<td>Few Units</td>
<td>Rotational</td>
</tr>
<tr>
<td>SLIDES</td>
<td>Slump</td>
</tr>
<tr>
<td>Many Units</td>
<td>Rotational</td>
</tr>
<tr>
<td>Rockslide</td>
<td>Debris slide</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>ALL UNCONSOLIDATED</td>
<td>Rock</td>
</tr>
<tr>
<td></td>
<td>Fragments</td>
</tr>
<tr>
<td>Dry</td>
<td>Rock fragment</td>
</tr>
<tr>
<td>FLOWS</td>
<td>flow</td>
</tr>
<tr>
<td>Wet</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rapid</td>
</tr>
<tr>
<td></td>
<td>earthflow</td>
</tr>
<tr>
<td></td>
<td>Sand or silt</td>
</tr>
<tr>
<td></td>
<td>flow</td>
</tr>
</tbody>
</table>

Table A-1. Classification of landslides, abbreviated version.

Figure A-23. Debris slide.
Sliding of rock, soil, clay mixtures over solid bedrock. Movement is slow to very rapid.
Figure A-24. Block-glide. Slow movement of blocks over a base with a low coefficient of friction - loess over clay in this case.

Figure A-25. Debris avalanche. Dry to moderately wet debris moving rapidly over bedrock. Movement is very rapid to extremely rapid.

Figure A-26. Debris flow. A very rapid flow in which there is a high water content in materials usually consisting of a mixture of rock, soil and clay.
considerable amounts of ice mixed with rock, making the movement of the rock glacier more rapid than glaciers at lower elevations and lower latitudes.

A.8124 Solifluction

This term, which literally means soil flowage, is applied to downslope movement of soils, rock debris, and other fragments in climates where the ground is solidly frozen in the winter and only partially thaws in the summer months. When thawing occurs, upper layers of the soil, which have been forced up and deranged by frost heaving, are bathed in melt-water. Lower layers of the soil remain frozen. Water above the frozen layer lubricates the interface. This facilitates flowage and slow movement of the upper layers over the lower frozen layers, even on very low slopes. The moving mass of soil and debris takes sheet, lobate, or tongue-like forms as it moves. Where valleys are present, it will move into and down them. The nature of the debris depends on the composition of the soil. On Bear Island in the North Atlantic the surface is covered with a thick flowing mud in the warm months, whereas in places on the Falkland Islands the debris is made up of quartzite fragments.

A.8125 Mudflow

Mudflows occur most frequently in deserts where fine weathering products are dry most of the year. When rain does fall it often comes in large quantities, perhaps with a large part or all of the annual rainfall coming in a single rain. Water seeps into the weathering products, and the mixture gathers momentum as it moves rapidly down steep slopes. These flows follow existing channels and gullies. Although a mudflow is not dry, the mass does not necessarily contain much free water. Sometimes even large boulders will float in the mud. Mudflows are favored by intermittent water supply, lack of vegetation, and abundant unconsolidated rock debris.

Some of the most disastrous mudflows have occurred on the steep slopes of the San Gabriel Mountains of southern California. Mudflows there are often preceded by extensive forest fires that

March '78
destroy the vegetative cover. One such flow started on a warm day when the heat caused melting of the snow cover in the high mountains. Melt-waters percolated into the thick, weathered cover of decaying schists. When the weathered material became saturated, it broke loose, leaving a scar extending 300 metres up the mountainside with cliffs 46 metres high around the edge. The mudflow continued for five days and at its height splashed mud 6 metres into the air, leaving a mud coating on treetops. The mixture was about 25 percent water.

A.813 Landslide Classification

The Highway Research Board landslide committee has proposed a classification of landslides (Table A-8.1) that includes most types of mass movement (Eckel, 1958). This classification is structured to bring out the interrelationships of the various factors involved in mass movements. It does not, however, differentiate such forms of movement as solifuction, creep, rock glacier, and talus accumulations, which are described separately.

A.8131 Landslides

Landslides are defined as "the downward and outward movement of slope-forming materials composed of natural rock, soils, artificial fills, and combinations thereof" (Eckel, 1958). (Sharpe [1938] restricted the term landslide to relatively dry masses). The type of material involved is classified according to its state prior to initial movement or, if the type of movement changes, according to its state at the time of the change of movement.

The type of movement and type of material provide the primary basis for the classification, with the amount of moisture, the nature of the surface on which movement occurs, and the speed of movement allowing finer distinctions within the broader framework of the classification.

A.8132 Falls

Falls occur when the mass in motion travels most of the distance through the air. Included are free falls, bounces, and rolling of rock and
debris fragments without much interaction of one fragment with another.

A.8133 Slides

Slides include movements caused by finite shear failure along one or several surfaces (Figs. A-23, A-24, and A-25). The mass may divide into only a few units or it may be broken into many units. When there are only a few units the material in motion is not greatly deformed. The movements may be controlled by surface of weakness such as fractures, faults, or bedding planes. The masses may move as a slump with movement along internal slip surfaces, which are usually concave upward, or as a block-slide movement (Fig. A-24) in which the units move out and down along a more or less planar surface of weakness, for example, bedding, fractures (Fig. A-34), faults, or the original ground surface. The mass in movement may break down into many smaller units when it is intensively fractured or when thin beds are separated by zones of weakness. The size of the individual unit is comparable to or less than the displacements between units. Movements of such masses are likely to go beyond the original slip surface so that parts of the mass slide over the ground surface.

A.8134 Flows

This designation is used when the form taken by the moving material or the apparent distribution of velocities and displacements resembles that of viscous flow (Figs. A-26 to A-30). Slip surfaces usually are either not visible or are temporary. The size of the individual particles in the moving mass is generally very small compared with the amount of movement.

When the movement is a combination of the three principal types of movement, the landslide may be designated complex. The following scale of rate of movement has been used by the Highway Research Board:

March '78
Inventory

Extremely rapid 3 m/sec. or more
Very rapid 0.003 - 3 m/sec.
Rapid 1.5 m - 0.003 m/sec.
Moderate 1.5 m/month - 1.5 m/day
Slow 1.5 m/year - 1.5 m/month
Very slow 0.03 m/5 years - 0.3 m/month
Extremely slow less than 0.3 m in 5 years

A.814 Principles Governing Mass Movements

The primary force involved in mass movement is the force of gravitational attraction, a body force that acts on every particle throughout the materials of the earth's crust. This force is directed downward toward the center of the earth and it acts with nearly uniform magnitude on surficial materials, yet some of these materials are so situated in their environment that they become unstable and move downslope while others remain stable. Chief among the factors that influence stability are the following:

1. a) The nature of the material.
   b) The structure of the material and its surroundings.
   c) The slope of the ground surface.
   d) The presence of water, ice, compressed air, or steam in the material.
   e) The presence or absence of stabilizing ground cover such as forests.

The factors combine in a variety of ways to determine the degree of stability.

Streams, glaciers, and dry mass movements are all driven by gravity. One might reasonably expect to have little difficulty in distinguishing a stream from a glacier, and either of them from a dry mass movement but the distinction is not so clear-cut. Glaciers carry heavy loads of rock, soil, and debris; so do streams; and mass movements usually contain some proportion of water or ice. The three types of movement are represented in Fig. A-35 by a triangular diagram that is indicative of the gradational character of each.

A.8141 Nature of the Material

Some earth materials are inherently strong, for example, massive granite, basalt, and
Figure A-27. Sand or silt flow underwater in uniform, saturated sand or silt. Movement is rapid.

Figure A-28. Earth flow. Mostly plastic flow here of weathered shale over unweathered shale.

Figure A-29. Loess flow (dry) as it occurred in Kansu Province, China (1920). Movement was extremely rapid.

Figure A-30. Rapid earth flow of wet soil. Flow has occurred in glacial clay and silt in this case.
Figure A-31. Slump. A rotational slump in bedrock is shown. Movement is at slow to moderate rates.

Figure A-32. Slump and earth flow combined, involving rotational slump of bedrock and soil.

Figure A-33. Failure by lateral spreading in clay over a soft clay. Movement is usually very rapid. See section on Alaskan earthquake.
Figure A-34. Close-up detail of some of the large rocks dislodged in the famous Frank slide, Alberta. These massive blocks of limestone slid along fractures during the landslide.
Figure A-35. Process of degradation.
Degradation is accomplished through breakdown and transportation of the crust. Under the pull of gravity these decay products move downhill, transported dry in water, in ice and in combinations of these three.
Inventory

quartzite, where the mineral components of the rock form an interlocking network of crystals or where the fragments are tightly cemented together. The bonds between the particles of such rocks are more uniformly strong in all directions through the rock mass than is found in most sedimentary and metamorphic rocks. Weakness in such rock masses usually is caused by structures (e.g., fractures) that may divide the massive rock into blocks. Among metamorphic rocks, planes of inherent weakness may arise as a result of compositional layering. Planes of foliation, schistosity, slaty cleavage, as well as fractures, are planes of weakness along which the rock may break.

The physical properties of sections of sedimentary rocks vary from layer to layer so that the layering generally imparts a plane of inherent weakness although individual strata may be uniformly strong in all directions. Some layers may be soluble (e.g., limestone, gypsum); others may have open interconnected pore spaces (e.g., sandstone, conglomerate); some, like shale, may be cleaved or subject to expansion on wetting.

Unconsolidated sediment also has a wide range of physical properties. The stability of fragmental materials such as sand, silt, and pebbles is greatly influenced by the degree of sorting, the angularity of the particles, the degree of cementation, the porosity and presence of fluids in the pore spaces, and even the texture of the surfaces of the individual fragments. The stability of clay is closely related to the degree of saturation with water and to the weight of the overlying material.

The principles governing mass movement differ with the types of material involved. Some materials owe their weakness to the existence of planes of weakness along which parting or sliding is possible. Instability in such materials is increased by anything that tends to induce slip or parting along those planes. Each fragment is capable of movement in granular materials so process or conditions that favor rotation, rolling or mass slip may induce instability.
Inventory

A.8142 The Role of Water

Water is usually present in the ground and it may play a crucial role in causing movement by one of the following mechanisms:

a) When clay colloids absorb water their plasticity is increased; the shearing resistance of wet clay is less than that of dry clay.

b) The chemical weathering of a number of common minerals is facilitated or caused by water, and clay is often a by-product of this weathering.

c) Water, especially rainwater, can dissolve rocks such as limestone and thus lead to reduction of strength of the rock and to development of cavities and the opening of fractures.

d) Water may act as a lubricant, reducing the frictional resistance between surfaces or between points of contact between fragments.

e) When a granular mass is saturated with water, the water has a buoyant effect, reducing the effective weight of each submerged grain by the weight of the displaced volume of water.

f) Under some conditions (treated later under ground water) water rising to the surface of the ground may be under pressure and will exert upward force on the material through which it moves.

A.815 Processes of Movement

A.8151 Fall

Free falls occur only on the steep slopes that are characteristic of massive rocks, such as igneous and metamorphic, or tightly cemented sedimentary units, although a few unconsolidated sediments may also stand in near-vertical cliffs. Rocks from the cliff may be wedged off by frost action, causing a face bounded by a fracture to fall away, or undercutting may simply proceed until the unsupported weight of the overhanging rock exceeds the breaking strength of the rock and it fails.
Subsidence and Collapse

Subsidence and collapse are significant forms of mass movement in areas where subsurface water is actively dissolving and removing rock, effectively undermining the surficial materials. Limestone, gypsum, salt, and anhydrite are the most common rocks that are likely to dissolve in sufficient quantity to produce large-scale subsidence or collapse; and of course the melting of ice frequently produces this result. Subsidence may also occur following release of gas or removal of large quantities of ground water or oil from reservoirs in unconsolidated or semi-consolidated sediment.

Subsidence is the gradual lowering of surface materials into space opened as result of removal of rock below. If the rock being removed is strong or if it is overlain by rock that is strong, a large cavity may be developed before failure takes place. Failure in such cases is likely to be sudden, followed by the collapse of the roof into the cave. The broken rock may form a coarse breccia when collapse occurs, but a crude layering may be preserved when subsidence takes place.

Sliding on a Surface

Sliding on a surface may be examined in terms of a block on an inclined plane (Fig. A-36). The weight of the block, which is directed down, may be resolved into two components— one acting down the inclined plane and the other perpendicular to the plane which is counterbalanced by the push of the plane against the rock. If the block is not moving, the component of force directed down the plane is counterbalanced by frictional resistance to such movement along the contact between the plane and the block. Instability can be induced by either increasing the inclination of the plane (steepening the slope) or reducing the frictional forces between the plane and the block.

The slope can be increased in nature as a result of either erosion or uplift; or man may cause the increase by removal of near-surface materials. The friction between the block and the plane is due to the nature of the surface, the presence of lubricants, and the weight of the
Figure A-36. Forces acting on a sliding block on an inclined plane. The weight is shown resolved into two components - one perpendicular to the inclined plane and the second acting down the plane.

Figure A-37. Terms applied to parts of a landslide. (after Varnes, 1958)
Inventory

The slope required for sliding is steep when the friction is great, but movements on very low slopes are possible when frictional resistance is low.

The plane may be a fracture surface, a fault, a bedding plane, or the surface of the ground. The block may be a large or small block of rock, massive or not, bounded by joints or masses separated by erosion from their natural continuations. One of the most common and potentially dangerous situations in which this type of mass movement occurs is that found where steeply inclined strata or fractures dip in the same direction as the slope of the ground surface and are undercut in the valley by streams, glaciers, or highway construction. When undercutting penetrates massive rocks and cuts into shales or other rocks with low shearing resistance, failure is likely because most strata are fractured and these permit separation as part of the mass slides downslope. Water may enter the potential zone of movement through fractures, and if the potential slide zone contains clay, resistance to shear in the zone will be significantly reduced.

A.8154 Slump

The term slump is applied to movements that involve a rotational shear type of sliding motion (Fig. A-37). These often combine with other types of mass movement, earth flow or mudflow, slides, falls and so on, and are one of the most common types of mass movement. Movement in a slump is more or less rotational about an axis that is parallel to the slope. Movements take place on internal slip surfaces; these surfaces appear as cracks in the ground at the head of the slump mass and usually have an accurate form, being concave toward the slumping mass. The slump may assume a spoonlike shape, as is common when slumps occur in uniform granular material, or they may have a cylindrical form where the slip surface runs parallel to the slope for some distance. Several varieties of slump are illustrated in Figs. A-32, and A-37; these differ in the nature of the internal slip surface and its relationship to the slope and to the structure of the slump mass. The slip surfaces tend to follow planes or zones of

March '78
weakness, such as the old soil surface where landfills have been placed, or jointed surfaces, faults, clay or shale zones, and highly cleaved zones; all of these are marked by low frictional resistance to sliding. Frictional resistance may be reduced further by wetting. Water flows into these zones of movement through cracks at the head of the slump, which pull open. As the slump mass rotates, the surface is tilted and water is directed toward the open cracks.

A.8155 Plastic Flow

Clay and clay mixtures are plastic; that is, they behave as elastic material if they are stressed below some limiting value, but if loaded beyond that limit they flow and deform continuously. Plastic behavior can be induced either by adding load on the material or by changing the plasticity of the material, notably by adding water to it. Water seeping down along fractures or through pore spaces into a claystone or mudstone may make the clay more plastic and thereby induce plastic flow or sliding. Shale can be altered to clay by water; limestone can be dissolved by ground water, leaving clay residue; and fault breccias are subject to similar weathering effects. Plastic flow can be initiated by adding weight artificially, as has happened during road construction over salt beds in the salt basins of Utah, and over clay beds in the Coastal Plain. Failure of the Fort Peck Dam in Montana was attributed to swelling and plastic flow of clays under the dam when water accumulated in the reservoir and seeped down into the clay layers. Plastic flow in the clays under the Panama Canal was caused by excessive loading when dredged material was piled along the sides of the canal.

A.8156 Failure of Granular Materials

Uncemented granular materials assume slopes of a certain steepness if they are free to move. If the granular material is uniform, the slope of that material does not exceed a particular value, called the angle of repose, usually 30 to 40 degrees. That angle depends on the shape of the fragments; rounded fragments tend to have lower angles of repose than rough-smooth-surfaced fragments. The angle of repose is a function of

March '78
Inventory

the size of particles, degree of sorting, density of materials, and the amount of anhydrous constituents. In short, the angle of repose is essentially a reflection of the cohesiveness of the fragments.

A.8157 Fluid Flow

We find in nature a completely gradational transition from forms of entirely dry mass movement to stream flow. The behavior of water in stream flow is true fluid flow of a viscous liquid. Liquids cannot support shear deformation; instead they move continuously under any applied shearing stress. The viscosity of a fluid is the internal friction or internal resistance the fluid offers to applied stresses. Because the viscosity of water is low, it cannot stand at different levels in a container or in a natural stream system. Fluid flow may be nearly laminar, in which one layer slips over another, or turbulent, in which the flow pattern of a particle of water follows an irregular path of swirls and loops.

As the water content of soil or debris on a slope increases, the clay fraction absorbs water and the plasticity of the mass increases; the contacts between solid fragments are lubricated; and eventually, if water content becomes very high the fragments are buoyed by the water. Under these conditions the mass flows in a manner analogous to a viscous liquid as the internal frictional resistance of the mass is reduced. Mudflows and solifluction are examples of this general form of mass movement.

March '78
Methodology For Designation Of Es Category For
82F - Cranbrook S.Y.U.

A.821 Es: Sensitive or Problem Soil Areas

Information available at the soil association
member level was used for this designation. The
parameters used to define an area of land as
sensitive were the following:

a) surficial material
b) texture
c) soil drainage
d) depth to bedrock
e) slope

Surficial materials were grouped into four
classes as follows:

Morainal (M)

Generally describes materials deposited by or
adjacent to glacier ice, but also includes colluvial
materials, i.e., loose, incoherent deposits derived
from bedrock and transported chiefly by gravity. All
are heterogeneous.

Sedimentary (S)

All materials transported and deposited by
water or wind action.

Organic (O)

Formed by accumulation of plant materials.

Rock (R)

Areas of rock, at the surface, which may be
consolidated or poorly consolidated.

March '78
The textures considered are as follows:

<table>
<thead>
<tr>
<th>Texture/symbol</th>
<th>Grain Size of Dominant Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>r Rubbly</td>
<td>Larger than 2 mm</td>
</tr>
<tr>
<td>b Bouldery</td>
<td>Larger than 64 mm</td>
</tr>
<tr>
<td>g Gravelly</td>
<td>2 mm - 64 mm</td>
</tr>
<tr>
<td>s Sandy</td>
<td>0.4 mm - 2 mm</td>
</tr>
<tr>
<td>f Fine Sandy</td>
<td>0.06 mm - 0.4 mm</td>
</tr>
<tr>
<td>g Silty</td>
<td>0.004 mm - 0.06 mm</td>
</tr>
<tr>
<td>c Clayey</td>
<td>Less than 0.004 mm</td>
</tr>
</tbody>
</table>

The slope classes considered are as follows:

<table>
<thead>
<tr>
<th>Class</th>
<th>Slope %</th>
<th>Slope Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0-9</td>
<td>A-D</td>
</tr>
<tr>
<td>2</td>
<td>10-14</td>
<td>E</td>
</tr>
<tr>
<td>3</td>
<td>15-30</td>
<td>F</td>
</tr>
<tr>
<td>4</td>
<td>31-60</td>
<td>G</td>
</tr>
<tr>
<td>5</td>
<td>60+</td>
<td>H</td>
</tr>
</tbody>
</table>

The depths to bedrock considered are as follows:

<table>
<thead>
<tr>
<th>Class</th>
<th>Name</th>
<th>Depth (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Thin</td>
<td>0-50</td>
</tr>
<tr>
<td>2</td>
<td>Shallow</td>
<td>50-200</td>
</tr>
<tr>
<td>3</td>
<td>Deep</td>
<td>200+</td>
</tr>
</tbody>
</table>

Shallow soils as designated by the legend for 82F were considered as shallow for this classification. Thin soils were those members defined as a lithic subgroup.

The amalgamation of soil drainage classes considered are as follows:

<table>
<thead>
<tr>
<th>Moisture Class</th>
<th>Soil Drainage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry</td>
<td>Well and rapid</td>
</tr>
<tr>
<td>Moist</td>
<td>Moderately well and imperfect</td>
</tr>
<tr>
<td>Wet</td>
<td>Poorly and very poorly</td>
</tr>
</tbody>
</table>

Surficial material, texture and moisture class are combined into what is termed a potential hazard rating. Five classes of potential hazard rating are defined and are designated as follows:

March '78
Inventory

Potential Hazard Rating

Moisture

<table>
<thead>
<tr>
<th>Texture-Material</th>
<th>Dry</th>
<th>Moist</th>
<th>Wet</th>
</tr>
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<tbody>
<tr>
<td>RM</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>bM</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>qM</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>sM</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>fM</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>cM</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>bS</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>gS</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>sS</td>
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<td>2</td>
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</tr>
<tr>
<td>fS</td>
<td>3</td>
<td>4</td>
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</tr>
<tr>
<td>gS</td>
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<td>5</td>
<td>5</td>
</tr>
<tr>
<td>cS</td>
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<td>5</td>
<td>5</td>
</tr>
<tr>
<td>O</td>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

These potential hazard ratings (P.H.R.) are then combined with slope and depth to bedrock to define an actual hazard rating (A.H.R.). The following table illustrates this.

Actual Hazard Rating

<table>
<thead>
<tr>
<th>Slope Class</th>
<th>0-9%</th>
<th>10-14%</th>
<th>15-30%</th>
<th>31-60%</th>
<th>61+%</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.H.R. TSD</td>
<td>TSD</td>
<td>TSD</td>
<td>TSD</td>
<td>TSD</td>
<td>TSD</td>
<td>Depth</td>
</tr>
<tr>
<td>1</td>
<td>LLL</td>
<td>LLL</td>
<td>LLL</td>
<td>MMM</td>
<td>HHH</td>
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<tr>
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<td>LLL</td>
<td>MML</td>
<td>MMM</td>
<td>HHH</td>
<td>S shallow</td>
</tr>
<tr>
<td>3</td>
<td>LLL</td>
<td>LLL</td>
<td>MMM</td>
<td>HHH</td>
<td>HHH</td>
<td>D deep</td>
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<tr>
<td></td>
<td>MML</td>
<td>MMM</td>
<td>HHH</td>
<td>H H H</td>
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<td>4</td>
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</tr>
</tbody>
</table>

March '78
Inventory

The actual hazard rating \( H \) and \( h \) were then used to define those areas which would be designated as \( E_h \).

Examples:

\[ E_h \text{ classification equals "high". Actual Hazard Rating (A.H.R.).} \]

a) Deep, well-drained, rubbly colluvial material

1) \( P \cdot H \cdot R = 1 \)
2) \( A \cdot H \cdot R = \text{Low (0 to 30\% slopes)} \)
   Moderate (31 to 60\% slopes)
   High (greater than 60\% slopes)

b) Deep, imperfectly drained, sandy till material

1) \( P \cdot H \cdot R = 2 \)
2) \( A \cdot H \cdot R = \text{Low (0 to 30\% slopes)} \)
   Moderate (31 to 60\% slopes)
   High (greater than 60\% slopes)

(c) Thin, moderately well-drained, silty colluvial material

1) \( P \cdot H \cdot R = 3 \)
2) \( A \cdot H \cdot R = \text{Low (0\% to 14\% slopes)} \)
   Moderate (15\% to 30\% slopes)
   High (greater than 30\% slopes)

(d) Deep, well-drained, clayey lacustrine material

1) \( P \cdot H \cdot R = 4 \)
2) \( A \cdot H \cdot R = \text{Low (0\% to 9\% slopes)} \)
   Moderate (10\% to 14\% slopes)
   High (greater than 15\% slopes)

e) Deep, poorly drained, sandy fluvial material

1) \( P \cdot H \cdot R = 5 \)
2) \( A \cdot H \cdot R = \text{High (all slopes)} \)

March '78
A.9  Snow Avalanche Protection Zones

A.91  Introduction

In British Columbia's mountainous and snowy terrain the snow avalanche is a significant natural event which should be understood by forest resource managers. The destructive potential of tons of snow moving down steep slopes at speeds which may exceed 250 km/hr ranks with the effects of other events such as flood, fire and earthquake. By means of land use planning, however, some protection may be afforded to people, man-made structures and natural resource values.

Snow on a slope always has a tendency to move downhill (Fig. A-38). Slope failure occurs if the stress exceeds the strength and friction within the snowpack and the support provided by trees and terrain irregularities. Snow then behaves fluidly and tends to be channelled by topography. Five types of motion may be distinguished:

a) powder avalanches - an aerosol of snow dust 2 to 20 times denser than air; little influenced by obstacles; speed 20-70 m/sec,

b) dry flowing avalanches - dry snow which moves along ground; not influenced by small terrain irregularities; speed 15-60 m/sec,

c) wet flowing avalanches - dense, wet snow readily deflected by terrain features; speed 5-30 m/sec,

d) mixed avalanches - a combination of powder and dry flowing types usually on steep terrain,

e) air blast - an air pressure wave which precedes a few avalanches and which has sufficient strength to destroy forest stands and move structures.

The following information is required for protection against avalanches by means of land use planning:

a) regional snow climate,

b) maximum and average slope angles of the avalanche start zone,

March '78
Inventory

c) shape of the avalanche track (the longitudinal and cross sectional profiles),

d) evidence of activity in the area based on vegetation analysis.

The next sections will discuss these factors in greater detail while the last part summarizes them into an avalanche hazard rating.

A.92 Climate

The most important factors affecting the distribution of snow and subsequent avalanche activity within a region are:

a) frequency and magnitude of snowfall,
b) direction and speed of wind during and immediately after a storm,
c) topography.

Avalanches are more frequent in regions of heavy snowfall. The amount of new snow available to slide or to become bonded to old snow is influenced also by the frequency of storms; e.g., does the snow arrive in a few intense storms or is it spread more thinly in frequent storms? Snow on the ground is layered and has structural properties determined by meteorological conditions during the time of deposit and also by changes in response to temperature and pressure.

Winds during and after a storm deposit and redeposit snow in response to topography (Fig. A-40).

Areas of accumulation (lee slopes, bowls, gullies, openings in the forest canopy) occur where windspeed drops. These areas may be identified on aerial photographs taken in the spring or early summer by the location of residual drifts except where modified by melt in response to aspect.

In the absence of detailed weather data for mountain ridge tops the general regional climate may give a broad indication of the type and amount of avalanche activity. Figure A-41 depicts the snow climates of British Columbia in zones of potential avalanche terrain.

March '78
Figure A-38.* In the horizontal snowpack, the gravity force and deformation (settlement) are both directed perpendicular to the ground. In an inclined snowpack, the shear component of the gravity force produces a downslope component of deformation.

*National Avalanche School. 1975 U.S.D.A. Forest Service*
Figure A-40.* Snow is eroded from acceleration zones and redeposited in deceleration zones. Four examples of transport are shown: (A) transport from the windward to the lee side of a ridge; (B) transport from a flat to a roll; (C) transport into a gully from side and top; and (D) transport through notches in a ridge crest.

Snow Climates of British Columbia in Zones of Potential Avalanche Terrain

Coastal
Coastal Transition
Northern and Dry Interior
Interior Transition
Interior Wet Belt

Figure A-41.
Description of Avalanche Tracks

Avalanche tracks are divided into three zones (Fig. A-42):

a) The starting zone
b) The track
c) The runout zone

Figure A-42

Start Zone

This is the area in which snow accumulates and in which structural failure of the snowpack occurs. The critical features of the start zone are:

a) Aspect - determines under which wind conditions snow will be accumulated and on the heat budget (incoming radiation) which can affect changes and stability in the snowpack.

b) Configuration and terrain irregularity - the configuration of the start zone determines how much area is potentially contributory to the avalanche. Irregularities such as uneveness of slope, rocks, trees and other obstructions tend to hold snow on a slope (Fig. A-43). Average mountain terrain requires about 60 cm of snow before it will slide. Smooth slopes (ice, grass, soil) may only require as little as 15 cm. The best protection against snow movement is the maintenance and encouragement of forest cover in March '78
Figure A-43. Irregular slopes with tree cover are less prone to avalanche activity than smooth slopes.

Figure A-44. Bed surface inclinations of 100 slab avalanches in the United States, Switzerland, and Japan.

Figure A-45. Avalanche Tracks

An avalanche in Track A often initiates, by undercutting, another avalanche in Track B.
Inventory

the starting zone.

c) Slope angle - the angle of the starting zone appears to be the most important factor influencing the frequency of avalanches. Slopes of low angle (less than 25°) are generally stable, for although structural failure may occur, the snowpack often does not move because of frictional resistance. Steep slopes (over 45° - 50°) generally do not accumulate enough snow to create a hazard except in maritime climates. Thus the critical angle of the starting zone lies between 25° to 45° (Fig. A-44). Open slopes produce large slides less frequently than do gulley-type zones under similar conditions.

A.932 Tracks

Avalanche tracks may be fed by more than one start zone. The shape of the track both in cross section and longitudinally influences avalanche behavior. Slides running in V-or-U-shaped tracks (channelled) move faster than those running on open slopes of similar angle. A bend in a channelled track will have an additional hazard area where the slide may occasionally leave its bed (Fig. A-45). Rolls or stops in the longitudinal profile will cause an avalanche to dissipate energy before reaching the valley.

A.933 Runout Zone

This is the area of low slope angle where the avalanche loses its energy and stops. The area covered by the runout will vary depending on the amount and type of snow and the effectiveness of obstacles in creating drag. If an entire start/accumulation zone releases during a heavy snow year, a slide may overrun previous historical limits. Also, fire or timber cutting may make more snow available to an avalanche and extend the runout zone.

Runout zones with no obstacles (frozen lakes, meadows) will allow snow to spread further but will show little evidence of the extent, while a zone in a narrow valley may extend up the opposite slope. An airblast zone may extend beyond the snow limit. In the Rogers Pass area, it was found that avalanches begin to slow down when they reach slopes less than

March '78
<table>
<thead>
<tr>
<th>Frequency: at least one avalanche in an interval of—</th>
<th>Vegetation clues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 2 years</td>
<td>Bare soil, willow, alder and other shrubs, no trees higher than about 1 to 2 meters. Broken trees.</td>
</tr>
<tr>
<td>2 - 10 years</td>
<td>Few trees higher than 1 to 2 meters. Immature trees of disaster species. Broken and alined trees of disaster species up to about 3 meters long. Damaged tree branches and bark.</td>
</tr>
<tr>
<td>10 - 25 years</td>
<td>Disaster species 3 to 20 years of age; dominant species present but younger than disaster species.</td>
</tr>
<tr>
<td>25 - 100 years</td>
<td>Disaster species approaching maturity; dominant species older and larger than for more frequent paths in same locality.</td>
</tr>
</tbody>
</table>

Figure A-46. *Vegetation as a rough indicator of avalanche frequency.* The vegetative clues will vary from one climatic zone to another and may vary from one soil type to another within the same climatic zone.
Figure A-47. Changes in age and species composition may identify the historical extent of slides.
Identification of Avalanche Tracks

The large, regularly occurring slides are easily identified because of the disturbance to vegetation. Large avalanches with infrequent return intervals, however, may require an analysis of vegetation for differences in age or species to indicate their frequency and extent (Fig. A-46). Small slide slopes or areas which are potential slide areas will require careful consideration based on:

a) slope angle,
b) local snow climate,
c) evidence of slides on similar slopes in the area,
d) density of tree cover,
e) tendency of snow to move as indicated by on-site indicators
   - deformed tree boles
   - broken branches
   - winter observations

Comparative analysis of sets of air photographs taken several years apart will reveal if slides are running further because of a heavy snow year or fire or timber cutting in the start zone. Such analysis will also indicate the general frequency of some tracks if it appears that tree cover is becoming re-established. (Fig. A-47).

Avalanche Prediction

Once potential avalanche sites have been identified, the prediction of how far and how often a particular site will run is a complex subject with several variables which cannot be easily measured. For land use planning an indication of the furthest extent and general frequency may be all that is required. Since the amount of snowfall or the forest cover in the start/catchment zone is subject to change, a generous margin should be allowed for, particularly if possible land uses include permanent structures or human activity during the winter season. Prediction by terrain analysis (vertical drop, track roughness, friction co-efficient, etc.) is theoretically possible, but complex, since the type of snow and the amount that will release cannot be determined accurately without continuous sampling in the start zones.

March '78
### Avalanche Hazard Rating

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<th>Hazard Factor</th>
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<th>Medium</th>
<th>Low</th>
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<tr>
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</tr>
<tr>
<td><strong>Start Zone</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual snowdepth</td>
<td>2 m+</td>
<td>0.5-2 m</td>
<td>0.5 m</td>
</tr>
<tr>
<td>Single snowfall</td>
<td>0.5 m+</td>
<td>0.25-0.5 m</td>
<td>0.25 m</td>
</tr>
<tr>
<td>Slope angle Interior</td>
<td>30°-45°</td>
<td>25°-30°</td>
<td>&lt;25°&gt;55°</td>
</tr>
<tr>
<td>Coast</td>
<td>30°-55°</td>
<td>25°-30°</td>
<td>&lt;25°&gt;65°</td>
</tr>
<tr>
<td>Configuration</td>
<td>bowls, lee slopes,(high snow accumulation)</td>
<td>slopes parallel to wind</td>
<td>wind swept slopes(low snow accum.)</td>
</tr>
<tr>
<td>Roughness</td>
<td>smooth</td>
<td></td>
<td>rough, rocky</td>
</tr>
<tr>
<td>Forest Cover</td>
<td>none</td>
<td>scattered forest cover 10 m+</td>
<td>extensive forest cover</td>
</tr>
<tr>
<td>Areas of accumulation</td>
<td>2 ha</td>
<td>1-2 ha</td>
<td>1 ha</td>
</tr>
<tr>
<td>Snowtrack</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope</td>
<td>Continuously steep, cliff bands</td>
<td>30° for most of length</td>
<td></td>
</tr>
<tr>
<td>Cross sectional profile</td>
<td>Steep-sided, narrow</td>
<td>flat, wide open</td>
<td></td>
</tr>
<tr>
<td>Top view</td>
<td>straight, few bends, uniform slope</td>
<td>winding with rolls &amp; steps</td>
<td></td>
</tr>
<tr>
<td>Forest cover</td>
<td>none, grass, willow, alder</td>
<td>patchy forest cover 10 m+ high</td>
<td>good cover 10 m+ high</td>
</tr>
<tr>
<td>History</td>
<td>recent extensions or broadening of snow tracks within last 40 to 50 years</td>
<td>no signs of snowtrack expansion</td>
<td></td>
</tr>
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</table>

Figure A-48. Avalanche Hazard Rating.
Inventory

Figure A-48 is a summary of the factors relevant to avalanche prediction. Prediction or forecasting is a complicated process and requires evaluation in the light of local experience. Thus this guide is a first approximation only.

References


Terrain and Vegetation of Snow Avalanche Sites of Rogers Pass, British Columbia. Division of Building Res.


March '78
Inventory

A.10 Water Source - Watershed Protection

Watershed management research indicates that forest harvesting and associated disturbances influence (a) the quantity, (b) the timing of flow and (c) the quality of the water in a watershed.

a) Water quantity

Forest management actions affect the hydrologic regime of the site. Reduction of the forest cover by harvesting (clear or selective logging) increases the water yield of a watershed by increasing the amount of precipitation reaching the ground and by reducing the evapotranspiration losses. This aspect is a particularly important consideration in the dry climate of the Interior of B.C. On the wetter Coast, associated with steeper slopes a raised water table decreases the stability of the soils.

b) Timing of flow

The timing of flow is closely associated with the water quantity. Higher flows are required during the summer periods of peak demand for municipal use and irrigation purposes.

Forest cover and forestry practices affect seasonal timing of the water yield by influencing the storage of water in the form of either soil water or snow within the watershed. Soil water is conserved by reducing the transpiration losses due to reduced forest cover.

Water storage in snow form can be maintained or even increased, under proper climatic conditions, by applying certain watershed management techniques. These techniques rely on creating openings, if possible, in different thermal regimes in the forest cover. Also, openings of a certain size and shape may favour snow accumulation while minimizing solar radiation and associated snow melt.

At present, artificial reservoir storage is the simplest and most often practiced method of storing water and timing its flow to users.

c) Water quality

High quality, clear, cool water is produced under

March '78
Inventory

a forest canopy. Forest cover provides protection to the mineral soil against the erosive forces of rainfall or running water; it prevents mass wasting of soil through the binding action of the root system and shades streams against solar heating.

The water quality is impaired when: 1) through erosion the sediment level is increased; 2) changes occur in the chemical properties of water; or 3) the temperature increases greatly.

1) Erosion and sedimentation

A certain amount of erosion and sedimentation is present in every stream system. The level is dependant on precipitation, soil properties, topography and vegetation. Erosion and sediment level is minimal in an undisturbed forest. The rate of erosion and consequent sedimentation increases, often markedly, as a result of forest harvesting and associated disturbances.

Accelerated erosion varies according to precipitation, soil properties, topography, vegetation — causes listed above — but depends greatly on the logging method and most of all, the extraction system. Roads and skid-trails, particularly where they intercept natural drainage patterns, are the chief sources of accelerated erosion and sedimentation associated with forest harvesting.

Proper planning, construction and maintenance of the extraction system can reduce the negative impact of forest harvesting on water quality.

In addition to this, areas susceptible to mass wasting (see Es category) i.e., stands growing on steep slopes on unstable soils should be deferred from logging. The felling of trees alone on these sites increases the danger of landslides by eliminating the anchoring affects of tree roots. Soil moisture also increases as a result of reduced transpiration.

Increased sediments from mass wasting or from poorly developed extraction systems, or from improperly selected logging methods all adversely affect the quality of water in a watershed.

March '78
2) Chemical contamination

In any forest ecosystem, large quantities of chemicals are stored in the biomass and in the transfer cycle between soil and plants. Disruption of the cycle by logging, particularly when followed by slash burning, can lead to release of chemical elements from storage by reducing plant material to ash, thereby increasing the levels of dissolved chemicals in the water. High concentration of these chemicals may reach harmful levels.

3) Water temperature

Denuding of stream banks can cause increases in water temperature through increased exposure of the stream to solar radiation.

Filter strips

Streams can be protected from adverse sediment load, chemical and temperature changes by leaving a strip of forest cover along both sides of the stream. The strip will maintain the natural shade, effectively prevent cross stream felling or skidding, and as a filter to slow runoff, facilitate infiltration and filter out some of the sediment. Valuable, mature conifers may be removed on a selection or individual basis, from these streamside strips, provided the trees are felled and extracted without damage to the stream, or the streambank, and do not detract from the effectiveness of the remaining strip.

In summary, watershed management techniques to maintain and/or increase the quantity and timing of flow of water are highly compatible with forest management techniques applied in timber harvesting, but these same techniques tend to decrease the quality of water. The level of impairment can be minimized by special efforts at the planning stage, by prescribing logging method and extraction technique least injurious to the site, by careful layout, construction and maintenance of the extraction system, and by deferring from logging high risk areas within the watershed.

References:


March '78
Inventory

Regulation of water yield and quality in British Columbia through forest management. (Doctoral thesis, U.B.C.)

Goodall, B.C. 1971.

Forestry practices and water. (Paper presented to annual meeting of Interior Tree Farm Foresters, Kelowna, B.C.)


Stewart, S.V. 1963.


Forest Land Use Committee of British Columbia Consensus Statement on the Management of Watersheds.

March '78
Inventory

A.11 Habitat Characteristics of Major Wildlife Species

S = Forest required primarily for shelter
F = Forest required primarily for food

a) Moose  S

- seasonal migration up and down mountain slopes
- winter in valley bottoms
- primarily browsers
- winter range characteristically consists of
  1) deciduous forest (low snow)
  2) willow-swamp complexes
- coniferous cover is required in close proximity for shelter.

b) Mule deer  SF

- prefers open coniferous forest, sub climax brush, steep and broken terrain
- winter range
  1) low snow - semi-open forest
  2) deep snow - feed on lichen and litter fall in closed-canopy coniferous forest
- spring range - south-aspect, open sidehills - rock bluff areas.

c) White-tailed deer  S

- prefers an interspersion of cover types; edges of hardwood forests, swamp areas, meadows
- winter range as above. Summer range is generally the same area as winter range.
- browse consists primarily of deciduous shrubs and saplings.
- some coniferous stands required for shelter

March '78
d) Caribou F
- usually alpine or subalpine, but can be driven by snow into forest land.
- when in timber, caribou feed on arboreal (growing in trees) lichens, requiring over-mature forest, 50-80% crown closure.
- caribou prefer the less steep forested areas
- often travel over frozen lakes in winter. In such areas, a leave strip along the shoreline may be required.

e) Rocky Mountain Elk S
- primarily a grazer, pawing through light snow to reach grasses in winter. Such grazing is supplemented by some deciduous browsing.
- prefers open areas, aspen, parkland.
- requires some coniferous timber for shelter in deep snow periods

f) Roosevelt Elk S
- primarily a browser
- requires coniferous forest with scattered small openings
- winters in the valley bottoms exclusively

g) Mountain Goat S
- steep, grassy, talus slopes, ravines, cliff areas
- ravine-side fingers of timber required for vertical migrations and cover, especially on coast
- minor food sources from mature forest

h) Bighorn Sheep S
- grassy, low-elevation, side-slopes form the winter range, usually with south-southwest aspect.
- steep, rugged cliff areas required for lambing

March '78
sites, adjacent to winter ranges.

i) Thinhorn Sheep
   - largely alpine
   - winter on low-elevation grassy slopes
   - no productive timber associated with these species

j) Grizzly Bear
   - spring range - avalanche, swamp complexes. Timber is required for cover along avalanche tracks.
   - autumn range - in salmon areas, grizzlies congregate along spawning reaches. If areas should accommodate them.
   - in non-salmon areas, grizzlies move into the alpine. No E.P.A. protection is required for this period.

k) Black Bear
   - no timber constraint required.

March '78
### A.12 Slope Conversion Chart

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Graph showing relationship between angles in degrees and percent.

![Figure A-52](image-url)