Report No. RRTAC 88-1

A PROPOSED EVALUATION SYSTEM FOR WILDLIFE HABITAT RECLAMATION IN THE MOUNTAINS AND FOOTHILLS BIOMES OF ALBERTA:

PROPOSED METHODOLOGY AND ASSESSMENT HANDBOOK

by

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Prepared for

The Mountain Foothills Reclamation Research Program (MFRRP)

of

THE LAND CONSERVATION AND RECLAMATION COUNCIL

(Reclamation Research Technical Advisory Committee)

and

THE COAL ASSOCIATION OF CANADA

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STATEMENT OF OBJECTIVE

This report was completed under the auspices of the Mountains and Foothills Reclamation Research Program. The opinions, findings, conclusions and recommendations expressed are those of the authors and do not necessarily reflect the views of the Alberta Government or The Coal Association of Canada. Specifically, any suggestions or implications contained in the report that the document serve as a step by step procedure leading to certification are not supported by the Alberta Government at this time.

This report is intended to provide Government and Industry staff with up to date technical information to assist in the development of guidelines and operating procedures. The report is also available to the Public so that interested individuals similarly have access to the best available information on land reclamation topics.

ALBERTA'S RECLAMATION RESEARCH PROGRAM

The regulation of surface disturbances in Alberta is the responsibility of the Land Conservation and Reclamation Council. The Council executive consists of a Chairman from the Department of Forestry, Lands and Wildlife. Among other functions, the Council oversees programs for reclamation of abandoned disturbances and reclamation research. The Reclamation Research Program was established to provide answers to the many practical questions which arise in reclamation. Funds for implementing both the operational and research programs are drawn from Alberta's Heritage Savings Trust Fund.

To assist in technical matters related to the development and administration of the Research Program, the Council appointed the Reclamation Research Advisory Committee (RRTAC). The Committee first met in March 1978 and consists of eight members representing the Alberta Departments of Agriculture, Energy, Forestry, Lands and Wildlife, Environment and the Alberta Research Council. The Committee meets regularly to update research priorities, review solicited and unsolicited research proposals, arrange workshops and otherwise act as a referral and coordinating body for Reclamation Research.

Additional information on the Reclamation Research Program may be obtained by contacting:

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Additional copies may be obtained from:

Publication Services
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11510 Kingsway Avenue
Edmonton, Alberta T5G 2Y5

RECLAMATION RESEARCH REPORTS

** 1. RRTAC 80-3: The Role of Organic Compounds in Salinization of Plains Coal Mining Sites. N.S.C. Cameron et al. 46 pp.

DESCRIPTION: This is a literature review of the chemistry of sodic mine spoil and the changes expected to occur in groundwater.

** 2. RRTAC 80-4: Proceedings: Workshop on Reconstruction of Forest Soils in Reclamation. P.F. Ziemkiewicz, S.K. Takyi, and H.F. Regier. 160 pp.

DESCRIPTION: Experts in the field of forestry and forest soils report on research relevant to forest soil reconstruction and discuss the most effective means of restoring forestry capability of mined lands.

N/A 3. RRTAC 80-5: Manual of Plant Species Suitability for Reclamation in Alberta. L.E. Watson, R.W. Parker, and P.F. Polster. 2 vols, 541 pp.

DESCRIPTION: Forty-three grass, fourteen forb, and thirty-four shrub and tree species are assessed in terms of their fitness for use in Reclamation. Range maps, growth habit, propagation, tolerance, and availability information are provided.

N/A 4. RRTAC 81-2: 1980 Survey of Reclamation Activities in Alberta. D.G. Walker and R.L. Rothwell. 76 pp.

DESCRIPTION: This survey is an update of a report prepared in 1976 on reclamation activities in Alberta, and includes research and operational reclamation, locations, personnel, etc.

N/A 5. RRTAC 81-3: Proceedings: Workshop on Coal Ash and Reclamation. P.F. Ziemkiewicz, R. Stien, R. Leitch, and G. Lutwick. 253 pp.

DESCRIPTION: Presents nine technical papers on the chemical, physical and engineering properties of Alberta fly and bottom ashes, revegetation of ash disposal sites and use of ash as a soil amendment. Workshop discussions and summaries are also included.

N/A 6. RRTAC 82-1: Land Surface Reclamation: An International Bibliography. H.P. Sims and C.B. Powter. 2 vols, 292 pp.

DESCRIPTION: Literature to 1980 pertinent to reclamation in Alberta is listed in Vol. 1 and is also on the University of Alberta computing system. Vol. 2 comprises the keyword index and computer access manual.

N/A 7. RRTAC 82-2: A Bibliography of Baseline Studies in Alberta: Soils, Geology, Hydrology and Groundwater. C.B. Powter and H.P. Sims. 97 pp.

DESCRIPTION: This bibliography provides baseline information for persons involved in reclamation research or in the preparation of environmental impact assessments. Materials, up to date as of December 1981, are available from the Alberta Environment Library.

N/A 8. RRTAC 83-1: Soil Reconstruction Design for Reclamation of Oil Sand Tailings. Monenco Consultants Ltd. 185 pp.

DESCRIPTION: Volumes of peat and clay required to amend oil sand tailings were estimated based on existing literature. Separate soil prescriptions were made for spruce, jack pine, and herbaceous cover types. The estimates form the basis of field trials.

N/A 9. RRTAC 83-3: Evaluation of Pipeline Reclamation Practices on Agricultural Lands in Alberta. Hardy Associates (1978) Ltd. 205 pp.

DESCRIPTION: Available information on pipeline reclamation practices was reviewed. A field survey was then conducted to determine the effects of pipe size, age, soil type, construction method, etc. on resulting crop production.

N/A 10. RRTAC 83-4: Proceedings: Effects of Coal Mining on Eastern Slopes Hydrology. P.F. Ziemkiewicz. 123 pp.

DESCRIPTION: Technical papers are presented dealing with the impacts of mining on mountain watersheds, their flow characteristics and resulting water quality. Mitigative measures and priorities were also discussed.

N/A 11. RRTAC 83-5: Woody Plant Establishment and Management for Oil Sands Mine Reclamation. Techman Engineering Ltd. 124 pp.

DESCRIPTION: This is a review and analysis of information on planting stock quality, rearing site preparation, planting and procedures necessary to ensure survival of trees and shrubs in oil sand reclamation.

*** 12. RRTAC 84-1: Land Surface Reclamation: A Review of International Literature. H.P. Sims, C.B. Powter, and J.A. Campbell. 2 vols, 1549 pp.

DESCRIPTION: Nearly all topics of interest to reclamation including mining methods, soil amendments, revegetation, propagation and toxic materials are reviewed in light of the international literature.

** 13. RRTAC 84-2: Propagation Study: Use of Trees and Shrubs for Oil Sand Reclamation. Techman Engineering Ltd. 58 pp.

DESCRIPTION: This report evaluates and summarizes all available published and unpublished information on large-scale propagation methods for shrubs and trees to be used in oil sand reclamation.

* 14. RRTAC 84-3: Reclamation Research Annual Report - 1983. P.F. Ziemkiewicz. 42 pp.

DESCRIPTION: This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results and expenditures.

** 15. RRTAC 84-4: Soil Microbiology in Land Reclamation. D. Parkinson, R.M. Danielson, C. Griffiths, S. Visser, and J.C. Zak. 2 vols, 676 pp.

DESCRIPTION: This is a collection of five reports dealing with re-establishment of fungal decomposers and mycorrhizal symboints in various amended spoil types.

** 16. RRTAC 85-1: Proceedings: Revegetation Methods for Alberta's Mountains and Foothills. P.F. Ziemkiewicz. 416 pp.

DESCRIPTION: Results of long-term experiments and field experience on species selection, fertilization, reforestation, topsoiling, shrub propagation and establishment are presented.

* 17. RRTAC 85-2: Reclamation Research Annual Report - 1984. P.F. Ziemkiewicz. 29 pp.

DESCRIPTION: This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results and expenditures.

** 18. RRTAC 86-1: A Critical Analysis of Settling Pond Design and Alternative Technologies. A. Somani. 372 pp.

DESCRIPTION: The report examines the critical issue of settling pond design and sizing and alternative technologies.

** 19. RRTAC 86-2: Characterization and Variability of Soil Reconstructed after Surface Mining in Central Alberta. T.M. Macyk. 146 pp.

DESCRIPTION: Reconstructed soils representing different materials handling and replacement techniques were characterized and variability in chemical and physical properties was assessed. The data obtained indicate that reconstructed soil properties are determined largely by parent material characteristics and further tempered by materials handling procedures. Mining tends to create a relatively homogeneous soil landscape in contrast to the mixture of diverse soils found before mining.

* 20. RRTAC 86-3: Generalized Procedures for Assessing Post-Mining Groundwater Supply Potential in the Plains of Alberta - Plains Hydrology and Reclamation Project. M.R. Trudell and S.R. Moran. 30 pp.

DESCRIPTION: In the Plains region of Alberta, the surface mining of coal generally occurs in rural, agricultural areas in which domestic water supply requirements are met almost entirely by groundwater. Consequently, an important aspect of the capability of reclaimed lands to satisfy the needs of a residential component is the post-mining availability of groundwater. This report proposes a sequence of steps or procedures to identify and characterize potential post-mining aquifers.

** 21. RRTAC 86-4: Geology of the Battle River Site: Plains Hydrology and Reclamation Project. A Maslowski-Schutze, R. Li, M. Fenton and S.R. Moran. 86 pp.

DESCRIPTION: This report summarzies the geological setting of the Battle River study site. It is designed to provide a general understanding of geological conditions adequate to establish a framework for hydrogeological and general reclamation studies. The report is not intended to be a detailed synthesis such as would be required for mine planning purposes.

** 22. RRTAC 86-5: Chemical and Mineralogical Properties of Overburden: Plains Hydrology and Reclamation Program. A. Maslowski-Schutze. 71 pp.

DESCRIPTION: This report describes the physical and mineralogical properties of overburden materials in an effort to identify individual beds within the bedrock overburden that might be significantly different in terms of reclamation potential.

* 23. RRTAC 86-6: Post-Mining Groundwater Supply at the Battle River Site: Plains Hydrology and Reclamation Project. M.R. Trudell, G.J. Sterenberg and S.R.-Moran. 49 pp.

DESCRIPTION: The report deals with the availability of water supply in or beneath cast overburden at the Battle River Mining area in east-central Alberta to support post-mining land use. Both groundwater quantity and quality are evaluated.

* 24. RRTAC 86-7: Post-Mining Groundwater Supply at the Highvale Site: Plains Hydrology and Reclamation Project. M.R. Trudell. 25 pp.

DESCRIPTION: This report evaluates the availability of water supply in or beneath cast overburden to support post-mining land use, including both quantity and quality considerations. The study area is the Highvale mining area in west-central Alberta.

* 25. RRTAC 86-8: Reclamation Research Annual Report - 1985. P.F. Ziemkiewicz. 54 pp.

DESCRIPTION: This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results and expenditures.

** 26. RRTAC 86-9: Wildlife Habitat Requirements and Reclamation Techniques for the Mountains and Foothills of Alberta. J.E. Green, R.E. Salter and D.G. Walker. 285 pp.

DESCRIPTION: This report presents a review of relevant North American literature on wildlife habitats in mountain and foothills biomes, reclamation techniques, potential problems in wildlife habitat reclamation, and potential habitat assessment methodologies. Four biomes (Alpine, Subalpine, Montane, and Boreal Uplands) and 10 key wildlife species (snowshoe hare, beaver, muskrat, elk, moose, caribou, mountain goat, bighorn sheep, spruce grouse, and white-tailed ptarmigan) are discussed.

** 27. RRTAC 87-1: Disposal of Drilling Wastes. L.A. Leskiw, E. Reinl-Dwyer, T.L. Dabrowski, B.J. Rutherford and H. Hamilton. 210 pp.

DESCRIPTION: Current drilling waste disposal practices are reviewed and criteria in Alberta guidelines are assessed. The report also identifies research needs and indicates mitigation measures. A manual included provides a decision-making flowchart to assist in selecting methods of environmentally safe waste disposal.

** 28. RRTAC 87-2: Minesoil and Landscape Reclamation of the Coal Mines in Alberta's Mountains and Foothills. A.W. Fedkenheuer, L.J. Knapik, and D.G. Walker. 174 pp.

DESCRIPTION: This report reviews current reclamation practices with regard to site and soil reconstruction and re-establishment of biological productivity. It also identifies research needs in the Mountain-Foothills area.

** 29. RRTAC 87-3: Gel and Saline Drilling Wastes in Alberta: Workshop Proceedings. D.A. Lloyd (compiler). 218 pp.

DESCRIPTION: Technical papers were presented which describe: the mud systems used and their purpose; industrial constraints; government regulations, procedures and concerns; environmental considerations in waste disposal; and toxic constituents of drilling wastes. Answers to a questionnaire distributed to participants are included in an appendix.

* 30. RRTAC 87-4: Reclamation Research Annual Report - 1986. 50 pp.

DESCRIPTION: This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results and expenditures.

* 31. RRTAC 87-5: Review of the Scientific Basis of Water Quality Criteria for the East Slope Foothills of Alberta. Beak Associates Consulting Ltd. 46 pp.

DESCRIPTION: The report reviews existing Alberta guidelines to assess the quality of water drained from coal mine sites in the East Slope Foothills of Alberta. World literature was reviewed within the context of the east slopes environment and current mining operations. The ability of coal mine operators to meet the various guidelines is discussed.

** 32. RRTAC 87-6: Assessing Design Flows and Sediment Discharge on the Eastern Slopes. Hydrocon Engineering (Continental) Ltd. and Monenco Consultants Ltd. 97 pp.

DESCRIPTION: The report provides an evaluation of current methodologies used to determine sediment yields due to rainfall events in well-defined areas. Models are available in Alberta to evaluate water and sediment discharge in a post-mining situation. SEDIMOT II (Sedimentology Disturbed Modelling Techniques) is a single storm model that was developed specifically for the design of sediment control structures in watersheds disturbed by surface mining and is well suited to Alberta conditions.

* 33. RRTAC 87-7: The Use of Bottom Ash as an Amendment to Sodic Spoil. S. Fullerton. 83 pp.

DESCRIPTION: The report details the use of bottom ash as an amendment to sodic coal mine spoil. Several rates and methods of application of bottom ash to sodic spoil were tested to determine which was the best at reducing the effects of excess sodium and promoting crop growth. Field trials were set up near the Vesta mine in East Central Alberta using ash readily available from nearby coal-fired thermal generating station. The research indicated that bottom ash incorporated to a depth of 30 cm using a subsoiler provided the best results.

* 34. RRTAC 87-8: Waste Dump Design for Erosion Control. R.G. Chopiuk and S.E. Thornton. 45 pp.

DESCRIPTION: This report describes a study to evaluate the influence of erosion from reclaimed waste dumps on downslope environments such as streams and rivers. Sites were selected from coal mines in Alberta's mountains and foothills, and included resloped dumps of different configurations and ages, and having different vegetation covers. The study concluded that the average annual amount of surface erosion is minimal. As expected, erosion was greatest on slopes which were newly regraded. Slopes with dense grass cover showed no signs of erosion. Generally, the amount of erosion decreased with time, as a result of initial loss of fine particles, the formation of a weathered surface, and increased vegetative cover.

** 35. RRTAC 87-9: Hydrogeology and Groundwater Chemistry of the Battle River Mining Area. M.R. Trudell, R.L. Faught and S.R. Moran. 97 pp.

DESCRIPTION: This report describes the premining geologic conditions in the Battle River coal mining area including the geology as well as the groundwater flow patterns, and the groundwater quality of a sequence of several water-bearing formations extending from the surface to a depth of about 100 metres.

** 36. RRTAC 87-10: Soil Survey of the Plains Hydrology and Reclamation Project - Battle River Project Area. T.M. Macyk and A.H. MacLean. 62 pp. plus maps.

DESCRIPTION: The report evaluates the capability of post-mining landscapes and assesses the changes in capability as a result of mining, in the Battle River mining area. Detailed soils information is provided in the report for lands adjacent to areas already mined as well as for lands that are destined to be mined. Characterization of the reconstructed soils in the reclaimed areas is also provided. Data were collected from 1979 to 1985. A series of maps supplement the report.

** 37. RRTAC 87-11: Geology of the Highvale Study Site: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze. 78 pp.

DESCRIPTION: The report is one of a series that describes the geology, soils and groundwater conditions at the Highvale Coal Mine study site. The purpose of the study was to establish a summary of site geology to a level of detail necessary to provide a framework for studies of hydrogeology and reclamation.

** 38. RRTAC 87-12: Premining Groundwater Conditions at the Highvale Site. M.R. Trudell and R. Faught. 83 pp.

DESCRIPTION: This report presents a detailed discussion of the premining flow patterns, hydraulic properties, and isotopic and hydrochemical characteristics of five layers within the Paskapoo Geological Formation, the underlying sandstone beds of the Upper Horseshoe Canyon Formation, and the surficial glacial drift.

* 39. RRTAC 87-13: An Agricultural Capability Rating System for Reconstructed Soils. T.M. Macyk. 27 pp.

DESCRIPTION: This report provides the rationale and a system for assessing the agricultural capability of reconstructed soils. Data on the properties of the soils used in this report are provided in RRTAC 86-2.

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* A $5.00 fee is charged for handling and postage.
** A $10.00 fee is charged for handling and postage.
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1.0 INTRODUCTION

Mining developments in the Mountains and Foothills of Alberta inevitably result in the disruption of some wildlife habitat, either during site development or through clearing of linear rights-of-way (as during road construction or drill testing). Recent feasibility studies and several ongoing reclamation programs have shown that wildlife habitat can be created through reclamation and habitat enhancement, using existing technology applicable to the environmental conditions and wildlife species found in these regions (Green et al. 1986). Although the capability currently exists to reclaim disturbed areas as wildlife habitat, no guidelines have been developed for evaluating success of wildlife habitat reclamation efforts. The development of guidelines for the reclamation of wildlife habitat was the primary objective of the wildlife component of the Mountains and Foothills Reclamation Research Program (MFRRP).

The Mountains Foothills Reclamation Research Program (MFRRP) is a joint industry/government program consisting of representatives from the Coal Association of Canada, Alberta Environment and Alberta Forestry, Lands and Wildlife. Initiated in 1984, the primary objectives of MFRRP were to summarize current information on reclamation methods for forestry, wildlife habitat and soil re-establishment, and to develop an appropriate method (or methods) for measuring reclamation success in the Mountains and Foothills biomes of Alberta. Because new and improved techniques for reclamation of disturbed sites are becoming available each year, the ability of industrial and government reclamation programs to achieve specific reclamation objectives is also improving. The summarization of operational techniques and development of assessment systems for such techniques is therefore a dynamic process that must be responsive to a continually improving information base.

A two phase study on wildlife habitat reclamation was begun by MFRRP in 1984, with the aim of delineating appropriate operational techniques (Phase I) and assessment methodology (Phase II). Phase I of the program involved a synthesis of information on techniques relevant to wildlife habitat reclamation in the Mountains and Foothills biomes of Alberta, and a review of habitat requirements of key wildlife species in these regions. Following completion of the Phase I report (Green et al. 1986), Environment Canada undertook an expansion of the geographical scope of the technical synthesis to include the Boreal Forest, Aspen Parkland and Prairie Grassland regions (Green and Salter 1987a; Green et al. 1987). As part of this latter study, a techniques manual for the reclamation of wildlife habitat in the Canadian prairie provinces was also developed (Green and Salter 1987b).

Phase II of the program, begun in June 1986, involved the development of an assessment methodology for evaluating the success of wildlife habitat reclamation programs. Definitions of reclaimed habitat and guidelines for assessment will allow project proponents to define the objectives of their reclamation programs, to develop strategies to achieve these goals, and to identify and correct deficiencies prior to assessment. Established guidelines will also permit government regulatory agencies to consistently and fairly evaluate reclamation of wildlife habitat in different areas, and to identify inadequacies in habitat reclamation programs.

The present MFRRP Phase II wildlife study (this study) focuses on the development of guidelines and procedures for the assessment of reclaimed wildlife habitat in the Mountains and Foothills regions of Alberta. Results of the study are summarized in this technical report and an assessment handbook (Appendix I). The technical report provides background documentation for material contained in the handbook, including a discussion of reclamation planning, a listing of reclamation habitats and associated key wildlife species, conditions required for development, recommended revegetation species, suitable reclamation techniques, a description of the recommended assessment techniques and a glossary of basic terminology. The assessment handbook contains basic information necessary for evaluating wildlife habitat reclamation, including assessment scoresheets for 15 different reclamation habitats, standard methodologies for measuring habitat variables used as assessment criteria, and minimum requirements for certification. This handbook is intended as a field manual that could potentially be used by site operators and reclamation officers.

2.0 OBJECTIVES

The primary objective of the MFRRP Phase II study was to develop a workable evaluation procedure for the assessment of lands reclaimed to wildlife habitat in the Mountains and Foothills biomes of Alberta. More specifically, the study was to identify and describe potentially reclaimable wildlife habitats and associated key wildlife species in the study area, develop an effective method of evaluating and certifying the reclamation of such habitats and, finally, outline mensuration techniques for field assessments of reclaimed habitats.

3.0 RECLAMATION PLANNING AND EVALUATION

Land reclamation programs at regulated surface operations in the Mountains and Foothills biomes of Alberta are generally comprised of three components:

1. development and reclamation (D&R) planning,
2. reclamation operations and implementation, and
3. reclamation evaluation,

regardless of whether the designated land use is forestry, agriculture, wildlife and/or recreation. In developing assessment guidelines for wildlife habitat, it is important to understand the tasks involved in each of these three components of the reclamation process.

3.1 RECLAMATION PLANNING

From a wildlife perspective, reclamation planning refers to :

1. the identification of the type and location of landform units that will be present on the reclamation site following project development. For purposes of both planning and evaluation, a landform is defined as a biophysical unit described by elevation, slope, aspect and/or soil conditions. Examples of reclamation landforms include steep, south-facing slopes, cliffs, rolling hills, and flatlands. A reclamation site is the total disturbed area towards which reclamation efforts are directed, and may contain one or more landforms;

2. the selection of a key wildlife species for each landform unit within the reclamation area or for the entire reclamation area. A key species is defined as a locally occurring bird or mammal species of high socio-economic, ecological and/or management importance, that represents the general habitat requirements of a number of other wildlife species. The key species selected for each landform type is normally one that is known to be associated with the same or similar landforms elsewhere in the region;

3. the determination of the desired response of the key species (e.g., provision of food, hiding cover and/or escape cover for the key species); and

4. the selection of habitats (including plant species composition), habitat sizes (areas) and habitat juxtaposition/interspersion which will best meet the desired objectives, and which are best suited to biophysical conditions of the site (e.g., aspect, slope, soil type, moisture availability). Based on a knowledge of each key species' habitat requirements, one or more reclamation habitats are selected for development in association with each landform unit. A reclamation habitat refers to a habitat developed within a landform and defined by botanical composition (e.g., vegetation associations such as meadows and shrublands), water form type (e.g., watercourses and lakes/ponds) or physical characteristics (e.g., cliffs and talus slopes). This stage of the planning process matches a key species' habitat requirements with the landform and other site features that provide the most suitable conditions for reclamation habitat development.

This aspect of reclamation will be done at the development and reclamation (D&R) planning phase of regulatory approval and may involve representatives from the Alberta Fish and Wildlife Division, Alberta Forestry and the proponent. Prior to development, the reclamation plan must be approved by the Alberta Land Conservation and Reclamation Council (ALCRC). The reclamation plan describes the specific objectives of the reclamation project, which will serve as the standards (which must be met) for assessment of the reclamation area. Because of the need to develop a reclamation plan that is specific to the unique conditions of each reclamation area, it is extremely difficult to provide generalized guidelines or criteria for reclamation planning.

3.2 RECLAMATION OPERATIONS AND IMPLEMENTATION

Reclamation operations and implementation involve the construction and restoration of a site following development, according to the standards specified in the approved reclamation plan. Compliance with the reclamation plan is demonstrated through regular inspections by the Reclamation Council field staff and the Annual Reports of reclamation activities to the ALCRC. Modifications to the reclamation plan resulting from changes in the development and/or the predicted site conditions (e.g., slope, aspect) can be incorporated during operations and implementations, upon approval from the ALCRC.

Reclamation of wildlife habitat is a relatively new field of reclamation (Green et al. 1986), and new or improved techniques for reclamation or enhancement of wildlife habitat are continually becoming available as the number and quality of habitat reclamation projects increases. In the Phase I MFRRP Wildlife Study, techniques for reclamation of wildlife habitat that are applicable in the Mountains and Foothills biomes of Alberta were reviewed, and methodologies were described for restoration or enhancement of landforms, water forms, vegetation and special features (e.g., cliffs, talus, nest boxes)(Green et al. 1986).

3.3 RECLAMATION EVALUATION

Reclamation evaluation refers to the measurement of reclaimed wildlife habitat based on a set of pre-defined criteria. It is the final step of the reclamation approval process, designed to assess the adequacy of the reclamation operations in meeting the objectives of the the reclamation plan. The development of evaluation criteria for reclamation of wildlife habitat was the primary objective of the MFRRP Phase II Wildlife Study.

As part of the Phase I MFRRP Wildlife Studies, Green et al. (1986) reviewed a variety of habitat and population-based methods for assessing habitat capability in both natural and reclaimed areas. Based on this review, it was concluded that habitat-based methods are preferable to population-based assessments as the latter can be influenced over the short and long term by a large number of factors such as climate, disease, predation and hunting pressures.

Two habitat-based methods for evaluation of reclaimed areas for wildlife are currently available to the government and project proponents: (1) habitat capability assessments and (2) compliance assessments. Habitat capability assessments measure the success of a reclaimed habitat at providing food and/or cover for selected wildlife species.

For example, if a site had been designated as a lowland/riparian shrubland for moose in the reclamation plan, assessment of the site would be dependent on the successful establishment (and existence) of a low-lying, poorly-drained landform, with moderate to dense shrub cover comprised predominantly of preferred browse species for moose, and suitable ground cover. For this particular example, establishment of the habitat unit, and particularly the stabilization of vegetation, may require a period of 10-20 years. The Habitat Evaluation Procedures (HEP) of the United States Fish and Wildlife Service (USFWS 1980a,b) are the most widely used, systematic procedures for evaluation of wildlife habitat capability, and are an excellent example of habitat capability assessments (see Green et al. [1986]).

In the case of evaluation systems involving compliance with an approved reclamation plan, assessment is based on the provision of those landforms, water forms and soils specified in the reclamation plan (i.e., compliance) which are capable of supporting the vegetation community(ies) of interest. Approval occurs when adequate landforms, water forms and soil are present, as described in the reclamation plan, and when an adequate revegetation plan has been implemented. Using the example of moose habitat (as described above), approval of the site would be dependent on the successful establishment of a low-lying, poorly-drained landform, and the demonstration that shrub seedlings and ground cover were at least self-sustaining. Most of the wildlife habitat reclamation projects in the province are presently based on compliance with an approved reclamation plan.

For those reclamation habitats (to be discussed in later sections) which have no revegetation component (e.g., talus, cliffs), the two evaluation systems are basically identical. Where revegetation components are involved, the two systems remain similar with respect to the assessment of landforms, water forms and soil conditions but differ in terms of the time period and methods required to certify revegetation components. In the reclamation of some types of wildlife habitat, the potential time difference between these two systems may be large, as some vegetation communities, particularly tree/shrub mix habitats, require long periods of time to establish and mature.

The major impediment to the adoption of a compliance system is our currently poor understanding of plant growth performance on reclaimed areas. Little information is available on the growth rates, survival and vigor of ground cover, shrubs and trees on reclaimed areas in the Mountains and Foothills regions of Alberta, or the principal environmental factors (e.g., climate, soils) that limit plant performance. Consequently, we cannot accurately predict the capability of a revegetated habitat at maturity based on observations made within a short period after plant establishment.

Because of the paucity of growth performance information, the guidelines for assessment of many of the reclamation habitats described in this technical report and assessment handbook are based primarily on habitat suitability, and require the establishment and existence of tree, shrub and/or ground covers that meet the requirements of wildlife for food, hiding cover and/or thermal cover. However, as our knowledge of plant growth performance on reclaimed areas improves and we are better able to predict future habitat conditions based on current vegetation parameters, it will be possible to reformulate the proposed guidelines to measure vegetation conditions at an earlier stage of development on reclaimed areas. Hence, with better information on community development in reclaimed areas, habitat suitability systems can evolve towards a capability (compliance) evaluation system.

In the interim, assessment of wildlife habitat reclamation areas could involve several stages or milestone evaluations, linked to the successful establishment of landforms, water forms, soil bases and vegetation. In reclaiming an area for wildlife habitat, reclamation operations generally will involve four steps:

1. the establishment of the final landform for the area (this may involve recontouring or specialized development of the site to create specific types of landforms such as swales, ridges, or knob and kettle terrain);

2. the optional development of water forms (e.g., watercourses, wetlands and lake/ponds) to complement the landforms;

3. the establishment of a soil base that is compatible with the landforms and/or water forms within the reclamation area, and that is capable of supporting the proposed plant communities for the habitat unit or reclamation area; and

4. revegetation of each habitat unit and, if necessary, the development of special habitat features.

The first three steps are now generally completed within a short-time period (e.g., several months to a year) following completion of the site development, and represent a major portion of the total reclamation costs and manpower requirements. The fourth task, revegetation, is generally implemented shortly after the establishment of a soil base (to reduce soil erosion), but the stabilization of plant communities (e.g., self-sustaining tree, shrub and/or ground covers) may require 3-5 years in the case of meadow and some shrub communities, and much longer periods of time in the case of conifer tree/shrub mix communities. Evaluation of revegetation success, if based on habitat capability, may therefore require similar periods of time to that required for community maturation.

In a multi-staged evaluation process, successful establishment of landforms, water forms and soils, as per the approved reclamation plan, could serve as one of the first milestones in the evaluation of a wildlife habitat reclamation site This first milestone could involve a separate inspection and evaluation for each step (landform, water form and soil) or a single inspection and evaluation for the three steps combined. A second, and perhaps final, milestone could involve assessment and approval of the revegetation program. A multi-staged evaluation process would not only complement the existing annual reporting process to the Alberta Land Conservation and Reclamation Council, but, from a proponent's perspective, would also reduce the period of time in which a major portion of the reclamation security bond was retained by the government. Consequently, such an approach may make wildlife habitat reclamation more attractive to industry, and encourage project proponents to include more complex wildlife habitats (e.g., tree/shrub mix habitats, conifer habitats, cliff and talus habitats) in the reclamation plan. In the short-term, use of such a process may also promote research on the establishment and stabilization of plant communities on reclaimed sites.

4.0 RECLAMATION HABITATS RECOGNIZED FOR THE MOUNTAINS AND FOOTHILLS BIOMES

Based on the types of physical and/or biological features present on a reclamation site, three broad classes of habitats can be developed in the Mountains and Foothills biomes. These are:

1. vegetation-based habitats;
2. water-based habitats; and
3. slope/cliff-based habitats.

A total of 10 vegetation-based habitats are recognized for reclamation purposes. These are defined by their botanical structure (i.e., meadow, shrubland, shrub meadow, tree/shrub mix) and, in some cases, their elevational range (i.e., lowland, upland or alpine). However, for any given habitat, the actual botanical composition selected for reclamation may vary from site to site, depending on localized moisture conditions, aspect, etc. For example, willow and alder species would be appropriate for developing a shrubland habitat on a cool north-facing slope, while saskatoon would be more successfully introduced on drier south-facing slopes.

Several criteria have been adopted to define the various vegetation-based habitats. To facilitate botanical measurements for evaluation purposes, all habitats, with the exception streamside riparian habitats, must have a minimum area of 3 ha and a width of at least 100 m at one point along their length. Because of their linear configuration, streamside riparian habitats must be a minumum of 10 m wide and at least 100 m long. To distinguish between trees and shrubs, trees are defined as any woody vegetation greater than 5 m in height, while shrubs are defined as any woody vegetation less than or equal to 5 m in height. Other botanical criteria for defining the habitats, modified from Klar and Stelfox (1985), are presented in the habitat descriptions below.

Water-based reclamation habitats refer to watercourses, wetlands (i.e., shallow marshes) and small lakes/ponds which are constructed or altered during development or operation of the site. In each case, the habitats are considered to extend to the high water mark of the waterbody in question and, consequently, are comprised of both the open water and emergent zones of the waterbody. Minimum size requirements of water-based habitats are presented in the habitat descriptions below.

Slope-based reclamation habitats refer to steep, generally unvegetated cliffs and talus developed from the headwalls of open pit operations. Cliffs must have slopes exceeding 50° and must have a minimum height and length to be recognized as such (see descriptions below). Talus is simply defined as an apron of rock forming at the base of a cliff, sloping at variable angles.

Each of the recognized reclamation habitats is discussed in a separate section below. Each section provides a description of the habitat of interest and its importance to wildlife, the conditions under which the habitat normally occurs within the Mountains and Foothills biomes, and the general guidelines for developing such a habitat. It should be recognized that no attempt has been made to provide detailed technical information on seeding/transplanting, fertilization, soil reconstruction or other aspects of reclamation required for the development of the habitats. The reclamation guidelines presented pertain only to broad site selection, recommended botanical mixes and appropriate landscape design.

4.1 ALPINE MEADOW

4.1.1 Description

Alpine meadows are defined as grass or sedge-dominated communities occupying sites above 2000 m in elevation. To be classified as a meadow habitat, the combined ground cover of grasses, sedges, mosses/lichens, forbs and low (<0.5 m) shrubs, on average, must be > 25% within the boundaries of the reclamation habitat and grasses and sedges must comprise > 40% of this value.

Depending on their botanical composition, alpine meadows can be important year-round forage sources for bighorn sheep, caribou, mountain goat and white-tailed ptarmigan. They can also be important feeding areas for elk during the spring and summer months, when grasses, sedges and forbs within such habitats are high in crude protein and other essential nutrients. Because meadow vegetation offers little or no escape or thermal cover for key wildlife species, the overall value of alpine meadows to wildlife is enhanced where these habitats occur on rolling topography (providing visual and microclimatic cover) or are in proximity to talus, cliffs or other forms of escape cover.

Key Species: bighorn sheep, caribou, elk, mountain goat, white-tailed ptarmigan

4.1.2 Suitable Conditions For Alpine Meadow Development

Alpine meadows occur naturally on high elevation ridge-tops and slopes. Sedge-dominated communities generally develop on poorly drained regosols and gleysols on cooler slopes, while grasses are more common on well-drained regosols and brunisols on more southerly aspects (Strong and Leggat 1981).

4.1.3 Reclamation Techniques

Because of the difficult growing conditions at high elevations, relatively few graminoid species have been successfully utilized as reclamation stock for alpine meadows. Some of the more successful species include alpine bluegrass, bearded wheatgrass and sheep fescue.

As previously discussed, the overall value of meadows to wildlife is enhanced where such habitats are developed close to suitable escape or thermal cover such as shrublands or cliffs. Alternatively, the habitat value of meadows can also be improved by providing topographic cover for wildlife through surface contouring, prior to meadow establishment.

4.2 UPLAND MEADOW

4.2.1 Description

Upland meadows are defined as grass or sedge-dominated communities occupying relatively dry, well-drained sites up to 2000 m in elevation. To be classified as a meadow habitat, the combined ground cover of grasses, sedges, forbs and low (< 0.5 m) shrubs, on average, must be > 25% within the boundaries of the reclamation habitat and grasses and sedges must comprise > 60% of this value. In addition, the shrub and tree canopy cover of the area must not exceed 10% and 5%, respectively. Sites supporting a more even mix of grass and shrubs are classified as mixed habitats (e.g., shrub meadows).

Depending on their botanical composition, upland meadows can be important year-round forage sources for elk, bighorn sheep and, to a lesser extent, mountain goat. They can also be important foraging areas for caribou during the spring and summer months, when grasses and sedges within such habitats are high in crude protein and other essential nutrients. Because grasses and sedges offer no escape or thermal cover for key wildlife species, the overall value of upland meadows to wildlife is enhanced where these habitats occur on rolling topography (providing visual cover) or are in proximity to shrublands, forests, cliffs or other forms of cover.

Key Species: bighorn sheep, caribou, elk, mountain goat

4.2.2 Suitable Conditions For Upland Meadow Development

Upland meadow communities generally occur on well-drained, steep south-facing slopes where solar insolation and evapotranspiration rates are high (Strong and Leggat 1981). They may also develop on cooler, moister sites after a major disturbance (e.g., fire) but are generally not persistent, being outcompeted by shrubs and trees with deeper root structures.

4.2.3 Reclamation Techniques

Persistent meadow communities are best developed on dry south-facing slopes with a high degree of exposure to wind and sun. Reclamation species should include a mixture of warm season grasses with variable growth patterns. For example, such early developing species as green needle grass and alpine bluegrass should be included in the planting mixture to provide high quality forage soon after snowmelt. To complement such species, grasses which develop later in the growing season, produce a greater above-ground biomass and are more digestible and nutritious in their cured state (e.g., crested wheatgrass, sheep fescue) should also be planted to ensure that adequate overwintering forage is available.

As previously discussed, the overall value of meadows to wildlife is enhanced where such habitats are developed close to suitable escape or thermal cover such as shrublands, forests or cliffs. Alternatively, the habitat value of meadows can be improved by providing topographic cover for wildlife through surface contouring, prior to meadow establishment.

4.3 LOWLAND/RIPARIAN MEADOW

4.3.1 Description

Lowland/riparian meadows are defined as grass or sedge-dominated communities occupying sites with moderately wet to saturated soils. While primarily occupying valley bottom elevations, such habitats may also occur within localized depressions and catch basins up to subalpine elevations. To be classified as a meadow habitat, the combined ground cover of grasses, sedges, forbs and low (< 0.5 m) shrubs, on average, must be > 25% within the boundaries of the reclamation habitat and grasses and sedges must comprise > 60% of this value. In addition, the shrub and tree canopy cover of the area must not exceed 10% and 5%, respectively. Sites supporting a more even mix of grass and shrubs are classified as mixed habitats (e.g., shrub meadows).

Depending on their botanical composition, lowland/riparian meadows can be important year-round forage sources for caribou and, to a lesser extent, elk. Because grasses and sedges offer no escape or thermal cover for key wildlife species using this habitat, the overall value of lowland/riparian meadows to wildlife is enhanced where these habitats occur in proximity to shrublands, forests, cliffs or other forms of cover.

Key Species: caribou, elk

4.3.2 Suitable Conditions For Lowland/Riparian Meadow Development

Sedge-dominated communities generally occur on moderately to poorly drained organic or gleysolic soils (Strong and Leggat 1981), immediately adjacent to waterbodies or watercourses, or in depressional areas with water tables at or near the surface. On slightly better drained soils, grass-dominated meadows can develop but are frequently less persistent than sedge meadows, advancing more readily to shrubland habitat as a normal successional pattern.

4.3.3 Reclamation Techniques

Persistent lowland/riparian meadows are best developed on flat to gently sloping sites with moderately wet to saturated soils. On wetter sites, reclamation species should include a mixture of moisture tolerant sedges and grasses such as awned sedge, reed canarygrass and marsh reedgrass. The inclusion of sedges in the mixture is of particular importance as such species tend to retain higher crude protein levels in their cured state than most grasses (Reynolds et al. 1978), providing a higher quality overwintering forage for ungulates. Crested wheatgrass, redtop, smooth brome, Canada bluegrass and red fescue are better suited to less saturated sites.

As previously discussed, the overall value of meadows to wildlife is enhanced where such habitats are developed close to suitable escape or thermal cover such as shrublands, forests, cliffs and even open water. Surface contouring and reshaping, prior to meadow establishment, cannot be extensively used in this habitat to provide topographic cover for wildlife, as such an activity would likely alter the moisture regime of the site, making it less favourable for meadow development. However, creation of a knob and kettle terrain would provide opportunities for lowland meadow development in the kettle depressions.

4.4 UPLAND SHRUBLAND

4.4.1 Description

Upland shrublands are defined as shrub-dominated communities occupying sites from lower valley slopes to the upper reaches of the subalpine zone (i.e., 2000 m asl). To be classified as a shrubland habitat, the canopy cover of shrubs, on average, must be > 25% within the boundaries of the reclamation habitat and tree canopy cover must not exceed 5%. Sites supporting a more even mix of trees and shrubs are classified as mixed habitats (e.g., deciduous tree/shrub mix).

Depending on their botanical composition and structure, upland shrublands can be important habitats for elk, moose, snowshoe hare and white-tailed ptarmigan, and will also be used by caribou and mountain goat to a lesser degree. They are an excellent browse source for these species and also provide escape cover once their canopies reach an adequate density and height.

Because shrublands do not provide effective thermal cover, their habitat value is enhanced where they are situated adjacent to coniferous or mixedwood forest stands. Shrublands occurring on rolling terrain also have enhanced habitat value over shrublands on flatter or homogeneously sloping areas, as they provide greater microclimatic diversity and localized areas of improved thermal cover.

Key Species: elk, moose, snowshoe hare, white-tailed ptarmigan

4.4.2 Suitable Conditions For Upland Shrubland Development

Upland shrublands develop under a variety of biophysical conditions in the Mountains and Foothills biomes, either as early successional vegetation communities or localized climax stands. In general, the more persistent shrub stands occur on imperfectly drained sites, although certain species can also dominate the transition zone between dry meadows and moister forested areas for long periods of time. A variety of shade-intolerant successional shrubland communities will also develop throughout the Mountains and Foothills biomes after major disturbances such as fires or clearing activities.

4.4.3 Reclamation Techniques

Shrublands offer one of the more functional and easily established habitats for reclamation purposes. Although they can be developed on a variety of aspects, slopes, soils and moisture conditions, shrubland reclamation efforts are generally most successful on cool slopes or flat well-drained areas. A variety of shrub species which provide forage and/or escape cover can be selected for reclamation, including willows, dwarf birch, alders, red-osier dogwood, chokecherry, buffalo-berry, low-bush cranberry, saskatoon and silverberry. Several of these have the added advantage of being berry producers (e.g., chokecherry, buffalo-berry, saskatoon) or nitrogen fixers (e.g., silverberry, alders). As all of the above are commonly used reclamation species, the actual reclamation mix used will depend on site conditions and the key species of wildlife of concern. In general, alders, birch and willows should be utilized on cool, moist sites (i.e., north and east aspects, higher elevations), with the remaining species being more suited to warmer, moderate to well-drained sites. Shrub species with moderately tall mature growth forms (i.e., up to 3.0 m in height) such as chokecherry, alder and some willows are ideally suited for ungulate use, as the majority of their biomass falls within the browsing range of these animals.

More prostrate shrubs such as snowberry and buffaloberry are a more accessible source of food and cover for snowshoe hares.

As previously discussed, the overall value of shrublands to wildlife is enhanced where such habitats are developed close to suitable thermal cover such as coniferous or mixedwood forests. Alternatively, the habitat value of shrublands can be improved by providing increased microclimatic diversity and improved thermal cover for wildlife through surface contouring, prior to shrubland establishment.

4.5 LOWLAND/RIPARIAN SHRUBLAND

4.5.1 Description

Lowland/riparian shrublands are defined as shrub-dominated communities occupying sites with wet or poorly drained soils. While primarily occupying valley bottom elevations, such habitats may also occur along drainage courses up to subalpine elevations. To be classified as a shrubland habitat, the canopy cover of shrubs, on average, must be > 25% within the boundaries of the reclamation habitat and tree canopy cover must not exceed 5%. Sites supporting a more even mix of trees and shrubs are classified as mixed habitats (e.g., deciduous tree/shrub mix).

Depending on their botanical composition and structure, lowland/riparian shrublands can be important habitats for beaver, moose and snowshoe hare, and will also be used by elk to a lesser degree. They are an excellent browse source for these species and also provide escape cover once their canopies reach an adequate density and height.

Because lowland/riparian shrublands do not provide effective thermal cover, their habitat value is enhanced where they are situated adjacent to coniferous or mixedwood forest stands.

Key Species: beaver, moose, snowshoe hare

4.5.2 Suitable Conditions For Lowland/Riparian Shrubland Development

Lowland/riparian shrublands generally occur on moderately to poorly drained organic or gleysolic soils (Strong and Leggat 1981), immediately adjacent to waterbodies or watercourses, or in depressional areas with water tables at or near the surface. A variety of shade-intolerant successional shrubland communities will also develop throughout lowland areas after major disturbances such as fires or clearing activities, but these habitats are far less persistent than shrublands maintained by excessive soil moisture.

4.5.3 Reclamation Techniques

Shrublands offer one of the more functional and easily established habitats for reclamation purposes. A variety of shrub species which provide forage and/or escape cover can be selected for lowland/riparian shrubland reclamation, including willows, dwarf birch, alders and red-osier dogwood. Some of these have the added advantage of being berry producers (e.g., red-osier dogwood) or nitrogen fixers (e.g., alders). As all of the above are commonly used reclamation species for wet areas, the actual reclamation mix used will depend on the key species of wildlife of concern. Shrub species with moderately tall mature growth, forms (i.e., up to 3.0 m in height) such as alder and some willows are ideally suited for ungulate use, as the majority of their biomass falls within the browsing range of these animals. More prostrate shrubs such as dwarf birch are a more accessible source of food and cover for snowshoe hares.

As previously discussed, the overall value of shrublands to wildlife is enhanced where such habitats are developed close to suitable thermal cover such as coniferous or mixedwood forests, and their proximity to suitable waterbodies is an obvious requirement for beaver. Surface contouring and reshaping, prior to shrubland establishment, cannot be extensively used in this habitat to provide topographic cover for wildlife, as such an activity would likely alter the moisture regime of the site, making it less favourable for the development of persistent, moisture tolerant shrublands. However, creation of a knob and kettle terrain would provide opportunities for lowland/riparian shrubland development in the kettle depressions.

4.6 SHRUB MEADOW

4.6.1 Description

Shrub meadows are defined as a mosaic of shrublands and grass or sedge-dominated meadow communities. Although such habitats can occur, at least temporarily, on a variety of aspects and elevational ranges, they are generally associated with valley bottom areas. To be classified as a shrub meadow habitat, the canopy cover of shrubs and trees within the boundaries of the reclamation habitat must average 11-25% and $\leq 5\%$, respectively. In addition, the combined ground cover of grasses, sedges, forbs and low ($<$ 0.5 m) shrubs must each be $> 25\%$ and grasses and sedges must comprise $> 60\%$ of this value.

Depending on their botanical composition and structure, shrub meadows can be important year-round habitats for elk. They are an excellent browse and forage source for this species and also provide escape cover where their shrub canopies reach an adequate density and height.

Because shrub meadows do not provide effective thermal cover, their habitat value is enhanced where they are situated adjacent to coniferous or mixedwood forest stands. Shrub meadows occurring on rolling terrain also have enhanced habitat value over those on flatter or homogeneously sloping areas, as they provide greater microclimatic diversity and localized areas of improved thermal cover.

Key Species: elk

4.6.2 Suitable Conditions For Shrub Meadow Development

Shrub meadows generally represent the ecotone between lowland/riparian and upland meadow communities and shrublands. In general, the more persistent shrub meadow habitats occur on imperfectly drained sites adjacent to wet lowland meadow communities, although such habitats can also dominate the transition zone between upland meadows and shrublands for long periods of time.

4.6.3 Reclamation Techniques

Although they can be developed on a variety of aspects, slopes, soils and moisture conditions, shrub meadow reclamation efforts are generally most successful on flat imperfectly drained areas. A variety of shrub species which provide forage and/or escape cover can be selected for reclamation, including willows, dwarf birch, alders and red-osier dogwood. Some of these have the added advantage of being berry producers (e.g., red-osier dogwood) or nitrogen fixers (e.g., alders). As all of the above are commonly used reclamation species, the actual reclamation mix used will depend on the key species of wildlife of concern. Shrub species with moderately tall mature growth forms (i.e., up to 3.0 m in height) such as alder and some willows are ideally suited for ungulate use, as the majority of their biomass falls within the browsing range of these animals.

Selection of the graminoid mix will largely be dependent on the moisture conditions of the site. On wetter sites, reclamation species should include a mixture of moisture tolerant sedges and grasses such as awned sedge, reed canarygrass and marsh reedgrass. The inclusion of sedges in the mixture is of particular importance as such species tend to retain higher crude protein levels in their cured state than most grasses (Reynolds et al. 1978), providing a higher quality overwintering forage for ungulates. Crested wheatgrass, redtop, smooth brome, Canada bluegrass and red fescue are better suited to less saturated sites.

As previously discussed, the overall value of shrub meadows to wildlife is enhanced where such habitats are developed close to suitable thermal cover such as coniferous or mixedwood forests. Alternatively, the habitat value of shrub meadows can be improved by providing increased microclimatic diversity and improved thermal cover for wildlife through surface contouring, prior to shrub meadow establishment.

4.7 DECIDUOUS TREE/SHRUB MIX

4.7.1 Description

This habitat type includes all deciduous-dominated treed vegetation, including woodland (5-25% tree canopy cover) and forest (>25% tree canopy cover). In order to be classified as deciduous tree/shrub mix, >80% of the tree cover must be of broad-leaved deciduous trees.

Dense shrub and herbaceous understories are often associated with this type of vegetation, which provides a major source of food and building materials for beaver (deciduous trees and shrubs) as well as a source of browse and herbage for snowshoe hare. Deciduous tree/shrub mix is also used for browsing by moose and to some extent by elk (but they are not listed as key species below as they are more strongly associated with other habitat types). Escape cover and shade are provided by this habitat during summer but its value as winter thermal cover, at least for large mammals, is minimal.

Key Species: beaver, snowshoe hare

4.7.2 Suitable Conditions for Deciduous Tree/Shrub Mix Development

Deciduous tree/shrub habitat develops primarily on dry, warm (south and west facing) slopes, often in association with dry grassland. It also occurs under more mesic conditions along slope bases and over flat areas.

4.7.3 Reclamation Techniques

Establishment of moderately dense aspen tree cover (50-75% canopy cover), with an understory of aspen and balsam poplar saplings and shrubs such as rose, saskatoon, red osier dogwood, white meadowsweet, alder, buffaloberry, snowberry, shrubby cinquefoil and juniper will both mimic natural conditions and provide good browsing opportunities for the key species associated with this habitat.

Habitat developed for beaver must be near a suitable waterbody or watercourse and should be developed primarily for tree cover, although tall mature shrubs will provide an additional food source. A dense shrub layer composed of low-growing and medium-height shrubs should be the primary component of habitat developed for snowshoe hare. A dense herbaceous layer established under deciduous tree cover on mesic sites will provide additional foraging opportunities for hares.

4.8 DECIDUOUS-CONIFEROUS TREE/SHRUB MIX

4.8.1 Description

Deciduous-coniferous tree/shrub mix includes all mixedwood vegetation with a tree canopy cover of >5%, and with broad-leaved deciduous trees and coniferous trees each making up 20-80% of the total tree cover.

The deciduous component of this vegetation type offers some foraging opportunities for a number of key species (primarily moose, elk and beaver), but it is a primary habitat only for snowshoe hare. This vegetation type also provides shade and escape cover for moose and elk during summer, and some thermal cover (due to the coniferous component) during winter.

Key Species: moose, elk, snowshoe hare

4.8.2 Suitable Conditions for Deciduous-Coniferous Tree/Shrub Mix Development

Mixedwood vegetation co-dominated by deciduous and coniferous trees develops under a wide variety of biophysical conditions in the Foothills and Mountains regions. Composition depends on site conditions (primarily soil moisture and slope), past disturbances (clearing, fire) and successional stage. Moderately well-drained soils on gentle to moderate slopes provide the best site conditions. Early and mid-successional stages are characterized by a predominance of deciduous trees, with conifers occurring primarily in the understory. Late successional stages are dominated by coniferous trees.

4.8.3 Reclamation Techniques

This habitat type is composed naturally of admixtures of aspen, balsam poplar, paper birch, lodgepole pine, white spruce and subalpine fir, all suitable reclamation species (Watson et al. 1980). A variety of shrubs that provide forage and escape cover for snowshoe hares, one of the key species for this habitat, can be established; these include rose, willow, silverberry, buffaloberry, red osier dogwood, white meadowsweet, alder and ground juniper.

4.9 UPLAND CONIFEROUS TREE/SHRUB MIX

4.9.1 Description

This habitat type includes all coniferous-dominated treed vegetation, including woodland (5-25% tree canopy cover) and forest (>25% tree canopy cover) occurring on imperfectly to rapidly drained mineral soils. In order to be classified as coniferous tree/shrub mix, >80% of the tree cover must be of coniferous trees.

Mature, lichen-bearing conifer woodlands and forests provide critical habitat for caribou. Spruce grouse and snowshoe hares make wide use of conifer habitat, the latter particularly where a shrub layer has developed. Dense conifer stands also provide escape and thermal cover for moose and elk, and to some extent for mountain goats, bighorn sheep and white-tailed ptarmigan.

Key Species: caribou, moose, elk, snowshoe hare, spruce grouse

4.9.2 Suitable Conditions for Upland Coniferous Tree/Shrub Mix Development

Conifer-dominated habitat develops under a wide variety of biophysical conditions in the Mountains and Foothills biomes. Tree species composition depends on site conditions (soil moisture, slope exposure and altitude), past disturbances (clearing, fire) and successional stage (Strong and Leggat 1981).

Extensive, monotypic stands of open lodgepole pine predominate on rapidly to well-drained sites and/or warm slopes. Douglas fir and limber pine occur on some steep, xeric sites in the Foothills and major mountain valleys; dwarfed Engelmann spruce, whitebark pine and subalpine larch occur at altitudinal treeline.

Moderately to imperfectly drained sites and/or cool slopes are dominated by lodgepole pine in early succession, but these sites succeed to white and black spruce (lower altitudes) or Engelmann spruce and subalpine fir (higher altitudes).

4.9.3 Reclamation Techniques

Development of conifer habitats can be useful in a variety of reclamation situations. Small areas (3 ha or more) of dense spruce growth can be established in association with extensive meadow or shrubland habitat to provide escape and thermal cover for ungulates.

For more extensive forested areas, relatively minor manipulation during forest development can provide suitable habitat for snowshoe hare and spruce grouse. Small openings planted with grasses and forbs, an interspersion of open, moderate and closed canopy cover, and understory thickets of willow, alder and ground juniper will benefit both of these species.

Conifer forests allowed to succeed to a climax state (spruce/fir composition) in moderately to poorly drained conditions and/or on cool slopes will eventually provide suitable foraging habitat for caribou.

4.10 LOWLAND CONIFEROUS TREE/SHRUB MIX (MUSKEG)

4.10.1 Description

Muskeg includes all vegetation developed on wet organic soils and with a tree canopy cover > 5%. Wet organic or gleysolic sites with < 5% tree cover are classified as either lowland/riparian shrublands or lowland/riparian meadows, depending on extent of shrub cover.

Muskeg can provide important foraging habitat for moose during spring and summer, and for snowshoe hare year-round. Depending on tree and shrub densities, it may also provide escape and thermal cover for these key species.

Key Species: moose, snowshoe hare

4.10.2 Suitable Conditions for Lowland Coniferous Tree/Shrub Mix (Muskeg) Development

This habitat type is widespread throughout the Foothills, occurring in depressional, poorly drained situations. Soils are typically organic, wet or water-saturated, cold, acidic and nutrient-deficient (Strong and Leggat 1981).

4.10.3 Reclamation Techniques

Muskeg vegetation typically consists of black spruce and tamarack in the tree layer, dwarf birch, willow and Labrador tea in the shrub layer, and sedges, mosses and horsetails as ground cover. Most of these have not been tested in reclamation situations, although tamarack is known to re-establish on burned muskegs, and some sedges can probably be established on saturated organic soils (Watson et al. 1980).

While the difficult growing conditions typical of muskeg habitat makes it a generally poor candidate for reclamation, retention or improvement of muskeg may be useful in some reclamation situations, particularly where it will provide supplementary cover or forage for moose or snowshoe hare. To maximize its utility, muskeg should always be situated adjacent to other major habitats (or vice versa) for these species.

4.11 WATERCOURSE

4.11.1 Description

Watercourses are defined as linear drainage channels containing flowing water for all or part of the year.

Watercourses provide important habitat for both beaver and muskrat. They also provide a source of drinking water, and opportunities for development of streambank vegetation for use by a variety of other key wildlife species.

Key Species: beaver, muskrat

4.11.2 Suitable Conditions for Watercourse Development

Because watercourses are essentially drainage collection channels, they develop naturally along the route of least resistance to surface water flow. Wide bottomlands with a shallow, consistent gradient and well-vegetated catchment basins are the best locations for development of watercourses intended for use by wildlife.

4.11.3 Reclamation Techniques

Natural drainage on reclamation sites can be manipulated through contouring of landforms, and through design of the shape and gradient of the collection channel. For use by beaver and muskrat, watercourses should contain water year-round, and should have a wide (1.5-7.5 m), sinuous channel, water depths in excess of 1.5 m, low gradients (preferably <5%), and well-defined, stable banks.

Newly constructed streambanks should be stabilized by means of revegetation with meadow and shrubland habitats. Most, and if possible all of the catchment basin should be vegetated to minimize erosion and sedimentation.

Submergent vegetation (duckweeds and pondweeds) should be established within a watercourse as a food source for muskrats. Establishment of emergent vegetation (cattail, bulrushes, bur-reeds) in quiet backwater areas will provide an additional source of forage. Establishment of deciduous tree/shrub mix or shrubland adjacent to a watercourse will provide a source of food and building materials for beaver.

4.12 WETLAND

4.12.1 Description

Wetlands are defined as small waterbodies with depths of <1.5 m throughout most (>80%) of their area, and comprising both open water areas and emergent vegetation.

Wetlands provide optimal habitat for muskrats, and may be used as a source of drinking water by other key species.

Key Species: muskrat

4.12.2 Suitable Conditions for Wetland Development

Wetlands develop in depressional areas where standing water normally persists year-round. In the most productive wetlands, periodic flooding and drawdowns maintain a balance among open water, stands of emergent vegetation, and meadow and shrubland habitats along shore.

4.12.3 Reclamation Techniques

Shallow basins, borrow pits, sedimentation ponds and sewage treatment lagoons all provide potential sites for development of wetland reclamation habitat. Some physical modifications may be necessary to provide optimal conditions. Size should be 0.2 ha or more, and the shoreline irregular. Water depths should be 0.5-1.5 m throughout most of the wetland, but with isolated areas >1.5 m in depth.

Emergent vegetation (cattail, bulrushes, bur-reeds, reed grasses, horsetails) should be established over approximately 50% of the wetland area, with the rest remaining as open water. Submergent or floating vegetation (duckweeds and pondweeds) can be established in open water areas. Lowland/riparian meadows and shrublands are suitable habitats for establishment along shore.

4.13 LAKE/POND

4.13.1 Description

Lakes and ponds are defined as waterbodies with average water depths >1.5 m, with open water comprising >80% of the surface area, and with small areas of emergent plant growth. They differ from wetlands primarily in terms of greater water depth and less extensive emergent growth.

Lakes and ponds provide important habitat for beaver and muskrat. Where pond lilies and other aquatic species are present, lakes and ponds may be used as foraging habitat by moose during spring and summer. They also provide a source of drinking water for other key species.

Key species: beaver, muskrat, moose

4.13.2 Suitable Conditions for Lake/Pond Development

Lakes and ponds develop in gently rolling to steep terrain, wherever drainage is entrapped by topographic features and an impervious substrate. Although outlet streams are common features of natural waterbodies, runoff from the surrounding watershed must be sufficient to replenish annual water losses from outflow and evaporation.

4.13.3 Reclamation Techniques

Sedimentation ponds, end pits and tailings ponds all provide potential sites for development of lake/pond reclamation habitat. Some physical modifications may be necessary to provide optimal conditions. Lakes/ponds <1 ha in size are suitable for use by muskrat, but waterbodies intended for use by beaver should be larger. Shorelines of large waterbodies should be irregular. Water depths should be >3 m throughout most of the waterbody, but with some shoreline areas 0.5-1.5 m in depth to permit development of emergent vegetation.

Emergent vegetation (cattail, bulrushes, bur-reeds, reed grasses, horsetails) should occupy up to 20% of the waterbody area, with the rest remaining as open water. Submergent or floating vegetation (duckweeds, yellow pond lily, pondweeds) can be established in deep water areas. Lowland/riparian meadows, shrublands and deciduous tree/shrub mix are suitable habitats for establishment along shore. An accessible source of deciduous trees and shrubs along the shore is a requisite of waterbodies intended for use by beaver.

4.14 CLIFF

4.14.1 Description

Cliffs (highwalls) are defined as exposed faces of sedimentary, metamorphic or igneous rock with a slope of 50° or more, a vertical rise of at least 8 m and a miminum length of 100 m. They may occur naturally in a development site or may be developed during excavation. Cliffs can be comprised of a single rock face, contiguous multiple rock faces or multiple rock faces separated by vegetated slopes. Cliffs are of greater value to wildlife if they are developed in association with talus (along all or parts of the cliff base), are interspersed with vegetated slopes, and/or have grass meadows/shrub meadows adjacent to their base.

Highwalls provide an opportunity to develop and enhance cliff reclamation habitats for a variety of wildlife, most notably mountain goats, bighorn sheep, and raptors. Cliff habitats provide escape terrain for bighorn sheep and mountain goats as well as secluded areas for kidding and lambing. Isolated ledges and holes on cliffs provide secure nesting sites and perches for raptors and corvids and consistent thermal wind currents for raptor flight. Fissures and holes near the cliff base and along accessible ledges may be utilized as burrow sites by small mammals.

Key Species: mountain goat, bighorn sheep, golden eagle

4.14.2 Suitable Conditions for Cliff Development

As highwalls are created only during certain types of mining operations in the Mountains and Foothills biomes, their occurrence and location will be dictated by the mining operation and geological formations in the development area. The decision to maintain and develop a highwall as cliff habitat should be based on the relative abundance of natural cliffs in surrounding areas and the presence of wildlife species that commonly utilize cliff habitats.

4.14.3 Reclamation Techniques

Igneous, metamorphic and competent sedimentary rock are the preferred rock base for cliff habitats, as most other base materials erode or slump easily. If bedding planes of the rock or the composition of the highwall will result in large scale wall failures, the highwall should be recontoured. Cliff habitats should be located perpendicular to the slope contours and near the top of a divide rather than parallel to the contours or in a drainage bottom.

If a highwall is intended as escape terrain for bighorn sheep or mountain goats, surficial alterations of the highwall face may be necessary to provide adequate escape routes. Ledges should be constructed to provide interconnected routes up the cliff face and into the adjacent areas around the cliff face. Existing safety benches may provide suitable routes across and up the highwall. Helicopter seeding of safety benches and ledges can provide forage on or adjacent to the newly created escape terrain.

Ledges or shallow caves in the cliff face can be left intact or created to provide raptor and corvid nest sites. Blasting of holes in the highwall face can create suitable nest sites for some birds.

4.15 TALUS

4.15.1 Description

Talus is defined as an apron of unconsolidated coarse rock pieces, with variable slopes and a minimum length of 100 m.

Talus is usually associated with cliff habitats and should be incorporated into most highwall enhancement projects. Talus provides reproductive and hibernation habitat for a number of species of small mammals and birds. The pika is the only obligate talus species of wildlife in the Mountains and Foothills biomes but white-tailed ptarmigan (one of the key wildlife species), ground squirrels (golden-mantled, Columbian), hoary marmots, and bushy-tailed wood rats also inhabit talus. Depth of talus and interstices among the rocks are important as they permit animals to move inside the talus to the right temperature and humidity regimes. Talus also provides mountain goats and bighorn sheep with access to highwall habitats.

Key Species: bighorn sheep, mountain goat, white-tailed ptarmigan

4.15.2 Suitable Conditions for Talus Development

As coarse rock fragments are usually produced or are readily available only during certain types of mining operations in the Mountains and Foothills regions, the opportunity to develop talus areas will be dictated by the location and type of mining operation. In addition, as talus is preferably developed in association with highwalls, the occurrence of or potential for highwall habitats will also influence the development of talus habitat. The selection of talus habitat as a reclamation end use should be based on the occurrence of natural talus habitat in surrounding areas and the presence of wildlife species that commonly utilize talus habitats.

4.15.3 Reclamation Techniques

Talus can be created by free-dumping rock waste or large rock pieces. Piles should be a minimum of 2-3 m deep. It should preferably be composed of large metamorphic rocks or competent sedimentary rocks as opposed to small rubble or soft rocks, because the latter two types erode easily and do not provide stable living places for wildlife. Individual rock pieces should be at least 0.5 - 1.5 m^3. Talus of varying heights, slopes and depths is preferred as it provides a greater diversity of microsites. Larger talus areas also are preferred because they provide more habitat and are more stable than small talus areas.

Where possible, talus should be developed immediately adjacent to the base of a cliff habitat. Talus in proximity to a permanent water source also improves the value for wildlife.

5.0 THE ASSESSMENT METHODOLOGY

5.1 BACKGROUND

In recent years, wildlife research has shifted away from population-based studies to more cost-effective and standardized wildlife habitat classification and evaluation techniques for the purposes of impact assessment and wildlife management. The greater use of habitat-based techniques has been rationalized as follows:

"Numbers of species and numbers of individuals often may change for unpredictable reasons but habitat potential remains unchanged. Because of its relative stability, it is this habitat potential which should be documented by the wildlife manager interested in ecologically valid impact assessment" (USFWS 1980a).

Regardless of the scale at which they are applied, habitat classification and evaluation systems are based on the assumption that certain measurable biophysical variables within any given unit of land are directly related to that area's potential to support a given wildlife species. In the case of broad ecological mapping (1:250,000 to 1:1,000,000 scale) for strategic planning and assessment of wildlife resources, such as that recently completed by the Alberta Fish and Wildlife Division (Beak 1987), suitable predictive variables can include such broad biophysical parameters as general vegetation form, soil group, relief, regional precipitation and even geologic parent material.

For the purposes of localized assessments of wildlife habitat, more detailed predictive abilities are required as the wildlife-supporting capabilities of site-specific cover types or areas, rather than large ecological units, need to be determined. Consequently, the variables used become more detailed in nature, and may include such measurements as forest canopy composition, forest canopy closure, densities of browse species, etc. In either situation, the relationships between habitat suitability and the habitat or biophysical variables considered of importance to the species are generally synthesized in habitat evaluation models. The development of such models permits the rapid conversion of biophysical measurements or conditions into an index of habitat suitability.

Habitat evaluation models have been used in the assessment handbook as a framework for developing certification criteria for reclamation programs, based on the assumption that techniques used to evaluate the capability of natural habitats can be appropriately modified to evaluate reclamation sites. The models, developed in a format similar to Habitat Suitability Index (HSI) models employed by the U.S. Fish and Wildlife Service in their Habitat Evaluation Procedures program (USFWS 1980b), generate HSI values ranging from 0.0 (unsuitable habitat) to 1.0 (optimal habitat). More details on model development and application are provided in the section below.

5.2 MODEL DEVELOPMENT

As discussed in the previous section, 15 types of wildlife habitats have been recognized as potential reclamation objectives for the Mountains and Foothills regions of Alberta. HSI models have been prepared for each appropriate reclamation habitat/key wildlife species combination. An example of HSI model components and format is presented in Figure 1, using moose and shrublands as the species-habitat combination. As demonstrated, each model has four major components, including:

1. life requisites;

2. important assessment variables and associated significance weighting factors;

3. selected methods of variable measurements; and

4. categories or ranges of variable measurements and associated suitability ratings.

5.2.1 Life Requisites

Food and cover are the two major life requisites which affect a species abundance and survival. An area's suitability for a given wildlife species is directly related to the ability of that area to supply such requisites.

In each of the models, the habitat in question is evaluated based on the life requisite it best provides. For example, talus and highwalls/cliffs offer little foraging potential for bighorn sheep and are evaluated only on their ability to provide escape cover. For some species-habitat combinations (e.g., moose and shrublands), food and cover are closely interrelated, and habitat factors important in providing one are also important in providing the other. In such cases, a single food/cover life requisite has been recognized in the models.

5.2.2 Important Assessment Variables And Associated Significance Weighting Factors

Each model incorporates the two or more habitat (biophysical) variables considered to best reflect habitat suitability from a food, food/cover or cover perspective. Recently prepared accounts of particularly significant habitat requirements of key wildlife species (Nietfield et al. 1984; Eccles et al. 1986; Green and Salter 1987; Green et al. 1987) were relied on as major information sources during variable selection and model development. In general, each variable selected for incorporation into the models meets three criteria:

1. the variable is clearly related to the capacity of an area to support the wildlife species in question;

2. there is a basic understanding of the relationship of the variable to habitat suitability (e.g., what is the best and worst value for the variable and how does the variable interact with other habitat features); and

3. the variable is practical to measure, either in the field or from remotely sensed data sources.

Weighting factors are applied to each variable within a given model to permit a variable's relative importance to habitat suitability to be incorporated into model calculations. In simple additive models, these weighting factors sum to 1.0. However, this is not the case where more complex modelling techniques are utilized (see Section 5.3).

Figure 1. Habitat Evaluation Criteria and Scoring for Upland Shrublands Reclaimed for Elk or Moose.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Food/ Cover	Shrub Abundance	1.0	V3 -Shrub canopy cover	<5%	N/A
				5-<25%	N/A
				25-<50%	0.7
				50-<75%	1.0
				75-<95%	0.9
				≥95%	0.7
	Botanical Composition (Shrubs)	0.5	V1a -% of shrub canopy cover comprised of preferred browse species (elk/moose)	<20%	0.2
				20-<40%	0.4
				40-<60%	0.6
				60-<80%	0.8
				≥80%	1.0
	Shrub Canopy Height	0.5	V2 -2/3 of mean shrub height	<0.5m	0.2
				0.5-<1.0m	0.6
				1.0-<1.5m	1.0
				1.5-<2.0m	1.0
				2.0-<2.5m	1.0
				2.5-<3.0m	0.6
				≥3.0m	0.2
	Topographic Diversity	0.2	V4 -degree of surface relief along sampling transect (does not refer to elevational change up or down a slope)	-flat/constant slope (<1m of relief)	0.0
				-undulating (1-<2m of relief)	0.5
				-rolling (2-<5m of relief)	0.8
				-steeply rolling (≥5m of relief)	1.0

Habitat Suitability Index (HSI) = {(1.0 x V3 SI) x [(0.5 x V1a SI) + (0.5 x V2 SI)]}+ (0.2 x V4 SI)

N.B. - Where calculated HSI > 1.0, then final HSI = 1.0.

5.2.3 Selected Methods of Variable Measurements

Because several methods of measurement are frequently available for any given variable, the most appropriate method for field implementation had to be selected for each variable. In general, the method selected met with one or both of the following criteria:

1. it involves an ocular estimate or simple measurement, and avoids labour intensive activities such as plot clipping, etc; and

2. it produces values similar in format to those generated by provincial and federal ecosystem assessment techniques (Walmsley et al. 1980; Alberta Energy and Natural Resources 1984; Corns and Annas 1986); hence it provides biophysical measurements suitable for comparison with those available for natural, undisturbed areas.

5.2.4 Categories or Ranges of Variable Measurements and Associated Suitability Ratings

For each variable, a range of values can be encountered and measured in the field under natural conditions. These 'natural' values provide a comparative basis for assessing reclamation success. In Figure 1, example values have been listed for each of the habitat variables under the title Variable Categories. Each variable value or category contributes to the provision of life requisites to a unique degree. Consequently, each category is associated with a particular habitat suitability, and hence, is assigned a suitability index (SI). SIs range in value from 0.0 (minimum score) to 1.0 (maximum score). An SI value of 1.0 is assigned to the variable's measurement corresponding to habitat conditions considered optimal for supporting animal numbers. Other measurements of the same variable are assigned proportionately lower values, based on animal abundance expected to occur under such habitat conditions.

Variable categories and associated SIs in each model were developed based on a knowledge of potential conditions encountered in natural habitats and the habitat preferences of the wildlife species in question. For example, shrub canopy closures of 50-75% (see Figure 1) are commonly encountered on cooler moist slopes of the foothills and offer an excellent supply of food and cover for moose, hence their SI rating of 1.0. However, denser shrub stands (75-95%) such as encountered on snow slides, can actually impede moose movements and constitute less than optimal habitat (i.e., SI = 0.8).

5.3 MODEL MECHANICS

To assess the overall habitat suitability of a site for a given wildlife species, habitat variables selected for modelling are measured on site and assigned an appropriate SI value, based on the variable category in which they fall. A HSI value for the site is then calculated through an arithmetic combination of the weighted SI values for each of the habitat variables. In the simplest of models where weighting factors sum to 1.0, SI values are multiplied by their weighting factor and then summed to generate the HSI value. However, slight variations to this format occur as follows:

1. the use of "modifying"variables - Frequently, variables are used in the models which detract from, rather than enhance, the food or cover value of an area. For example, in the moose model (Table 4a), shrub abundance alone is considered to dictate the amount of food potentially available in a shrubland

(i.e., weighting of 1.0). Unfavourable shrub height and composition can only detract from these supplies. Consequently, the weighted SI values of these latter two variables are summed and then multiplied by the SI value of shrub abundance to produce the desired modifying effect.

2. the use of "compensatory" habitat variables - For some species, optimal food or cover values may be achieved when any one of several habitat variables approach optimal conditions. In such cases, weighting values are structured to permit overall food or cover HSI value to exceed 1.0. This permits the food or cover value of an area demonstrating slightly sub-optimal conditions for one particular habitat variable to be enhanced to optimal conditions (i.e., HSI of 1.0 or more) by a second or third habitat variable. In the moose model (Table 4a), adequate shrub abundance alone can provide ideal escape cover. However, where below-optimal shrub abundance occurs, the cover value of a site can be enhanced by rolling terrain which offers additional visual protection for the animals. Consequently, topographic diversity has been incorporated into the model as a compensatory variable for escape cover and has been weighted 0.2 in significance.

(N.B.: where the use of a compensatory variable results in an HSI value exceeding 1.0, that value is reduced to 1.0.)

5.4 APPLICATIONS OF MODEL OUTPUT

5.4.1 Evaluating Reclamation Success Based On HSI Values

A major function of the HSI values generated from the habitat models is to provide a numerical basis for the rejection or certification of a reclamation habitat. A value of 0.5 has been suggested as the minimum acceptable standard for any given reclamation habitat at the time of final assessment. On a scale of 0.0 to 1.0, this value represents a habitat of moderate suitability for the species in question, and could be likened to a Class 3 to 4 rating by the Canada Land Inventory program (i.e., moderate limitations to wildlife production). While this certification value may appear low for a reclamation program designed to create and enhance wildlife habitat, it was selected recognizing two major factors:

1. the HSI models developed for assessment purposes are based on the food and cover preferences of wildlife in naturally occurring habitats. In spite of recent advances in botanical reclamation (i.e., fertilization and transplant techniques, availability of nursery stock), reclamation programs are frequently faced with establishing communities on reconstructed soils with potential nutrient and moisture imbalances. Consequently, the development of high quality habitat may be an unreasonable expectation in many areas; and

2. many mine developments result in the removal of forested communities considered poor from a habitat perspective. Consequently, the creation of even moderate quality replacement habitat can represent a major improvement in localized habitat capability.

However, acceptance of an HSI of 0.5 as the minimum standard for any given reclamation habitat should be based on field testing of the proposed habitat assessment models (see below).

Most mine developers implementing a habitat reclamation approach would prefer to see site assessments undertaken after a 3-7 year period. While this is sufficient time to fully develop such habitats as highwalls/cliffs and talus, many vegetation habitats, particularly those with predominant tree and shrub components, will require more time to develop conditions comparable to natural habitats. Consequently, acceptable milestone HSI values have also been selected for such habitats for different assessment periods to permit the monitoring of habitat progression, the detection of deficiencies at an early date, and the implementation of necessary corrective measures to achieve certification by the final assessment date. Such milestone HSI values also incorporate some flexibility into the certification process, allowing final assessment periods to be negotiated between the developer and regulatory agencies. With additional research, the concept of milestone HSI values may also permit earlier certification of a site, providing that the precursors of the essential habitat components are present, and in the case of vegetation, are self-sustaining on the site (as discussed in Section 3.3). For example, with better predictive capabilities for vegetation growth performance on reclamation areas, it may be possible to modify parameters for tree and shrub canopy cover and height to permit assessment and certification of these habitat types within 3-5 years of planting.

During the selection of milestone HSI values, a number of assumptions had to be made on habitat development rates which could be reasonably expected on a reclamation site. Ideally, such assumptions should be based on available literature on vegetation dynamics in naturally recolonizing habitats. However, as discussed previously, there is a lack of such information, forcing the use of assumptions more arbitrary in nature. For example, it has been assumed that reclaimed grasslands and wetlands will achieve stability in biomass production in 7 years. Consequently, site assessment will be undertaken for these habitats after 7 years, and an HSI value of 0.5 will be required for certification. Conversely, because browse production in a disturbed site will likely not peak for 12-15 years after the initial perturbation, assessment dates at 5, 10 and 15 years have been proposed for reclaimed shrublands, with milestone HSI values of 0.2, 0.4 and 0.5, respectively. In the reclamation assessment handbook (Appendix I), assessment periods and acceptable HSI values have been summarized for all species/habitat combinations.

It is of note that a biophysical data set is currently being developed by the Alberta Forest Research Branch which would prove helpful in the selection of botanically sound milestone HSI values. In their "Stand Dynamics" program, the Branch is collecting detailed botanical measurements at a variety of sites which were logged or disturbed 5 to 7 years ago (Jerry Foechler, pers. comm.). While this data is not currently available for distribution, it should be reviewed in future and used to "fine-tune" the selected HSI values, where necessary.

5.4.2 Evaluating Reclamation Success Based On Habitat Availability

A standardized, unitless measure of habitat availability [i.e., the Habitat Unit (HU)], reflecting both habitat quality and quantity, can be generated for any given reclamation habitat by simply multiplying the area of that habitat by its calculated HSI value. On a reclamation site with two or more reclaimed habitats, total habitat availability can also be readily calculated with the following formula:

$$HU = \sum_{i=1}^{n}(HSI_i \times A_i)$$

where HSI_i = the HSI value for reclamation habitat i
A_i = the area of reclamation habitat i
n = the number of individual reclamation habitats on site.

HUs offer a second means of assessing the success of a reclamation site for certification purposes. By determining the amount of habitat lost from project development (i.e., from pre-development assessments of habitat availability, using the HSI models presented in this document), the reclamation planner and regulatory agency have a quantitative basis for designing the reclamation program. Conceivably, a "no net habitat loss" policy could be adopted, where the reclamation program would create an equal or greater number of HUs than that destroyed by project development. Alternatively, a particular number of HUs for a given wildlife species and acceptable to both the developer and regulatory body could be negotiated. In either case, a threshold number of HUs would have to be present at the time of site assessment to obtain certification. The time of assessment and required number of HUs would be selected on a site-specific basis by the planning and regulatory bodies.

The use of HUs rather than HSIs as the assessment criteria offers the developer one major advantage on sites where two or more habitats have been developed. Using HSIs, controversy may arise where some habitats satisfy HSI requirements while others do not, and the certification of the site as a whole may be in jeopardy because of a limited area of unsuitable habitat development. The use of HUs represents more of an averaging system for site evaluation. Insufficient HUs generated from one or two smaller areas demonstrating poor reclamation success may be more than compensated for by larger areas which exceed their HU requirements, thus permitting overall site approval.

5.5 FIELD TESTING OF THE PROPOSED EVALUATION MODELS

The evaluation models proposed for the 15 reclamation habitats are based on currently available information on the habitat requirements of the key wildlife species. Due to the constraints of the Phase II study, field testing of the evaluation models was not possible. Prior to use of these models for assessment of any reclamation site, it is essential that these models be field tested to ensure that:

1. the models are responsive to the range of potential reclamation conditions that may be encountered in the Mountains and Foothills biomes of Alberta;

2. the minimum standard habitat values (i.e., minimum HSI values) are realistic and represent areas that are adequately reclaimed for wildlife use; and

3. the proposed methodologies for field measurements of the required habitat variables are implementable in reclamation areas within the Mountains and Foothills biomes, and that the proposed sampling intensity will provide reliable estimates of habitat quality.

A field testing program of the habitat evaluation models might involve the measurement of habitat parameters and the calculation of HSI values for natural habitats, naturally regenerating habitats (e.g., successional areas following a forest fire), reforestation areas, and reclamation areas.

6.0 RECLAMATION HABITAT ASSESSMENTS

The HSI models developed as assessment tools for each of the recognized reclamation habitats are discussed in the sections below. In each section, the key wildlife species, important assessment variables and model mechanics associated with each HSI model are reviewed. A species-specific summary table which presents the model's assessment variables (and their significance weightings), variable categories (and associated SI values) and formula has also been provided with each section.

No attempt has been made to provide details of on-site variable measurement techniques in the sections below, and only the general approaches to such measurements are presented. The exact methodology for each variable measurement is presented in the field handbook developed for this project.

6.1 ALPINE MEADOW

6.1.1 Important Assessment Variables

Alpine meadows are recognized as important habitats for bighorn sheep, mountain goat, caribou, elk, and white-tailed ptarmigan, providing a forage base for the ungulates, and food and cover for white-tailed ptarmigan. Major habitat factors or variables which directly govern the value of a meadow to ungulates and which have been selected as evaluation criteria include 1) forage abundance, 2) botanical composition (ground strata) and 3) topographic diversity. For white-tailed ptarmigan, the first two variables have also been used for evaluation purposes but topographic diversity has been replaced with the variable 'unconsolidated rock cover'.

6.1.1.1 Forage abundance. Forage abundance is the most important of the three variables for all key species as it is a direct measure of the amount of food (and cover, in the case of ptarmigan) available to wildlife. For ungulates, food values increase with increasing vegetative cover. However, for ptarmigan, optimal habitat consists of vegetative cover interspersed with unvegetated rocky areas (e.g., scree slopes, rock outcrops) which serve as nesting and escape cover. Consequently, cover values considered optimal for this species are lower than those for ungulates. Combined ground cover of grasses, sedges, mosses/lichens, forbs and low (< 0.5 m) shrubs is used as the measure of forage abundance, as this variable can be visually estimated in the field (using various plot methods) and provides a good indication of vegetative biomass.

Ground cover categories (based on Daubenmire [1959] cover classes) and associated species-specific suitability (SI) values are presented in Tables 1a-1c. For key ungulate species, a ground cover of > 75% is considered optimal. A more stringent requirement for optimal cover ratings (i.e., > 95% cover) is not considered reasonable for alpine meadows, where growing conditions are extremely harsh. For white-tailed ptarmigan, which prefer a mosaic of vegetation and rock, vegetative cover values of 50 - < 75% are considered to be optimal. For all species, a cover value of < 25% is considered to fall outside of the acceptable range for alpine meadows (see Section 4.1) and further evaluation is not possible.

Table 1a. Habitat Evaluation Criteria and Scoring for Alpine Meadows Reclaimed for Bighorn Sheep or Mountain Goat.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Food	Forage Abundance	1.0	V11 -combined ground cover of grasses, sedges, forbs and low (<0.5m) shrubs	<5%	N/A
				5-<25%	N/A
				25-<50%	0.5
				50-<75%	0.8
				75-<95%	1.0
				≥95%	1.0
	Botanical Composition (Ground Strata)	1.0	V21 -% of vegetative ground cover comprised of grasses and sedges	<20%	N/A
				20-<40%	N/A
				40-<60%	0.5
				60-<80%	0.8
				≥80%	1.0
	Topographic Diversity	0.2	V4 -degree of surface relief along sampling transect (does not refer to elevational change up or down a slope)	-flat/constant slope (<1m of relief)	0.0
				-undulating (1-<2m of relief)	0.5
				-rolling (2-<5m of relief)	0.8
				-steeply rolling (≥5m of relief)	1.0

Habitat Suitability Index (HSI) = [(1.0 x V11 SI) x (1.0 x V21 SI)] + (0.2 x V4 SI)

N.B. - HSI value cannot exceed 0.49 where alpine meadow is more than 250 m from talus or cliff habitat with an HSI value of 0.5 or more.
- Where calculated HSI > 1.0, then final HSI = 1.0.

Table 1b. Habitat Evaluation Criteria and Scoring for Alpine Meadows Reclaimed for Caribou or Elk.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Food	Forage Abundance	1.0	V11 -combined ground cover of grasses, sedges, forbs and low (<0.5m) shrubs	<5%	N/A
				5-<25%	N/A
				25-<50%	0.5
				50-<75%	0.8
				75-<95%	1.0
				≥95%	1.0
	Botanical Composition (Ground Strata)	1.0	V21 -% of vegetative ground cover comprised of grasses and sedges	<20%	N/A
				20-<40%	N/A
				40-<60%	0.8
				60-<80%	1.0
				≥80%	0.7
	Topographic Diversity	0.2	V4 -degree of surface relief along sampling transect (does not refer to elevational change up or down a slope)	-flat/constant slope (<1m of relief)	0.0
				-undulating (1-<2m of relief)	0.5
				-rolling (2-<5m of relief)	0.8
				-steeply rolling (≥5m of relief)	1.0

Habitat Suitability Index (HSI) = [(1.0 x V11 SI) x (1.0 x V21 SI)] + (0.2 x V4 SI)

N.B. - HSI value cannot exceed 0.49 where alpine meadow is more than 250 m from shrubland habitat with an HSI value of 0.5 or more.
- Where calculated HSI > 1.0, then final HSI = 1.0.

Table 1c. Habitat Evaluation Criteria and Scoring for Alpine Meadows Reclaimed for White-tailed Ptarmigan.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Food	Forage Abundance	1.0	V11 -combined ground cover of grasses, sedges, forbs and low (<0.5m) shrubs	<5%	N/A
				5-<25%	N/A
				25-<50%	0.7
				50-<75%	1.0
				75-<95%	0.8
				≥95%	0.6
	Botanical Composition (Ground Strata)	1.0	V21 -% of vegetative ground cover comprised of grasses and sedges	<20%	N/A
				20-<40%	N/A
				40-<60%	1.0
				60-<80%	0.8
				≥80%	0.5
	Unconsolidated Rock Cover	0.2	V22 - ground cover of unconsolidated rock> 0.5 m^3 in volume	<5%	0.0
				5-<25%	0.8
				25-<50%	1.0
				50-<75%	0.7
				75-<95%	NA
				≥95%	NA

Habitat Suitability Index (HSI) = [(1.0 x V11 SI) x (1.0 x V21 SI)] + (0.2 x V22 SI)

N.B. - Where calculated HSI > 1.0, then final HSI=1.0.

6.1.1.2 Botanical composition (ground strata). A meadow's botanical composition largely dictates its value as a food source for some species, and this variable is used to modify the suitability rating of vegetative cover in all of the key species models. In general, grasses and sedges are considered to be the most important forages of the key ungulate species (and particularly bighorn sheep), as they provide digestible and relatively nutritious material throughout the year. However, a greater variety of forbs and low shrubs in addition to sedges and grasses is considered optimal for ptarmigan.

The percent of the total vegetative ground cover comprised of grasses and sedges is used as the measure of botanical composition. For bighorn sheep and mountain goat, habitat suitability is considered to increase with increasing grass and sedge dominance. However, for the remaining key species which utilize forbs and low shrubs to a greater degree, the highest categories of grass and sedge cover have been assigned slightly lower SI values.

6.1.1.3 Topographic diversity. A meadow's cover value can be enhanced for ungulates where the habitat occurs on rolling topography, as such terrain can provide localized areas of improved microclimatic conditions and visual protection for the animals. Consequently, topographic diversity has been included in the meadow HSI model for these species as a 'compensatory' variable (see Section 5.3) with a significance weighting of 0.2, designed to increase the habitat suitability ratings of areas with less than optimal vegetative cover and composition but favourable terrain. This variable is not considered of particular significance to ptarmigan as vegetation alone can adequately provide their cover needs, and it has not been incorporated into the evaluation model for this species.

Simple descriptive categories have been developed for this variable, based on surface contours and vertical relief, and habitat suitability is considered to increase with increasing surface complexity. On-site assessments of this variable are to be made visually along sampling transects established within reclaimed meadow habitats.

6.1.1.4 Unconsolidated rock cover. A meadow's habitat value can be enhanced for ptarmigan with the presence of scattered stretches of unconsolidated rock, areas which are used by this species for visual protection and nesting cover. Consequently, rock cover has been included in the meadow HSI model for these species as a 'compensatory' variable (see Section 5.3) with a significance weighting of 0.2, designed to increase the habitat suitability ratings of areas with less than optimal vegetative cover and composition but favourable rock cover.

Relatively coarse rock fragments are preferred as cover by ptarmigan. Therefore, the percent ground cover comprised of unconsolidated rock fragments each with a minimum diameter of 0.5 m is used as the measure of this variable. Cover values of 25-50% are considered optimal, with greater rock cover limiting forage availability.

6.1.1.5 Other factors. A meadow's position relative to other habitats can influence its habitat suitability. Because of the limited escape cover provided by meadows, their value is reduced if adequate shrubland, talus or cliff habitat is not present in the immediate vicinity. Because decisions on appropriate habitat interspersion and juxtaposition should have been resolved during the initial reclamation planning stages, these factors are not incorporated directly into the habitat evaluation models used for reclamation assessments. However, qualifiers have been developed for the ungulate models to limit the calculated value of alpine meadows which are too far removed from adjacent favourable cover types, and these appear at the bottom of Tables 1a and b. Such qualifiers were not considered necessary for ptarmigan which can adequately use alpine vegetation as cover.

6.1.2 Explanation of Model Formula

6.1.2.1 Bighorn sheep, mountain goat, caribou, elk. The food value of a meadow for these ungulates is directly influenced by forage abundance, as measured by vegetative ground cover (V11). An unfavourable botanical composition (V21) can only detract from this food value. Therefore, the SI value for forage abundance is modified (multiplied) by the SI value for botanical composition.

The cover value of a meadow for these ungulates is directly influenced by topographic diversity (V4). Therefore, the weighted SI value for topographic diversity is added to the above calculation to increase the suitability ratings of areas with suboptimal forage cover but favourable terrain conditions.

Potential modifications to formula output are listed at the bottom of Table 1a and b.

6.1.2.2. White-tailed ptarmigan. The food and cover value of a meadow for ptarmigan is directly influenced by forage abundance, as measured by vegetative ground cover (V11). An unfavourable botanical composition (V21) can only detract from the food and/or cover value of a meadow. Therefore, the SI value for forage abundance is modified (multiplied) by the SI value for meadow composition.

The cover value of a meadow for ptarmigan is directly influenced by unconsolidated rock cover (V22). Therefore, the weighted SI value for rock cover is added to the above calculation to increase the suitability ratings of areas with suboptimal forage abundance but favourable cover conditions.

6.2 UPLAND MEADOW

6.2.1 Important Assessment Variables

Upland meadows are recognized as important habitats for bighorn sheep, mountain goat, caribou and elk, providing a forage base for these ungulates. Major habitat factors or variables which directly govern the value of a meadow to ungulates and which have been selected as evaluation criteria include 1) forage abundance, 2) botanical composition (ground strata) and 3) topographic diversity.

6.2.1.1 Forage abundance. Forage abundance is the most important of the three variables for all key species as it is a direct measure of the amount of food available. Consequently, habitat suitability increases with increasing vegetative cover. Combined ground cover of grasses, sedges, mosses/lichens, forbs and low (< 0.5 m) shrubs is used as the measure of forage abundance, as it can be visually estimated in the field (using various plot methods) and provides a good indication of vegetative biomass.

Ground cover categories (based on Daubenmire [1959] cover classes) and associated species-specific suitability (SI) values are presented in Tables 2a-2b. A ground cover of > 95% is considered optimal (i.e., SI=1.0), with a ground cover of 75-<95% being rated only slightly less (0.9). A cover value of < 25% is considered to fall outside of the acceptable range for upland meadows (see Section 4.2) and further evaluation is not possible.

6.2.1.2 Botanical composition (ground strata). A meadow's botanical composition largely dictates its value as a food source for wildlife, and this variable is used to modify the suitability rating of vegetative cover in all of the key species models. In general, grasses and sedges are considered to be the most important forages of the key ungulate species (and particularly bighorn sheep), as they provide digestible and relatively nutritious material throughout the year. However, caribou and elk have a greater preference for forbs and low shrubs (in addition to sedges and grasses) than do sheep.

The percent of the total vegetative ground cover comprised of grasses and sedges is used as the measure of botanical composition. For bighorn sheep and mountain goat, habitat suitability is considered to increase with increasing grass and sedge dominance. However, for the remaining key species which utilize forbs and low shrubs to a greater degree, the highest categories of grass and sedge cover have been assigned slightly lower SI values.

6.2.1.3 Topographic diversity. A meadow's cover value can be enhanced for ungulates where the habitat occurs on rolling topography, as such terrain can provide localized areas of improved microclimatic conditions and visual protection for the animals. Consequently, topographic diversity has been included in the meadow HSI model for these species as a 'compensatory' variable (see Section 5.3) with a significance weighting of 0.2, designed to increase the habitat suitability ratings of areas with less than optimal forage abundance and composition but favourable terrain.

Simple descriptive categories have been developed for this variable, based on surface contours and vertical relief, and habitat suitability is considered to increase with increasing surface complexity. On-site assessments of this variable are to be made visually along sampling transects established within reclaimed meadow habitats.

6.2.1.4 Other factors. A meadow's position relative to other habitats can influence its habitat suitability. Because of the limited escape cover provided by meadows, their value is reduced if adequate shrubland, tree/shrub mix, talus or cliff habitat is not present in the immediate vicinity. Because decisions on appropriate habitat interspersion and juxtaposition should have been resolved during the initial reclamation planning stages, these factors are not incorporated directly into the habitat evaluation models used for reclamation assessments. However, qualifiers have been developed for the ungulate models to limit the calculated value of upland meadows which are too far removed from adjacent favourable cover types, and these appear at the bottom of Tables 2a and b.

Table 2a. Habitat Evaluation Criteria and Scoring for Upland Meadows Reclaimed for Bighorn Sheep or Mountain Goat.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Food	Forage Abundance	1.0	V11 -combined ground cover of grasses, sedges, forbs and low (<0.5m) shrubs	<5%	N/A
				5-<25%	N/A
				25-<50%	0.5
				50-<75%	0.7
				75-<95%	0.9
				≥95%	1.0
	Botanical Composition (Ground Strata)	1.0	V21 -% of vegetative ground cover comprised of grasses and sedges	<20%	N/A
				20-<40%	N/A
				40-<60%	N/A
				60-<80%	0.7
				≥80%	1.0
	Topographic Diversity	0.2	V4 -degree of surface relief along sampling transect (does not refer to elevational change up or down a slope)	-flat/constant slope (<1m of relief)	0.0
				-undulating (1-<2m of relief)	0.5
				-rolling (2-<5m of relief)	0.8
				-steeply rolling (≥5m of relief)	1.0

Habitat Suitability Index (HSI) = [(1.0 x V11 SI) x (1.0 x V21 SI)] + (0.2 x V4 SI)

N.B. - HSI value cannot exceed 0.49 where upland meadow is more than 250 m from talus or cliff habitat with an HSI value of 0.5 or more.
- Where calculated HSI > 1.0, then final HSI = 1.0.

Table 2b. Habitat Evaluation Criteria and Scoring for Upland Meadows Reclaimed for Caribou or Elk.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Food	Forage Abundance	1.0	V11 -combined ground cover of grasses, sedges, forbs and low (<0.5m) shrubs	<5%	N/A
				5-<25%	N/A
				25-<50%	0.5
				50-<75%	0.7
				75-<95%	0.9
				≥95%	1.0
	Botanical Composition (Ground Strata)	1.0	V21 -% of vegetative ground cover comprised of grasses and sedges	<20%	N/A
				20-<40%	N/A
				40-<60%	N/A
				60-<80%	1.0
				≥80%	0.7
	Topographic Diversity	0.2	V4 -degree of surface relief along sampling transect (does not refer to elevational change up or down a slope)	-flat/constant slope (<1m of relief)	0.0
				-undulating (1-<2m of relief)	0.5
				-rolling (2-<5m of relief)	0.8
				-steeply rolling (≥5m of relief)	1.0

Habitat Suitability Index (HSI) = [(1.0 x V11 SI) x (1.0 x V21 SI)] + (0.2 x V4 SI)

N.B. - HSI value cannot exceed 0.49 where upland meadow is more than 250 m from shrubland or tree/shrub mix habitat with an HSI value of 0.5 or more.
- Where calculated HSI > 1.0, then final HSI = 1.0.

6.2.2 Explanation of Model Formula

6.2.2.1 Bighorn sheep, mountain goat, caribou, and elk. The food value of a meadow for these ungulates is directly influenced by forage abundance, as measured by vegetative ground cover (V11). An unfavourable botanical composition (V21) can only detract from the food value of a meadow. Therefore, the SI value for forage abundance is modified (multiplied) by the SI value for botanical composition.

The cover value of a meadow for these ungulates is directly influenced by topographic diversity (V4). Therefore, the weighted SI value for topographic diversity is added to the above calculation to increase the suitability ratings of areas with suboptimal forage cover but favourable terrain conditions.

Potential modifications to formula output are listed at the bottom of Tables 2a and b.

6.3 LOWLAND/RIPARIAN MEADOW

6.3.1 Important Assessment Variables

Lowland/riparian meadows are recognized as important habitats for caribou and elk, providing a forage base for these ungulates. Major habitat factors or variables which directly govern the value of a meadow to ungulates and which have been selected as evaluation criteria include 1) forage abundance, 2) botanical composition (ground strata) and 3) horsetail abundance.

6.3.1.1 Forage abundance. Forage abundance is the most important of the three variables for the key species as it is a direct measure of the amount of food available. Consequently, habitat suitability increases with increasing vegetative cover. Combined ground cover of grasses, sedges, mosses/lichens, forbs and low (< 0.5 m) shrubs is used as the measure of forage abundance, as it can be visually estimated in the field (using various plot methods) and provides a good indication of vegetative biomass.

Ground cover categories (based on Daubenmire [1959] cover classes) and associated species-specific suitability (SI) values are presented in Table 3. A ground cover of > 95% is considered optimal (i.e., SI=1.0), with a ground cover of 75-95% being rated only slightly less (0.9). A cover value of < 25% is considered to fall outside of the acceptable range for lowland/riparian meadows (see Section 4.3) and further evaluation is not possible.

6.3.1.2 Botanical composition (ground strata). A meadow's botanical composition largely dictates its value as a food source for wildlife, and this variable is used to modify the suitability rating of vegetative cover in all of the key species models. In general, grasses and sedges are considered to be the most important forages of the key species, as they provide digestible and relatively nutritious material throughout the year. However, both caribou and elk also utilize forbs and low shrubs and a variety of such forages should also be present for optimal conditions.

Table 3. Habitat Evaluation Criteria and Scoring for Lowland/Riparian Meadows Reclaimed for Caribou or Elk.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Food	Forage Abundance	1.0	V11 -combined ground cover of grasses, sedges, forbs and low (<0.5m) shrubs	<5%	N/A
				5-<25%	N/A
				25-<50%	0.5
				50-<75%	0.7
				75-<95%	0.9
				≥95%	1.0
	Botanical Composition (Ground Strata)	1.0	V21 -% of vegetative ground cover comprised of grasses and sedges	<20%	N/A
				20-<40%	N/A
				40-<60%	N/A
				60-<80%	1.0
				≥80%	0.7
	Horsetail Abundance	0.2	V23 -ground cover of horsetail species	<5%	0.4
				5-<25%	1.0
				≥ 25%	0.7

Habitat Suitability Index (HSI) = [(1.0 x V11 SI) x (1.0 x V21 SI)] + (0.2 x V23 SI)

N.B. - HSI value cannot exceed 0.49 where lowland/riparian meadow is more than 250 m from shrubland or tree/shrub mix habitat with an HSI value of 0.5 or more.
- Where calculated HSI > 1.0, then final HSI = 1.0.

The percent of the total vegetative ground cover comprised of grasses and sedges is used as the measure of botanical composition. A value of 60-80% is considered optimal, with forbs and low shrubs comprising up to 39% of the remaining meadow flora (see Table 3).

6.3.1.3 Horsetail abundance. A meadow's food value can be enhanced for caribou and elk where the habitat supports horsetails, a preferred forage of both key species. Consequently, horsetail abundance has been included in the meadow HSI model for these species as a 'compensatory' variable (see Section 5.3) with a significance weighting of 0.2, designed to increase the habitat suitability ratings of areas with less than optimal forage conditions.

The percent ground cover of horsetail species is used as the variable measurement. A cover value of 5-25% is considered optimal for both species.

6.3.1.4 Other factors. A meadow's position relative to other habitats can influence its habitat suitability. Because of the limited escape cover provided by meadows, their value to some wildlife species is reduced if adequate shrubland or tree/shrub mix is not present in the immediate vicinity. Because decisions on appropriate habitat interspersion and juxtaposition should have been resolved during the initial reclamation planning stages, these factors are not incorporated directly into the habitat evaluation models used for reclamation assessments. However, qualifiers have been developed for the models to limit the calculated value of lowland/riparian meadows which are too far removed from adjacent favourable cover types, and these appear at the bottom of Table 3.

6.3.2 Explanation of Model Formula

6.3.2.1 Caribou and elk. The food value of a meadow for these ungulates is directly influenced by forage abundance, as measured by vegetative ground cover (V11). An unfavourable botanical composition (V21) can only detract from the food value of a meadow. Therefore, the SI value for forage abundance is modified (multiplied) by the SI value for botanical composition.

The food value of a meadow for these ungulates is further enhanced by horsetail cover (V23). Therefore, the weighted SI value for this variable is added to the above calculation to increase the suitability ratings of areas with suboptimal forage conditions.

Potential modifications to formula output are listed at the bottom of Table 3.

6.4 UPLAND SHRUBLAND

6.4.1 Important Assessment Variables

Upland shrublands are recognized as important habitats for elk, moose, snowshoe hare and white-tailed ptarmigan, providing both food and cover. Major habitat factors or variables which directly govern a shrubland's value to such wildlife and which have been selected as evaluation criteria include 1) shrub abundance, 2) shrub canopy height, 3) botanical composition (shrubs) and 4) topographic diversity.

6.4.1.1 Shrub abundance. Shrub abundance is the most important of the four factors as it directly influences the amount of food and cover available to wildlife. In general, food and cover values increase with increasing shrub abundance, although for larger wildlife species, excessively dense shrublands (e.g., snow slide thickets) may actually impede movements and are not considered optimal habitats. Shrub canopy cover is used as the measure of shrub abundance, as it can be rapidly measured in the field (using the line intercept method) and provides a good indication of shrub biomass.

Shrub cover categories (based on Daubenmire [1959] cover classes) and associated species-specific suitability (SI) values are presented in Tables 4a-4c. For key ungulate species, a canopy cover of 50 - < 75% is considered optimal. Denser canopies, which can impede movement and reduce the amount of the habitat utilized by the animals, have been assigned lower suitability ratings, as have more open canopies which offer reduced amounts of food and cover. For snowshoe hare and white-tailed ptarmigan, habitat suitability is considered to be directly related to shrub canopy cover, and 95-100% cover is considered optimal. For all species, a cover value of < 25% is considered to fall outside of the acceptable range for shrublands (see Section 4.4) and further evaluation is not possible.

6.4.1.2 Shrub canopy height. Shrub canopy height can detract from browse and cover availability. Overmature tall shrubs may support the majority of their browsable material above the feeding range of wildlife and will offer little foliage at low levels for cover. Similarly, low prostrate shrubs may be unavailable as food or cover during winter because of snow cover. Consequently, canopy height has been used as a 'modifying' variable (see Section 5.3) in the models for elk/moose, hare and ptarmigan, with a significance weighting of 0.5.

Given the shape of most shrubs, it has been assumed that the majority of a shrub's browsable twigs occur at a height of approximately 2/3 that of the top of the shrub. Consequently, 2/3 of the mean height of sampled shrubs has been used as the measure of shrub height and, hence, availability, rather than mean shrub height.

Shrub height categories and associated species-specific suitability values are presented in Tables 4a-4c. They have been developed based on the size and, hence, feeding range and cover requirements of animals, and on anticipated maximum snow depths of 1m for the Mountains and Foothills biomes. Heights of 1.0 - < 2.5 m are considered optimal for ungulates for year-round browsing, while heights of 1.0 - < 1.5 m are more appropriate for snowshoe hare. All shrub heights above 1.0 m are considered to be optimal for white-tailed ptarmigan as they can fly to the top of all shrubs.

6.4.1.3 Botanical composition (shrubs) A shrubland's botanical composition largely dictates its value as a food source for some species. For example, a shrubland comprised of unpalatable species can provide excellent escape cover but limited forage. Consequently, botanical composition has been included as a modifying variable in the models for elk/moose and ptarmigan, with a significance weighting comparable to canopy height (i.e., 0.5). Shrub species considered to be optimal for ungulates are willows, saskatoon and red-osier dogwood, while willows are primarily utilized by white-tailed ptarmigan. Because snowshoe hares are opportunistic feeders, primarily utilizing those shrub species which are most available within a given area, botanical composition has not been included as an evaluation criterion for snowshoe hare habitat.

Table 4a. **Habitat Evaluation Criteria and Scoring for Upland Shrublands Reclaimed for Elk or Moose.**

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Food/ Cover	Shrub Abundance	1.0	V3 -Shrub canopy cover	<5%	N/A
				5-<25%	N/A
				25-<50%	0.7
				50-<75%	1.0
				75-<95%	0.9
				≥95%	0.7
	Botanical Composition (Shrubs)	0.5	V1a -% of shrub canopy cover comprised of preferred browse species (elk/moose)	<20%	0.2
				20-<40%	0.4
				40-<60%	0.6
				60-<80%	0.8
				≥80%	1.0
	Shrub Canopy Height	0.5	V2 -2/3 of mean shrub height	<0.5m	0.2
				0.5-<1.0m	0.6
				1.0-<1.5m	1.0
				1.5-<2.0m	1.0
				2.0-<2.5m	1.0
				2.5-<3.0m	0.6
				≥3.0m	0.2
	Topographic Diversity	0.2	V4 -degree of surface relief along sampling transect (does not refer to elevational change up or down a slope	-flat/constant slope (<1m of relief)	0.0
				-undulating (1-<2m of relief)	0.5
				-rolling (2-<5m of relief)	0.8
				-steeply rolling (≥5m of relief)	1.0

Habitat Suitability Index (HSI) = {(1.0 x V3 SI) x [(0.5 x V1a SI) + (0.5 x V2 SI)]}+ (0.2 x V4 SI)

N.B. - Where calculated HSI > 1.0, then final HSI = 1.0.

Table 4b. Habitat Evaluation Criteria and Scoring for Upland Shrublands Reclaimed for Snowshoe Hare.

LIFE REQUISITE PROVIDED	HABITAT FACTORS USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
	Shrub Abundance	1.0	V3 -Shrub canopy cover	<5%	N/A
				5-<25%	N/A
				25-<50%	0.5
				50-<75%	0.7
				75-<95%	0.9
				≥95%	1.0
Food/ Cover	Shrub Canopy Height	1.0	V2 -2/3 of mean shrub height	<0.5m	0.2
				0.5-<1.0m	0.6
				1.0-<1.5m	1.0
				1.5-<2.0m	0.9
				2.0-<2.5m	0.7
				2.5-<3.0m	0.4
				≥3.0m	0.2

Habitat Suitability Index (HSI) = (1.0 x V3 SI) x (1.0 x V2 SI)

Table 4c. Habitat Evaluation Criteria and Scoring for Upland Shrublands Reclaimed for White-tailed Ptarmigan.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Food/ Cover	Shrub Abundance	1.0	V3 -Shrub canopy cover	<5%	N/A
				5-<25%	N/A
				25-<50%	0.5
				50-<75%	0.7
				75-<95%	0.9
				≥95%	1.0
	Botanical Composition (shrubs)	0.5	V16 -% of shrub canopy cover comprised of preferred browse species (ptarmigan)	<20%	0.2
				20-<40%	0.4
				40-<60%	0.6
				60-<80%	0.8
				≥80%	1.0
	Shrub Canopy Height	0.5	V2 -2/3 of mean shrub height	<0.5m	0.2
				0.5-<1.0m	0.6
				1.0-<1.5m	1.0
				1.5-<2.0m	1.0
				2.0-<2.5m	1.0
				2.5-<3.0m	1.0
				≥3.0m	1.0

Habitat Suitability Index (HSI) = (1.0 x V3 SI) x [(0.5 x V16 SI) + (0.5 x V2 SI)]

The percent of the total shrub canopy cover comprised of preferred browse species has been used as the measure of shrubland composition. For all wildlife with browsing preferences, habitat suitability increases with the increasing dominance of preferred browse species.

6.4.1.4 Topographic diversity. A shrubland's cover value can be enhanced for ungulates where the habitat occurs on rolling topography, as such terrain can provide localized areas of improved microclimatic conditions and additional visual protection for the animals. Consequently, topographic diversity has been included in the shrubland HSI model for these species as a 'compensatory' variable (see Section 5.3) with a significance weighting of 0.2, designed to increase the habitat suitability ratings of areas with less than optimal shrub abundance but favourable terrain. This variable is not considered of particular significance to hares and ptarmigan as vegetation alone can adequately provide their cover needs, and it has not been incorporated into the evaluation model for these species.

Simple descriptive categories have been developed for this variable, based on surface contours and vertical relief, and habitat suitability is considered to increase with increasing surface complexity. On-site assessments of this variable are to be made visually along sampling transects established within reclaimed shrubland habitats.

6.4.1.5 Other factors. A shrubland's position relative to other habitats can influence its habitat suitability. Because of the limited thermal cover provided by shrublands, their value to some wildlife species is reduced if adequate coniferous or mixedwood cover is not present in the immediate vicinity. Similarly, "island" shrublands separated from other comparable cover by large expanses of open grasslands or unvegetated areas may be avoided by wildlife and, hence, have limited habitat value. Because decisions on appropriate habitat interspersion and juxtaposition should have been resolved during the initial reclamation planning stages, these factors are not incorporated directly into the habitat evaluation models used for reclamation assessments.

6.4.2 Explanation of Model Formula

6.4.2.1 Elk/moose. The food and cover value of a shrubland for elk and moose is directly influenced by shrub abundance, as measured by shrub canopy cover (V3). Unfavourable shrubland composition (V1a) and shrub canopy height (V2) can only detract from the food and/or cover value of a shrubland. Therefore, the SI value for shrub canopy cover is modified (multiplied) by the sum of the weighted SI values for shrubland composition and shrub canopy height.

The cover value of a shrubland for elk and moose is also directly influenced by topographic diversity (V4). Therefore, the weighted SI value for topographic diversity is added to the above calculation to increase the suitability ratings of areas with suboptimal shrub cover but favourable terrain conditions.

6.4.2.2 Snowshoe hare. The food and cover value of a shrubland for snowshoe hare is directly influenced by shrub abundance, as measured by shrub canopy cover (V3). Unfavourable shrub canopy height (V2) can only detract from the food and/or cover value of a shrubland. Therefore, the SI value for shrub canopy cover is modified (multiplied) by the SI value for shrub canopy height.

6.4.2.3 White-tailed ptarmigan. The food and cover value of a shrubland for ptarmigan is directly influenced by shrub abundance, as measured by shrub canopy cover (V3). Unfavourable shrubland composition (V16) and shrub canopy height (V2) can only detract from the food and/or cover value of a shrubland. Therefore, the SI value for shrub canopy cover is modified (multiplied) by the sum of the weighted SI values for shrubland composition and shrub canopy height.

6.5 LOWLAND/RIPARIAN SHRUBLAND

6.5.1 Important Assessment Variables

Lowland/riparian shrublands are recognized as important habitats for beaver, moose and snowshoe hare, providing both food and cover. Major habitat factors or variables which directly govern a shrubland's value to such wildlife and which have been selected as evaluation criteria include 1) shrub abundance, 2) shrub canopy height and 3) botanical composition (shrubs).

6.5.1.1 Shrub abundance. Shrub abundance is the most important of the three factors as it directly influences the amount of food and cover available to wildlife. In general, food and cover values increase with increasing shrub abundance, although for larger wildlife species, excessively dense shrublands may actually impede animal movements and are not considered optimal habitats. Shrub canopy cover is used as the measure of shrub abundance, as it can be rapidly measured in the field (using the line intercept method) and provides a good indication of shrub biomass.

Shrub cover categories (based on Daubenmire [1959] cover classes) and associated species-specific suitability (SI) values are presented in Tables 5a-5c. For moose and beaver, a canopy cover of 50 - < 75% is considered optimal. Denser canopies, which can impede animal movement (and shrub cutting activities, in the case of beaver) and reduce the amount of the habitat utilized by the animals, have been assigned lower suitability ratings, as have more open canopies which offer reduced amounts of food and cover. For snowshoe hare, habitat suitability is considered to be directly related to shrub canopy cover, and 95-100% cover is considered optimal. For all species, a cover value of < 25% is considered to fall outside of the acceptable range for shrublands (see Section 4.4) and further evaluation is not possible.

6.5.1.2 Shrub canopy height. Shrub canopy height can detract from browse and cover availability. Overmature tall shrubs may support the majority of their browsable material above the feeding range of some wildlife and will offer little foliage at low levels for cover. Similarly, low prostrate shrubs may be unavailable as food or cover during winter because of snow cover. Consequently, canopy height has been used as a 'modifying' variable (see Section 5.3) in the models for moose and hare, with a significance weighting of 0.5. For beaver, which fell and utilize entire shrubs, the amount of available shrub biomass increases with increasing shrub canopy height. Therefore, canopy height is considered to be a contributing, rather than a modifying variable in the shrubland model for beaver.

Table 5a. Habitat Evaluation Criteria and Scoring for Lowland/Riparian Shrublands Reclaimed for Beaver.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Food/ Cover	Botanical Composition (Shrubs)	1.0	V1b -% of shrub canopy cover comprised of preferred browse species (beaver)	<20%	0.2
				20-<40%	0.4
				40-<60%	0.6
				60-<80%	0.8
				≥80%	1.0
	Shrub Canopy Height	0.5	V2 -2/3 of mean shrub height	<0.5m	0.1
				0.5-<1.0m	0.3
				1.0-<1.5m	0.5
				1.5-<2.0m	0.7
				2.0-<2.5m	0.8
				2.5-<3.0m	0.9
				≥3.0m	1.0
	Shrub Abundance	0.5	V3 -Shrub canopy cover	<5%	N/A
				5-<25%	N/A
				25-<50%	0.7
				50-<75%	1.0
				75-<95%	0.9
				≥95%	0.7

Habitat Suitability Index (HSI) = [(0.5 x V2 SI) + (0.5 x V3 SI)] x (1.0 x V1b SI)

N.B. - HSI value cannot exceed 0.49 where shrubland is more than 30 m from a waterbody or watercourse with an HSI value of 0.5 or more.

Table 5b. Habitat Evaluation Criteria and Scoring for Lowland/Riparian Shrublands Reclaimed for Moose.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Food/ Cover	Shrub Abundance	1.0	V3 -Shrub canopy cover	<5%	N/A
				5-<25%	N/A
				25-<50%	0.7
				50-<75%	1.0
				75-<95%	0.9
				≥95%	0.7
	Botanical Composition (Shrubs)	0.5	V1a -% of shrub canopy cover comprised of preferred browse species (moose)	<20%	0.2
				20-<40%	0.4
				40-<60%	0.6
				60-<80%	0.8
				≥80%	1.0
	Shrub Canopy Height	0.5	V2 -2/3 of mean shrub height	<0.5m	0.2
				0.5-<1.0m	0.6
				1.0-<1.5m	1.0
				1.5-<2.0m	1.0
				2.0-<2.5m	1.0
				2.5-<3.0m	0.6
				≥3.0m	0.2

Habitat Suitability Index (HSI) = (1.0 x V3 SI) x [(0.5 x V1a SI) + (0.5 x V2 SI)]

Table 5c. **Habitat Evaluation Criteria and Scoring for Lowland/Riparian Shrublands Reclaimed for Snowshoe Hare.**

LIFE REQUISITE PROVIDED	HABITAT FACTORS USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
	Shrub Abundance	1.0	V3 -Shrub canopy cover	<5%	N/A
				5-<25%	N/A
				25-<50%	0.5
				50-<75%	0.7
				75-<95%	0.9
				≥95%	1.0
Food/ Cover	Shrub Canopy Height	1.0	V2 -2/3 of mean shrub height	<0.5m	0.2
				0.5-<1.0m	0.6
				1.0-<1.5m	1.0
				1.5-<2.0m	0.9
				2.0-<2.5m	0.7
				2.5-<3.0m	0.4
				≥3.0m	0.2

Habitat Suitability Index (HSI) = (1.0 x V3 SI) x (1.0 x V2 SI)

Given the shape of most shrubs, it has been assumed that the majority of a shrub's browsable twigs occur at a height of approximately 2/3 that of the top of the shrub. Consequently, two-thirds of the mean height of sampled shrubs has been used as the measure of shrub canopy height and, hence, availability, rather than mean shrub height.

Shrub height categories and associated species-specific suitability values are presented in Tables 5a-5c. For moose and snowshoe hare, they have been developed based on the size and, hence, feeding range and cover requirements of animals, and on anticipated maximum snow depths of 1 m for the Mountains and Foothills biomes. Heights of 1.0 - < 2.5 m are considered optimal for moose for year-round browsing, while heights of 1.0 - < 1.5 m are more appropriate for snowshoe hare. For beaver, shrub canopy height is considered to be directly related to the amount of available shrub biomass. Therefore, habitat suitability increases with increasing shrub canopy height for this species.

6.5.1.3 Botanical composition (shrubs). A shrubland's botanical composition largely dictates its value as a food source. For example, a shrubland comprised of unpalatable species can provide excellent escape cover but limited forage. Consequently, botanical composition has been included as a modifying variable in the models for moose and beaver. Shrub species considered to be optimal for ungulates are willows, saskatoon and red-osier dogwood, while willows are primarily utilized by beaver. Snowshoe hares are opportunistic feeders, primarily utilizing those shrub species which are most available within a given area. Consequently, botanical composition has not been included as an evaluation criterion for hare habitat.

The percent of the total shrub canopy cover comprised of preferred browse species has been used as the measure of shrubland composition. For all wildlife with browsing preferences, habitat suitability increases with the increasing dominance of preferred browse species.

6.5.1.4 Other factors. A shrubland's position relative to other habitats can influence its habitat suitability. Because of the limited thermal cover provided by shrublands, their value to some wildlife species is reduced if adequate coniferous or mixedwood cover is not present in the immediate vicinity. Similarly, "island" shrublands separated from other comparable cover by large expanses of open grasslands or unvegetated areas may be avoided by wildlife and , hence, have limited habitat value. For beaver, shrublands will not be of value if they are too far removed from suitable waterbodies or watercourses. Because decisions on appropriate habitat interspersion and juxtaposition should have been resolved during the initial reclamation planning stages, these factors are not incorporated directly into the habitat evaluation models used for reclamation assessments. However, a qualifier has been developed for the beaver model to limit the calculated value of shrublands which are too far removed from adjacent water-based habitats (Tables 5a).

6.5.2 Explanation of Model Formula

6.5.2.1 Beaver. The food and cover value of a shrubland for beaver is directly influenced by shrub abundance, as measured by shrub canopy cover (V3), and shrub canopy height (V2). Unfavourable shrubland composition (V1b) can only detract from the food and/or cover value of a shrubland. Therefore, the sum of the weighted SI values for shrub canopy cover and shrub canopy height is modified (multiplied) by the SI value for shrubland composition.

6.5.2.2 Moose. The food and cover value of a shrubland for moose is directly influenced by shrub abundance, as measured by shrub canopy cover (V3). Unfavourable shrubland composition (V1a) and shrub canopy height (V2) can only detract from the food and/or cover value of a shrubland. Therefore, the SI value for shrub canopy cover is modified (multiplied) by the sum of the weighted SI values for shrubland composition and shrub canopy height.

6.5.2.3 Snowshoe hare. The food and cover value of a shrubland for snowshoe hare is directly influenced by shrub abundance, as measured by shrub canopy cover (V3). Unfavourable shrub canopy height (V2) can only detract from the food and/or cover value of a shrubland. Therefore, the SI value for shrub canopy cover is modified (multiplied) by the SI value for shrub canopy height.

6.6 SHRUB MEADOW

6.6.1 Important Assessment Variables

Shrub meadows are recognized as an important habitat for elk, providing both food and cover. Major habitat factors or variables which directly govern a shrub meadow's value to such wildlife and which have been selected as evaluation criteria include 1) shrub abundance, 2) shrub canopy height, 3) botanical composition (shrubs), 4) forage abundance, 5) botanical composition (ground strata), and 6) topographic diversity.

6.6.1.1 Shrub abundance. Shrub abundance, as measured by canopy cover, directly influences the amount of browse and cover available within a shrub meadow habitat. However, by definition, a shrub meadow has a shrub canopy cover of only 5-25%, and shrubs contribute little to the overall food resources provided by the habitat. Consequently, this variable is assigned a significance weighting of only 0.3, considerably less than that assigned to forage abundance in the ground strata, and only one abundance category is recognized (i.e., 5-25%).

6.6.1.2 Shrub canopy height. Shrub canopy height can detract from browse and cover availability. Overmature tall shrubs may support the majority of their browsable material above the feeding range of elk and will offer little foliage at low levels for cover. Similarly, low prostrate shrubs may be unavailable as food or cover during winter because of snow cover. Consequently, canopy height has been used as a 'modifying' variable (see Section 5.3) in the model, with a significance weighting of 0.5.

Given the shape of most shrubs, it has been assumed that the majority of a shrub's browsable twigs occur at a height of approximately 2/3 that of the top of the shrub. Consequently, two-thirds of the mean height of sampled shrubs has been used as the measure of shrub canopy height and, hence, availability, rather than mean shrub height.

Shrub height categories and associated species-specific suitability values are presented in Table 6. They have been developed based on the size and, hence, feeding range and cover requirements of elk, and on anticipated maximum snow depths of 1 m for

Table 6. **Habitat Evaluation Criteria and Scoring for Shrub Meadows Reclaimed for Elk.**

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
	Shrub Abundance	0.3	V3 -Shrub canopy cover	<5%	N/A
				5-<25%	1.0
				25-<50%	N/A
				50-<75%	N/A
				75-<95%	N/A
				≥95%	N/A
	Botanical Composition (Shrubs)	0.5	V1a -% of shrub canopy cover comprised of preferred browse species (elk)	<20%	0.2
				20-<40%	0.4
				40-<60%	0.6
				60-<80%	0.8
				≥80%	1.0
	Shrub Canopy Height	0.5	V2 -2/3 of mean shrub height	<0.5m	0.2
				0.5-<1.0m	0.6
				1.0-<1.5m	1.0
				1.5-<2.0m	1.0
				2.0-<2.5m	1.0
Food/ Cover				2.5-<3.0m	0.6
				≥3.0m	0.2
	Forage Abundance	0.7	V11 -combined ground cover of grasses, sedges, forbs and low (<0.5m) shrubs	<5%	N/A
				5-<25%	N/A
				25-<50%	0.5
				50-<75%	0.7
				75-<95%	0.9
				≥95%	1.0
	Botanical Composition (Ground Strata)	1.0	V21 -% of vegetative ground cover comprised of grasses and sedges	<20%	N/A
				20-<40%	N/A
				40-<60%	N/A
				60-<80%	1.0
				≥80%	0.7

Table 6.....continued

Table 6.....continued

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
	Topographic Diversity	0.2	V4 -degree of surface relief along sampling transect (does not refer to elevational change up or down a slope)	-flat/constant slope (<1m of relief)	0.0
				-undulating (1-<2m of relief)	0.5
				-rolling (2-<5m of relief)	0.8
				-steeply rolling (≥5m of relief)	1.0

Habitat Suitability Index (HSI) = {(0.3 x V3 SI) x [(0.5 x V1a SI) + (0.5 x V2 SI)]} + [(0.7 x V11 SI) x (1.0 x V21 SI)] + (0.2 x V4 SI)

Simple descriptive categories have been developed for this variable, based on surface contours and vertical relief, and habitat suitability is considered to increase with increasing surface complexity. On-site assessments of this variable are to be made visually along sampling transects established within reclaimed shrubland habitats.

6.6.1.7 Other factors. A shrub meadow's position relative to other habitats can influence its habitat suitability. Because of the limited thermal cover provided by shrub meadows, their value to elk is reduced if adequate coniferous or mixedwood cover is not present in the immediate vicinity. Because decisions on appropriate habitat interspersion and juxtaposition should have been resolved during the initial reclamation planning stages, these factors are not incorporated directly into the habitat evaluation models used for reclamation assessments.

6.6.2 Explanation of Model Formula

6.6.2.1 Elk. The food and cover value of a shrub meadow for elk is partially influenced by shrub abundance (significance weighting of 0.3), as measured by shrub canopy cover (V3). Unfavourable shrub composition (V1a) and shrub canopy height (V2) can only detract from the food and/or cover value of a shrub meadow. Therefore, the weighted SI value for shrub canopy cover is modified (multiplied) by the sum of the weighted SI values for shrub composition and shrub canopy height.

The food value of a shrub meadow is primarily influenced by forage abundance (significance weighting of 0.7) within the ground strata, as measured by vegetative ground cover (V11). An unfavourable botanical composition (V21) can only detract from this food value. Therefore, the weighted SI value for forage abundance is modified (multiplied) by the SI value for botanical composition. This value is, in turn, added to the shrub-related calculation above.

Because topographic diversity (V4) increases the cover value of this habitat, the weighted SI value for this variable is added to the above calculation as a compensatory factor. The model is structured in such a way that the presence of favourable topography can add to, but its absence cannot detract from, the value of the habitat.

6.7 DECIDUOUS TREE/SHRUB MIX

6.7.1 Important Assessment Variables

For assessment purposes, it is assumed that this habitat provides tree canopy cover > 5%, and that > 80% of the tree cover consists of deciduous species. Habitats with less tree cover should be evaluated as meadows or shrublands. Habitats with mixed deciduous and coniferous tree cover (20-80% of each) should be evaluated as deciduous-coniferous tree/shrub mix. It is also assumed that minimum habitat area requirements, as determined during the reclamation planning stage, are met prior to assessment. These factors are not included in the assessment models.

Deciduous tree/shrub mix is an important habitat for beaver and snowshoe hare, providing both food and cover resources. Four major factors that directly govern habitat suitability for these species have been selected as evaluation criteria and, hence, model components. These are 1) tree abundance (beaver model only), 2) botanical composition of the tree layer (beaver model only), 3) shrub abundance and 4) shrub canopy height (snowshoe hare model only).

6.7.1.1 Tree abundance. The abundance of deciduous trees directly determines the amount of food and building material (for dams and lodges) available to beaver. Tree canopy cover is used as the measure of tree abundance for assessment purposes (Table 7a), as it can be rapidly measured in the field and provides a good indication of tree biomass. It is assumed that suitability values increase with increasing canopy cover, except for very dense growth (> 75%) which may impede cutting/felling activities.

6.7.1.2 Botanical composition (trees). The value of the tree layer as a source of food and building material for beaver is modified by its botanical composition. While a large number of deciduous species are used, depending on availability, distinct preferences are shown for relatively few species. For assessment purposes, these are considered to be limited to aspen and balsam poplar.

The percent of total tree cover comprised of preferred species is used as the measure of botanical composition. Habitat suitability is considered to increase with the increasing dominance of preferred species.

6.7.1.3 Shrub abundance. Shrubs and tree saplings (< 5.0 m) provide a secondary source of food and building materials for beaver and the primary food and cover source for hare. Consequently, this variable is included as a 'compensatory' and primary factor in the evaluation of deciduous tree/shrub mix for beaver and hare, respectively. Canopy cover is used as the measure of abundance. It is assumed that suitability values increase with increasing canopy cover for hare. However, very dense growth (> 75% cover) may impede the cutting/felling activities of beaver and this category has received a slightly reduced SI value for this species.

6.7.1.4 Shrub canopy height. Unlike beaver, hare can obtain browse from only a limited height range. Consequently, canopy height has been used as a 'modifying' variable (see Section 5.3) in the model for hare.

Given the shape of most shrubs, it has been assumed that the majority of a shrub's browsable twigs occur at a height of approximately 2/3 that of the top of the shrub. Consequently, 2/3 of the mean height of sampled shrubs has been used as the measure of shrub height and, hence, availability, rather than mean shrub height.

Shrub height categories and associated species-specific suitability values are presented in Table 7b. They have been developed based on the size and, hence, feeding range and cover requirements of hare, and on anticipated maximum snow depths of 1m for the Mountains and Foothills biomes. Heights of 1.0 - < 1.5 m are considered optimal for snowshoe hare.

6.7.1.5 Other factors. In addition to those variables described above, the suitability value of deciduous tree/shrub mix can be influenced by its position relative to other habitat types. For example, treed habitat developed for beaver must be near a suitable waterbody or watercourse to be used as a source of food and building materials. Because decisions on

Table 7a. Habitat Evaluation Criteria and Scoring for Deciduous Tree/Shrub Mix Reclaimed for Beaver.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
	Tree Abundance	1.0	V6 -Tree canopy cover	<5%	N/A
				5-<25%	0.4
				25-<50%	0.7
				50-<75%	1.0
				75-<95%	0.9
				≥95%	0.7
Food/ Cover	Botanical Composition (Trees)	1.0	V5a -% of tree canopy cover comprised of preferred browse species (beaver)	<20%	0.2
				20-<40%	0.4
				40-<60%	0.6
				60-<80%	0.8
				≥80%	1.0
	Shrub Abundance	0.2	V3 -Shrub canopy cover	<5%	0.0
				5-<25%	0.4
				25-<50%	0.7
				50-<75%	1.0
				75-<95%	0.9
				≥95%	0.7

Habitat Suitability Index (HSI) = [(1.0 x V5a SI) x (1.0 x V6 SI)] + (0.2 x V3 SI)

N.B. - HSI value cannot exceed 0.49 where deciduous tree/shrub mix is more than 30 m from a waterbody or watercourse with an HSI value of 0.5 or more.
- Where calculated HSI > 1.0, final HSI = 1.0

Table 7b. Habitat Evaluation Criteria and Scoring for Deciduous Tree/ Shrub Mix Reclaimed for Snowshoe Hare.

LIFE REQUISITE PROVIDED	HABITAT FACTORS USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
	Shrub Abundance	1.0	V3 -Shrub canopy cover	<5%	0.0
				5-<25%	0.3
				25-<50%	0.5
				50-<75%	0.7
				75-<95%	0.9
				≥95%	1.0
Food/ Cover	Shrub Canopy Height	1.0	V2 -2/3 of mean shrub height	<0.5m	0.2
				0.5-<1.0m	0.6
				1.0-<1.5m	1.0
				1.5-<2.0m	0.9
				2.0-<2.5m	0.7
				2.5-<3.0m	0.4
				≥3.0m	0.2

Habitat Suitability Index (HSI) = (1.0 x V3 SI) x (1.0 x V2 SI)

appropriate habitat interspersion and juxtaposition should have been resolved during the initial reclamation planning stages, these factors are not incorporated directly into the assessment models. However, a qualifier has been developed for the beaver model to limit the HSI value of deciduous tree/shrub mix that is too far removed from suitable water-based habitats for optimum utilization.

6.7.2 Explanation of Model Formula

6.7.2.1 Beaver. The food and cover value of a deciduous tree/shrub mix for beaver is directly influenced by tree abundance, as measured by tree canopy cover (V6). Unfavourable tree composition (V5a) can only detract from the food and/or cover value of such a habitat. Therefore, the SI value for tree abundance is modified (multiplied) by the SI value for botanical composition. Because shrubs provide a secondary source of food and cover in this habitat, the weighted SI value for shrub abundance (V3) is added to the calculated value above as a compensatory factor. The model is structured in such a way that the presence of shrubs can add to, but their absence cannot detract from, the value of the habitat.

6.7.2.2 Snowshoe hare. The food and cover value of a deciduous tree/shrub mix for snowshoe hare is directly influenced by shrub abundance, as measured by shrub canopy cover (V3). Unfavourable shrub canopy height (V2) can only detract from the food and/or cover value of such a habitat. Therefore, the SI value for shrub canopy cover is modified (multiplied) by the SI value for shrub canopy height.

6.8 DECIDUOUS-CONIFEROUS TREE/SHRUB MIX

6.8.1 Important Assessment Variables

For assessment purposes, it is assumed that this habitat provides tree canopy cover > 5%, and that the tree cover consists of both deciduous and coniferous species (20-80% of each). Habitats with less tree cover should be evaluated as meadows or shrublands. Habitats dominated by either deciduous or coniferous trees should be evaluated as deciduous tree/shrub mix or coniferous tree/shrub mix. It is also assumed that minimum habitat area requirements, as determined during the reclamation planning stage, are met prior to assessment. These factors are not included in the assessment models.

Deciduous-coniferous tree/shrub mix provides thermal and escape cover for elk and moose, and both food and cover resources for snowshoe hare. Because cover requirements of elk and moose are similar, a combined model has been developed for these species. The model evaluates only cover value, as deciduous-coniferous tree shrub mix is considered to be secondary elk/moose foraging habitat.

Four major factors that directly govern habitat suitability for elk, moose and/or snowshoe hare have been selected as evaluation criteria and, hence, model components. These are 1) tree abundance (elk/moose model only), 2) botanical composition of the tree canopy (elk/moose model only), 3) shrub abundance and 4) shrub canopy height (hare model only).

6.8.1.1 Tree abundance. The abundance of trees directly determines the amount of cover available to elk and moose. Dense tree growth provides both thermal and escape cover; it also intercepts snowfall, thus providing reduced snow depth conditions. Tree canopy cover is used as the measure of tree abundance for assessment purposes (Table 8a), as it can be rapidly measured in the field and provides a good indication of tree density. It is assumed that suitability values increase with increasing canopy cover, except for very dense growth (> 75%) which may impede movement.

6.8.1.2 Tree canopy composition. The value of the tree layer in providing thermal and escape cover for large ungulates is determined by its botanical composition. It is assumed that conifer trees provide the best cover, although deciduous trees have some cover value during the leaf-bearing season. The assignment of SI values in Table 8a is therefore based on the percentage composition of conifers in the tree layer (but note that by definition, conifer trees cannot comprise < 20% or > 80% of the total tree canopy cover in this habitat type).

6.8.1.3 Shrub abundance. Shrubs and tree saplings (< 5 m) provide a secondary source of cover for elk and moose, and hence their abundance is included as a 'compensatory' factor (significance weighting of 0.2; see Section 5.3) in the evaluation of deciduous-coniferous tree/shrub mix for these species. Shrub abundance is considered to be the primary factor governing the food and cover value of this habitat for hare.

Canopy cover is used as the measure of this variable. In general, it is assumed that suitability values increase with increasing canopy cover. However, very dense growth (i.e., > 75%) may impede the movement of elk and moose and this category has received a slightly reduced SI value for these species.

6.8.1.4 Shrub canopy height. Because of the limited browsing range of hare, shrub canopy height can detract from browse availability. Consequently, canopy height has been used as a 'modifying' variable (see Section 5.3) in the model for hare.

Given the shape of most shrubs, it has been assumed that the majority of a shrub's browsable twigs occur at a height of approximately 2/3 that of the top of the shrub. Consequently, 2/3 of the mean height of sampled shrubs has been used as the measure of shrub height and, hence, availability, rather than mean shrub height.

Shrub height categories and associated suitability values are presented in Table 8b. They have been developed based on the size and, hence, feeding range and cover requirements of hare, and on anticipated maximum snow depths of 1 m for the Mountains and Foothills biomes. Heights of 1.0 - < 1.5 m are considered optimal for snowshoe hare.

6.8.1.5 Other factors. In addition to those variables described above, the suitability value of deciduous-coniferous tree/shrub mix can be influenced by its position relative to other habitat types. For example, treed habitat developed for use as cover by elk and moose is most valuable when situated adjacent to suitable feeding areas (meadows and shrublands). Because decisions on appropriate habitat interspersion and juxtaposition should have been resolved during the initial reclamation planning stages, these factors are not incorporated directly into the assessment models.

Table 8a. Habitat Evaluation Criteria and Scoring for Deciduous-Coniferous Tree/Shrub Mix Reclaimed for Elk or Moose.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Cover	Tree Abundance	1.0	V6 -Tree canopy cover	<5%	N/A
				5-<25%	0.4
				25-<50%	0.7
				50-<75%	1.0
				75-<95%	0.9
				≥95%	0.7
	Tree Canopy Composition	1.0	V10 -% of tree canopy cover comprised of conifers	<20%	N/A
				20-<40%	0.4
				40-<60%	0.7
				60-<80%	1.0
				≥80%	N/A
	Shrub Abundance	0.2	V3 -Shrub canopy cover	<5%	0.2
				5-<25%	0.4
				25-<50%	0.7
				50-<75%	1.0
				75-<95%	0.9
				≥95%	0.7

Habitat Suitability Index (HSI) = [(1.0 x V6 SI) x (1.0 x V10 SI)] + (0.2 x V3 SI)

N.B. - Where calculated HSI > 1.0, final HSI = 1.0

Table 8b. **Habitat Evaluation Criteria and Scoring for Deciduous-Coniferous Tree/ Shrub Mix Reclaimed for Snowshoe Hare.**

LIFE REQUISITE PROVIDED	HABITAT FACTORS USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Food/ Cover	Shrub Abundance	1.0	V3 -Shrub canopy cover	<5%	0.0
				5-<25%	0.3
				25-<50%	0.5
				50-<75%	0.7
				75-<95%	0.9
				≥95%	1.0
	Shrub Canopy Height	1.0	V2 -2/3 of mean shrub height	<0.5m	0.2
				0.5-<1.0m	0.6
				1.0-<1.5m	1.0
				1.5-<2.0m	0.9
				2.0-<2.5m	0.7
				2.5-<3.0m	0.4
				≥3.0m	0.2

Habitat Suitability Index (HSI) = (1.0 x V3 SI) x (1.0 x V2 SI)

6.8.2 Explanation of Model Formula

6.8.2.1 Elk/moose. The cover value of a deciduous-coniferous tree/shrub mix for elk and moose is directly influenced by tree abundance (V6), as measured by tree canopy cover. Unfavourable tree composition (V10) can only detract from the cover value of this habitat. Consequently, the SI value for tree abundance is modified (multiplied) by the SI value for botanical composition. Because shrubs provide a secondary source of cover in this habitat, the weighted SI value for shrub abundance (V3) is added to the calculated value above as a compensatory factor. The model is structured in such a way that the presence of shrubs can add to, but their absence cannot detract from, the value of the habitat.

6.8.2.2 Snowshoe hare. The food and cover value of a deciduous-coniferous tree/shrub mix for snowshoe hare is directly influenced by shrub abundance, as measured by shrub canopy cover (V3). Unfavourable shrub canopy height (V2) can only detract from the food and/or cover value of such a habitat. Therefore, the SI value for shrub canopy cover is modified (multiplied) by the SI value for shrub canopy height.

6.9 UPLAND CONIFEROUS TREE/SHRUB MIX

6.9.1 Important Assessment Variables

For assessment purposes, it is assumed that this habitat provides tree canopy cover > 5%, and that > 80% of the tree cover consists of coniferous species. Habitats with less tree cover should be evaluated as meadows or shrublands. Habitats with mixed deciduous and coniferous tree cover (20-80% of each) should be evaluated as deciduous-coniferous tree/shrub mix. It is also assumed that minimum habitat area requirements, as determined during the reclamation planning stage, are met prior to assessment. These factors are not included in the assessment models.

Upland coniferous tree/shrub mix provides thermal and escape cover for elk and moose, and both food and cover resources for caribou, snowshoe hare and spruce grouse. Because cover requirements of elk and moose are similar, a combined model has been developed for these species. However, the model evaluates only cover value, as coniferous tree shrub mix is considered to be secondary elk/moose foraging habitat. Models evaluating both food and cover values have been developed for each of the other key species.

Five major factors that directly govern the habitat suitability value of upland coniferous tree/shrub mix have been selected as evaluation criteria and, hence, model components. These are 1) tree abundance (caribou, elk/moose and spruce grouse models), 2) tree canopy composition (spruce grouse model), 3) abundance and composition of the successional understory (caribou model), 4) shrub abundance (caribou, elk/moose, snowshoe hare and spruce grouse models) and 5) shrub canopy height (snowshoe hare model).

6.9.1.1 Tree abundance. The abundance of trees directly determines the amount of cover available to caribou, elk and moose. Dense tree growth provides both thermal and escape cover; it also intercepts snowfall, thus providing reduced snow depth conditions. Tree canopy cover is used as the measure of tree abundance for assessment purposes in the ungulate models (Tables 9a, 9b), as it can be rapidly measured in the field and provides a good indication of tree density. It is assumed that suitability values increase with increasing canopy cover, except for very dense growth (> 75%) which may impede movement.

The abundance of trees also directly determines the amount of both food and cover available to spruce grouse. As in the ungulate models, tree canopy cover is used as the measure of tree abundance for assessment purposes (Table 9d). Spruce grouse require dense clumps of conifers for cover, and an abundance of conifers for food, but also require relatively open areas for display purposes. It is assumed that these requirements are best met by moderately dense stands, and SI values in Table 9d are assigned on this basis.

6.9.1.2 Tree canopy composition. The value of the tree layer in providing thermal and escape cover for large ungulates is determined by its botanical composition. It is assumed that conifer trees provide the best cover, although deciduous trees have some cover value during the leaf-bearing season. Because, by definition, conifer trees must comprise > 80% of the total tree canopy cover in this habitat type, and because cover values do not vary greatly among conifer species, this factor is not included in the caribou or elk/moose models.

Botanical composition of the tree layer is included in the spruce grouse model in order to account for the feeding preferences of this species. For assessment purposes, preferred food species in the Mountains and Foothills regions are considered to be limited to lodgepole pine and white spruce. The percent of the tree canopy cover comprised of these two species is used as the measure of botanical composition, and habitat suitability is considered to increase with their increasing dominance.

6.9.1.3 Successional understory abundance. Caribou rely on old growth conifer forests for both food and cover, particularly during winter. Such forests take several decades to develop, and assessment of mature habitat will therefore be outside of the proposed habitat evaluation timeframe. However, assessment of the abundance of successional species in the understory layer relatively early in the forest development stage can be used to provide an indication of mature forest composition, and hence suitability for caribou. Therefore, for assessment purposes, a variable measuring the canopy cover of Engelmann spruce and subalpine fir (preferred climax species) is included in the caribou model (Table 9a). Habitat suitability is considered to increase with increasing canopy cover.

6.9.1.4 Shrub abundance. Shrubs and tree saplings (< 5 m) provide a secondary source of cover for caribou, elk and moose, and hence their abundance is included as a 'compensatory' factor (significance weighting of 0.2; see Section 5.3) in the evaluation of upland coniferous tree/shrub mix for these species. Shrub abundance is considered to be the primary factor governing the food and cover value of this habitat for hare (Table 9c).

Canopy cover is used as the measure of this variable. In general, it is assumed that suitability values increase with increasing canopy cover. However, very dense growth (i.e., > 75%) may impede the movement of elk, moose and caribou, and this category has received a slightly reduced SI value for these species.

Table 9a. Habitat Evaluation Criteria and Scoring for Upland Coniferous Tree/Shrub Mix Reclaimed for Caribou.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
	Successional Understory Abundance	1.0	V20 - % of tree canopy cover comprised of Engelmann spruce/ subalpine fir	<20%	0.4
				20-<40%	0.6
				40-<60%	0.8
				60-<80%	1.0
				≥80%	1.0
Food/ Cover	Tree Abundance	1.0	V6 -Tree canopy cover	<5%	N/A
				5-<25%	0.4
				25-<50%	0.7
				50-<75%	1.0
				75-<95%	0.9
				≥95%	0.7
	Shrub Abundance	0.2	V3 -Shrub canopy cover	<5%	0.2
				5-<25%	0.4
				25-<50%	0.7
				50-<75%	1.0
				75-<95%	0.9
				≥95%	0.7

Habitat Suitability Index (HSI) = [(1.0 x V20 SI) x (1.0 x V6 SI)] + (0.2 x V3 SI)

N.B. - Where calculated HSI > 1.0, final HSI = 1.0

Table 9b. Habitat Evaluation Criteria and Scoring for Upland Coniferous Tree/Shrub Mix Reclaimed for Elk or Moose.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
	Tree Abundance	1.0	V6 -Tree canopy cover	<5%	N/A
				5-<25%	0.4
				25-<50%	0.7
				50-<75%	1.0
				75-<95%	0.9
				≥95%	0.7
Cover	Shrub Abundance	0.2	V3 -Shrub canopy cover	<5%	0.2
				5-<25%	0.4
				25-<50%	0.7
				50-<75%	1.0
				75-<95%	0.9
				≥95%	0.7

Habitat Suitability Index (HSI) = (1.0 x V6 SI) + (0.2 x V3 SI)

N.B. - Where calculated HSI > 1.0, final HSI = 1.0

Table 9c. Habitat Evaluation Criteria and Scoring for Upland Coniferous Tree/Shrub Mix Reclaimed for Snowshoe Hare.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
	Shrub Abundance	1.0	V3 -Shrub canopy cover	<5%	0.0
				5-<25%	0.3
				25-<50%	0.5
				50-<75%	0.7
				75-<95%	0.9
Food/ Cover				≥95%	1.0
	Shrub Canopy Height	1.0	V2 -2/3 of mean shrub cover	<0.5 m	0.2
				0.5-<1.0 m	0.6
				1.0-<1.5 m	1.0
				1.5-<2.0 m	0.9
				2.0-<2.5 m	0.7
				2.5-<3.0 m	0.4
				≥3.0 m	0.2

Habitat Suitability Index (HSI) = [(1.0 x V2 SI) x (1.0 x V3 SI)]

Table 9d. Habitat Evaluation Criteria and Scoring for Upland Coniferous Tree/Shrub Mix Reclaimed for Spruce Grouse.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
	Tree Abundance	1.0	V6 -Tree canopy cover	<5%	N/A
				5-<25%	0.4
				25-<50%	0.7
				50-<75%	1.0
				75-<95%	0.7
				≥95%	0.4
Food/ Cover	Tree Canopy Composition	1.0	V5b -% of tree canopy cover comprised of preferred browse species (spruce grouse)	<20%	0.2
				20-<40%	0.4
				40-<60%	0.6
				60-<80%	0.8
				≥80%	1.0
	Shrub Abundance	0.2	V3 -Shrub canopy cover	<5%	0.2
				5-<25%	0.6
				25-<50%	1.0
				50-<75%	0.6
				75-<95%	0.2
				≥95%	0.0

Habitat Suitability Index (HSI) = [(1.0 x V6 SI) x (1.0 x V5b SI)] + [0.2 x V3 SI]

N.B. - Where calculated HSI > 1.0, final HSI = 1.0

Shrub abundance is also a determinant of habitat suitability for spruce grouse. Although this species normally occurs in areas with relatively open understories, dense shrub thickets provide nesting, brood-rearing and moulting cover, and berry-producing shrubs provide a summer food source. Total shrub canopy cover is used as the measure of shrub availability (Table 9d). It is assumed that shrub canopy cover of 25 - < 50% provides the optimal mix of shrub thickets and open understory areas.

6.9.1.5 Shrub canopy height. Because of the limited browsing range of hare, shrub canopy height can detract from browse availability. Consequently, canopy height has been used as a 'modifying' variable (see Section 5.3) in the model for hare.

Given the shape of most shrubs, it has been assumed that the majority of a shrub's browsable twigs occur at a height of approximately 2/3 that of the top of the shrub. Consequently, 2/3 of the mean height of sampled shrubs has been used as the measure of shrub height and, hence, availability, rather than mean shrub height.

Shrub height categories and associated suitability values are presented in Table 9c. They have been developed based on the size and, hence, feeding range and cover requirements of hare, and on anticipated maximum snow depths of 1 m for the Mountains and Foothills biomes. Heights of 1.0 - < 1.5 m are considered optimal for snowshoe hare.

6.9.1.6 Other Factors. In addition to those variables described above, the suitability value of upland coniferous tree/shrub mix can be influenced by its position relative to other habitat types. For example, treed habitat developed for use as cover by elk and moose is most valuable when situated adjacent to suitable feeding areas (meadows and shrublands). Because decisions on appropriate habitat interspersion and juxtaposition should have been resolved during the initial reclamation planning stages, these factors are not incorporated directly into the assessment models.

6.9.2 Explanation of Model Formula

6.9.2.1 Caribou. The current cover value of an upland coniferous tree/shrub mix for caribou is directly related to coniferous tree abundance (V6), as measured by tree canopy cover. The future suitability of this habitat for caribou is dependent on successional trends, as measured by the composition of its understory (V20). To permit this 'future suitability' to be incorporated into HSI calculations, the above cover value for this habitat is modified (multiplied) by the SI value for this variable.

Because shrubs provide a secondary source of cover in this habitat, the weighted SI value for shrub abundance (V3) is added to the calculated SI value as a compensatory factor. The model is structured in such a way that the presence of shrubs can add to, but their absence cannot detract from, the value of the habitat.

6.9.2.2 Elk/moose. The cover value of an upland coniferous tree/shrub mix for elk and moose is directly influenced by tree abundance (V6), as measured by tree canopy cover. Because shrubs provide a secondary source of cover in this habitat, the weighted SI value for shrub abundance is added to the SI value for tree abundance as a compensatory factor.

The model is structured in such a way that the presence of shrubs can add to, but their absence cannot detract from, the value of the habitat.

6.9.2.3 Snowshoe hare. The food and cover value of an upland coniferous tree/shrub mix for snowshoe hare is directly influenced by shrub abundance, as measured by shrub canopy cover (V3). Unfavourable shrub canopy height (V2) can only detract from the food and/or cover value of such a habitat. Therefore, the SI value for shrub canopy cover is modified (multiplied) by the SI value for shrub canopy height.

6.9.2.4 Spruce grouse. The food and cover value of an upland coniferous tree/shrub mix for spruce grouse is directly influenced by tree abundance (V6), as measured by tree canopy cover. Unfavourable canopy composition (V5b) can only detract from this value. Consequently, the SI value for tree abundance is modified (multiplied) by the SI value for botanical composition. Because shrubs provide a secondary source of food and cover in this habitat, the weighted SI value for shrub abundance (V3) is added to the above calculation as a compensatory factor. The model is structured in such a way that the presence of shrubs can add to, but their absence cannot detract from, the value of the habitat.

6.10 LOWLAND CONIFEROUS TREE/SHRUB MIX (MUSKEG)

6.10.1 Important Assessment Variables

For assessment purposes, it is assumed that this habitat provides coniferous and/or needle-leaved deciduous (i.e., tamarack) tree canopy cover of > 5%. Lowland habitats with less tree cover should be evaluated as meadows or shrublands.

Muskeg is an important habitat for moose and snowshoe hare, providing both food and cover resources. Five major factors that directly govern the habitat suitability value of muskeg have been selected as evaluation criteria and, hence, model components. These are 1) shrub abundance (moose and snowshoe hare models), 2) shrub canopy height (moose and snowshoe hare models), 3) botanical composition (shrubs) (moose model), 4) forage abundance (moose model) and 5) tree abundance (moose model).

6.10.1.1 Shrub abundance. Shrub abundance is an important habitat factor as it directly determines the amount of food and cover available to moose and hare. In general, food and cover values increase with increasing shrub abundance, although dense growth (i.e., > 75%) may impede movements of moose, and high canopy cover values are therefore assigned reduced SI values. Shrub canopy cover is used as the measure of shrub abundance, as it can be rapidly measured in the field (using the line intercept method) and provides a good indication of shrub biomass.

Shrub cover categories (based on Daubenmire [1959] cover classes) and associated species-specific suitability (SI) values are presented in Tables 10a and b. For moose, a canopy cover of 50 -> 75% is considered optimal. Denser canopies, which can impede animal movement and reduce the amount of the habitat utilized by the animals, have been assigned lower suitability ratings, as have more open canopies which offer reduced amounts of food and cover. For snowshoe hare, habitat suitability is considered to be directly related to shrub canopy cover, and 95-100% cover is considered optimal.

Table 10a. Habitat Evaluation Criteria and Scoring for Lowland Coniferous Tree/Shrub Mix (Muskeg) Reclaimed for Moose.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
	Tree Abundance	0.30	V6 -Tree canopy cover	<5%	N/A
				5-<25%	0.4
				25-<50%	0.7
				50-<75%	1.0
				75-<95%	0.9
				≥95%	0.7
	Shrub Abundance	0.70	V3 -Shrub canopy cover	<5%	0.2
				5-<25%	0.4
				25-<50%	0.7
				50-<75%	1.0
				75-<95%	0.9
				≥95%	0.7
Food/ Cover	Botanical Composition (shrubs)	0.35	V1a -% of shrub canopy cover comprised of preferred browse species (moose)	<20%	0.2
				20-<40%	0.4
				40-<60%	0.6
				60-<80%	0.8
				≥80%	1.0
	Shrub Canopy Height	0.35	V2 -2/3 of mean shrub height	<0.5 m	0.2
				0.5-<1.0 m	0.6
				1.0-<1.5 m	1.0
				1.5-<2.0 m	1.0
				2.0-<2.5 m	1.0
				2.5-<3.0 m	0.6
				≥3.0 m	0.3

Table 10a......continued

Table 10a......continued

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
	Forage Abundance	0.20	V11 -Combined ground cover of grasses, sedges, forbs and low (<0.5 m) shrubs	<5%	0.2
				5-<25%	0.4
				25-<50%	0.6
				50-<75%	0.8
				75-<95%	1.0
				≥95%	1.0

Habitat Suitability Index (HSI) = {(0.7 x V3 SI) x [(0.35 x V1a SI) + (0.35 x V2 SI)] + (0.2 x V11 SI)} + 0.3 (1.0 x V6 SI)

N.B. - Where calculated HSI > 1.0, final HSI = 1.0

Table 10b. Habitat Evaluation Criteria and Scoring for Lowland Coniferous Tree/Shrub Mix (Muskeg) Reclaimed for Snowshoe Hare.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Food/ Cover	Shrub Canopy Height	1.0	V2 -2/3 of mean shrub height	<0.5 m	0.2
				0.5-<1.0 m	0.6
				1.0-<1.5 m	1.0
				1.5-<2.0 m	0.9
				2.0-<2.5 m	0.7
				2.5-<3.0 m	0.4
				≥3.0 m	0.2
	Shrub Abundance	1.0	V3 -Shrub Canopy cover	<5%	0.0
				5-<25%	0.3
				25-<50%	0.5
				50-<75%	0.7
				75-<95%	0.9
				≥95%	1.0

Habitat Suitability Index (HSI) = [(1.0 x V2 SI) x (1.0 x V3 SI)]

6.10.1.2 Shrub canopy height. Shrub canopy height can detract from browse and cover availability. Overmature tall shrubs may support the majority of their browsable material above the feeding range of both moose and snowshoe hare, and will offer little foliage at low levels for cover. Similarly, low prostrate shrubs may be unavailable as food or cover during winter because of snow cover. Consequently, canopy height has been used as a 'modifying' variable (see Section 5.3) in the models for moose and hare.

Given the shape of most shrubs, it has been assumed that the majority of a shrub's browsable twigs occur at a height of approximately 2/3 that of the top of the shrub. Consequently, two-thirds of the mean height of sampled shrubs has been used as the measure of shrub canopy height and, hence, availability, rather than mean shrub height.

Shrub height categories and associated species-specific suitability values are presented in Tables 10a and b. They have been developed based on the size and, hence, feeding range and cover requirements of animals, and on anticipated maximum snow depths of 1 m for the Mountains and Foothills biomes. Heights of 1.0 - < 2.5 m are considered optimal for moose for year-round browsing, while heights of 1.0 - < 1.5 m are most appropriate for snowshoe hare.

6.10.1.3 Botanical composition (shrubs). A shrubland's botanical composition largely dictates its value as a food source. For example, a shrubland comprised of unpalatable species can provide excellent escape cover but limited forage. Consequently, botanical composition has been included as a modifying variable in the model for moose, with a significance weighting of 0.5. Shrub species considered to be optimal for moose are willows, saskatoon and red-osier dogwood. Snowshoe hares are opportunistic feeders, primarily utilizing those shrub species which are most available within a given area. Consequently, botanical composition has not been included as an evaluation criteria for hare habitat.

The percent of the total shrub canopy cover comprised of preferred browse species has been used as the measure of shrubland composition. Habitat suitability is considered to increase with the increasing dominance of preferred browse species.

6.10.1.4 Forage abundance. Muskeg provides critical feeding habitat for moose during spring and summer, when grasses, sedges, forbs and low (< 0.5 m) shrubs are most palatable and available. Forage abundance, as measured by total percent ground cover of the above, is therefore included as an assessment variable in the moose model (Table 10a). Habitat suitability is considered to increase with increasing ground cover.

6.10.1.5 Tree abundance. The abundance of trees directly determines the amount of cover available to moose, particularly in muskeg areas where shrub height is often low. Dense tree growth provides both thermal and escape cover; it also intercepts snowfall, thus providing reduced snow depth conditions. Tree canopy cover is used as the measure of tree abundance for assessment purposes in the moose model (Table 10a), as it can be rapidly measured in the field and provides a good indication of tree density. It is assumed that suitability values increase with increasing canopy cover, except for very dense growth (> 75%) which may impede movement.

6.10.1.6 Other factors. In addition to those variables described above, the suitability value of muskeg can be influenced by its position relative to other habitat types. Because decisions on appropriate habitat interspersion and juxtaposition should have been resolved during the initial reclamation planning stages, these factors are not incorporated directly into the assessment models.

6.10.2 Explanation of Model Formula

6.10.2.1 Moose. The food and cover value of a muskeg for moose is directly influenced by tree abundance (V6), with a significance weighting of 0.3, and shrub abundance (V3), with a significance weighting of 0.7. Unfavourable shrubland composition (V1a) and shrub canopy height (V2) can only detract from the food and/or cover value of a muskeg. Therefore, the weighted SI value for shrub canopy cover is modified (multiplied) by the sum of the weighted SI values for shrubland composition and shrub canopy height. This product is, in turn, added to the weighted SI value of tree abundance.

Because ground forage provides a secondary source of food in this habitat, the weighted SI value for forage abundance (V11) is added to the calculated value above as a compensatory factor. The model is structured in such a way that the presence of ground forage can add to, but its absence cannot detract from, the value of the habitat.

6.10.2.2 Snowshoe hare. The food and cover value of a shrubland for snowshoe hare is directly influenced by shrub abundance, as measured by shrub canopy cover (V3). Unfavourable shrub canopy height (V2) can only detract from the food and/or cover value of a shrubland. Therefore, the SI value for shrub canopy cover is modified (multiplied) by the SI value for shrub canopy height.

6.11 WATERCOURSE

6.11.1 Important Assessment Variables

Watercourses are an important habitat for beaver and muskrat, providing both food and cover resources. Five major factors that directly govern the habitat suitability value of watercourses have been selected as evaluation criteria and, hence, model components. These are 1) stream gradient (beaver model), 2) water depth (beaver and muskrat models), 3) bank characteristics (beaver model), 4) abundance of emergent vegetation (muskrat model) and 5) abundance of herbaceous terrestrial vegetation (muskrat model).

6.11.1.1 Stream gradient. Stream gradient is the major determinant of watercourse morphology and flow velocity, and hence of habitat suitability for beaver. High gradient streams, and the resultant high flow velocities, provide poor or unsuitable habitat. Based on known habitat requirements, stream gradients of $< 5\%$ are considered to be optimal (Table 11a).

High gradient streams are also unsuitable for occupation by muskrats. However, stream gradient is not included in the muskrat model on the assumption that high gradient streams will not support emergent growth, a distinguishing feature of good muskrat habitat which is used as a major assessment variable (see Section 6.11.1.4).

Table 11a. Habitat Evaluation Criteria and Scoring for Watercourse Reclaimed for Beaver.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
	Stream Gradient	1.0	V12 -Stream gradient	<5%	1.0
				5-<10%	0.5
				≥10%	0.0
	Water Depth	0.5	V13 -Average water depth (September)	<0.5 m	0.2
				0.5-<1.0 m	0.5
				1.0-<1.5 m	1.0
Food/ Cover				1.5-<2.0 m	1.0
				≥2.0 m	1.0
	Bank Characteristics	0.5	V14 -Bank Height/ slope	<0.5 m and/or <15°	1.0
				0.5-<1.5 m and/or 15-<30°	0.8
				1.5-<2.5 m and/or 31-<45°	0.4
				≥2.5 m and/or ≥45°	0.2

Habitat Suitability Index (HSI) = [1.0 x V12 SI] x [(0.5 x V13 SI) + (0.5 x V14 SI)]

N.B. - HSI value cannot exceed 0.49 where watercourse is more than 30 m from deciduous tree/shrub mix or shrubland habitat with HSI value of 0.5 or more.

6.11.1.2 Water depth. Beavers require certain minimum water depths for cover during summer, and to provide beneath-ice access to lodges and food caches during winter. Although they can control water depth and stability through dam-building, especially on small streams, continuous flow is required to maintain suitable water depth conditions. For assessment purposes, average water depth during September (when flow is at a low level) is used as a measure of year-round water availability. Depths >1 m are considered to be optimal (Table 11a), but depths below this figure are also considered to have some suitability on the assumption that they can potentially be increased by beavers through dam-building.

Muskrats also require certain minimum water depths, primarily for beneath-ice access to food resources during winter. Unlike beaver, they cannot control water depths. For assessment purposes, average water depth during September is used as a measure of year-round water availability. Depths of 0.5 - < 1.5 m are considered to be optimal (Table 11b) as they provide sufficient water for over-wintering while also providing optimal water depths for growth of emergent vegetation. Depths below this figure are also considered to have some suitability as they can be used during summer. Depths >1.5 m are considered to be suboptimal as they limit development of emergent plants, the major food source for this species.

6.11.1.3 Bank characteristics. Beavers require easy access to food and building materials (deciduous trees and shrubs) adjacent to watercourses. Low, gently sloping banks are considered to provide the best access to and from the water (Table 11a). Very steep and/or high banks will largely preclude access, and therefore provide unsuitable habitat conditions. High banks may also be indicative of large fluctuations in water levels and seasonally high flow velocities, both of which severely limit use of watercourses by beaver.

6.11.1.4 Abundance of emergent vegetation. Emergent vegetation provides the major food source for muskrats, and also provides direct cover and a source of building materials for houses. Its abundance is thus an important factor in the evaluation of habitat suitability. For assessment purposes, the abundance of emergent vegetation is measured as percent of the watercourse shoreline covered by emergents. This can easily be measured in the field and provides a good indication of emergent biomass. Continuous emergent cover is considered to be optimal (Table 11b).

6.11.1.5 Abundance of herbaceous terrestrial vegetation. Dense herbaceous vegetation growing immediately adjacent to watercourses provides a supplementary food source for muskrats. The availability of herbaceous vegetation is assumed to be reflected by canopy cover within 10 m of shore (Table 11b). Habitat suitability is considered to increase with increasing herbaceous cover.

6.11.1.6 Other factors. In addition to those variables described above, the suitability value of watercourse habitat can be influenced by its position relative to other habitat types. For example, a watercourse developed for beaver must be near a suitable source of food and building materials (i.e., deciduous tree/shrub mix or shrubland habitat). Because decisions on appropriate habitat interspersion and juxtaposition should have been resolved during the initial reclamation planning stages, these factors are not incorporated directly into the

Table 11b. Habitat Evaluation Criteria and Scoring for Watercourse Reclaimed for Muskrat.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Food/ Cover	Water Depth	1.0	V13 -Average water depth (September)	<0.5 m	0.2
				0.5-<1.0 m	1.0
				1.0-<1.5 m	1.0
				1.5-<2.0 m	0.8
				≥2.0 m	0.5
	Abundance of Emergent Vegetation	1.0	V19 -% of shoreline with emergent band	<5%	0.0
				5-<25%	0.2
				25-<50%	0.5
				50-<75%	0.7
				75-<95%	0.9
				≥95%	1.0
	Abundance of Herbaceous Terrestrial Vegetation	0.2	V17 -Herbaceous ground cover within 10 m of shore	<5%	0.2
				5-<25%	0.4
				25-<50%	0.6
				50-<75%	0.8
				75-<95%	1.0
				≥95%	1.0

Habitat Suitability Index (HSI) = [(1.0 x V19 SI) x (1.0 x V13 SI)] + [0.2 x V17 SI]

N.B. - Where calculated HSI > 1.0, final HSI = 1.0

assessment models. However, a qualifier has been developed for the beaver model to limit the HSI value of watercourses that are too far removed from suitable tree or shrub habitats for optimum utilization.

6.11.2 Explanation of Model Formula

6.11.2.1 Beaver. Stream gradient (V12) is considered to be the most significant evaluation factor, as it directly influences the ability of beaver to develop suitable instream habitat. Unfavourable water depths (V13) and bank characteristics (V14) can detract from instream habitat suitability. Consequently, the SI value for stream gradient is modified (multiplied) by the sum of the weighted values for water depth and bank characteristics. The calculated HSI value is reduced as appropriate, depending on the location of the watercourse relative to suitable deciduous tree/shrub mix or shrubland habitats, to derive the final HSI value.

6.11.2.2 Muskrat. The abundance of emergent vegetation (V19) directly determines the availability of food and cover for muskrat. Unfavourable water depth (V13) can only detract from this food and cover value. Consequently, the SI value for emergent vegetation is modified (multiplied) by the SI value for water depth. Because shoreline herbaceous vegetation provides a secondary source of food in this habitat, the weighted SI value for herbaceous vegetation (V17) is added to the calculated value above as a compensatory factor. The model is structured in such a way that the presence of such vegetation can add to, but its absence cannot detract from, the value of the habitat.

6.12 WETLAND

6.12.1 Important Assessment Variables

Wetlands are an important habitat for muskrat, providing both food and cover resources. Four major factors that directly govern the habitat suitability value of wetlands have been selected as evaluation criteria and, hence, model components. These are 1) water depth, 2) abundance of emergent vegetation, 3) abundance of submergent vegetation and 4) abundance of herbaceous terrestrial vegetation.

6.12.1.1 Water depth. Muskrats require certain minimum water depths, primarily for beneath-ice access to food resources during winter. For assessment purposes, average water depth during September (when water levels are reduced) is used as a measure of year-round water availability. Depths of 0.5 - < 1.5 m are considered to be optimal (Table 12) as they provide sufficient water for over-wintering while also providing optimal water depths for growth of emergent vegetation. Depths below this figure are also considered to have some suitability as they can be used during summer. Depths >1.5 m are considered to be suboptimal as they limit development of emergent plants, the major food source for this species.

6.12.1.2 Abundance of emergent vegetation. Emergent vegetation provides the major food source for muskrats, and also provides direct cover and a source of building materials for houses. Its abundance is thus an important factor in the evaluation of habitat suitability. For assessment purposes, the abundance of emergent vegetation is measured as percent of the total wetland area covered by emergents; this can easily be measured in the field and provides a good indication of emergent biomass. Emergent cover of 25 - < 75%, with the remainder in open water/submergents, is considered to be optimal (Table 12).

6.12.1.3 Abundance of submergent vegetation. Submergent vegetation can provide a locally and/or seasonally important food source for muskrats, particularly in the absence of emergent vegetation. It is also used as a source of building material. For assessment purposes, the abundance of submergent vegetation is measured as percent of the total wetland area supporting submergent growth. Submergent plant cover of 25 - < 75% of the wetland area, with the remainder supporting emergent cover, is considered to be optimal (Table 12).

6.12.1.4 Abundance of herbaceous terrestrial vegetation. Dense herbaceous vegetation growing immediately adjacent to wetlands provides a supplementary food source for muskrats. The availability of herbaceous vegetation is measured as canopy cover within 10 m of shore (Table 12). Habitat suitability is considered to increase with increasing herbaceous cover.

6.12.2 Explanation of Model Formula

6.12.2.1 Muskrat. The abundance of both emergent and submergent vegetation (V15 and V16, respectively) directly influences the food and cover value of this habitat for muskrat, and the weighted SI values for these two variables are summed to provide a combined suitability rating. Unfavourable water depth (V13) can only detract from this food and cover value. Consequently, the food/cover value is modified (multiplied) by the SI value for water depth. Because shoreline herbaceous vegetation provides a secondary source of food in this habitat, the weighted SI value for herbaceous vegetation (V17) is added to the calculated value above as a compensatory factor. The model is structured in such a way that the presence of such vegetation can add to, but its absence cannot detract from, the value of the habitat.

6.13 LAKE/POND

6.13.1 Important Assessment Variables

Lakes/ponds are important habitats for beaver and muskrat, providing both food and cover resources. Under certain conditions they can also provide important summer feeding habitat for moose. Six major factors that directly govern the habitat suitability value of lakes/ponds have been selected as evaluation criteria and, hence, model components. These are 1) water depth (beaver and muskrat models), 2) bank characteristics (beaver model), 3) abundance of water lilies (moose and beaver model), 4) abundance of emergent vegetation (muskrat model), 5) abundance of submergent vegetation (muskrat model) and 6) abundance of herbaceous terrestrial vegetation (muskrat model).

6.13.1.1 Water depth. Beavers require certain minimum water depths for cover during summer, and to provide beneath-ice access to lodges and food caches during winter. For assessment purposes, average water depth during September, the season of lowest water levels, is used as a measure of year-round water availability. Depths > 1 m are considered to be optimal (Table 13b). Although by definition lakes/ponds should not have average

Table 12. Habitat Evaluation Criteria and Scoring for Wetland Reclaimed for Muskrat.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Food/ Cover	Water Depth	1.0	V13 -Average water depth (September)	<0.5 m	0.2
				0.5-<1.0 m	1.0
				1.0-<1.5 m	1.0
				1.5-<2.0 m	0.8
				≥2.0 m	0.5
	Abundance of Emergent Vegetation	0.7	V15 -% of waterbody area supporting emergent cover	<5%	0.2
				5-<25%	0.6
				25-<50%	1.0
				50-<75%	1.0
				75-<95%	0.6
				≥95%	0.2
	Abundance of Submergent Vegetation	0.3	V16 -% of waterbody area supporting submergent cover	<5%	0.2
				5-<25%	0.6
				25-<50%	1.0
				50-<75%	1.0
				75-<95%	0.6
				≥95%	0.2
	Abundance of Herbaceous Terrestrial Vegetation	0.2	V17 -Herbaceous ground cover within 10 m of shore	<5%	0.2
				5-<25%	0.4
				25-<50%	0.6
				50-<75%	0.8
				75-<95%	1.0
				≥95%	1.0

Habitat Suitability Index (HSI) = {(1.0 x V13 SI) x [(0.7 x V15 SI) + (0.3 x V16 SI)]} + [0.2 x V17 SI]

N.B. - Where calculated HSI > 1.0, final HSI = 1.0

water depths < 1.5 m, waterbodies with depths below this figure are considered to have some suitability for occupation by beavers, on the assumption that water depths can potentially be increased through dam-building by this species. A qualifier is built into the model such that lakes/ponds with suboptimal water depths can be rated as suitable beaver habitat only if dammable outlets are present.

Muskrats also require certain minimum water depths, primarily for beneath-ice access to food resources during winter. Unlike beaver, they cannot control water depths. For assessment purposes, average water depth during September is used as a measure of year-round water availability. Depths of 1.5 m (the defined minimum average depth for lake/pond habitat) to 2 m are considered to be optimal (Table 13c). Depths > 2.0 m are considered to be suboptimal as they limit development of emergent plants, the major food source for this species.

6.13.1.2 Bank characteristics. Beavers require easy access to food and building materials (deciduous trees and shrubs) adjacent to lakes/ponds. Low, gently sloping banks are considered to provide the best access to and from the water (Table 13b). Very steep and/or high banks will largely preclude access, and therefore provide unsuitable habitat conditions.

6.13.1.3 Abundance of water lilies. Water lilies growing in lake/pond habitat provide a source of forage for moose during the summer months, and a supplementary food source for beaver. For assessment purposes, the abundance of water lilies is measured as the the percent of the total waterbody area supporting the floating leaves of this species (Tables 13a, 13b). It is assumed that suitability for both moose and beaver increases with increasing cover.

6.13.1.4 Abundance of emergent vegetation. Emergent vegetation provides the major food source for muskrats, and also provides direct cover and a source of building materials for houses. Its abundance is thus an important factor in the evaluation of habitat suitability. For assessment purposes, the abundance of emergent vegetation is measured as percent of the total waterbody shoreline supporting an emergent band; this can easily be measured in the field and provides a good indication of emergent biomass. It is assumed that suitability increases with increasing cover.

6.13.1.5 Abundance of submergent vegetation. Submergent vegetation can provide a locally and/or seasonally important food source for muskrats, particularly in the absence of emergent vegetation. It is also used as a source of building material. For assessment purposes, the abundance of submergent vegetation is measured as percent of the total waterbody area supporting submergent growth. Submergent cover of 25 - < 75% of the waterbody area is considered to be optimal (Table 13c).

6.13.1.6 Abundance of herbaceous terrestrial vegetation. Dense herbaceous vegetation growing immediately adjacent to lake/pond habitat provides a supplementary food source for muskrats. The availability of herbaceous vegetation is assumed to be reflected by canopy cover within 10 m of shore (Table 13c).

Table 13a. Habitat Evaluation Criteria and Scoring for Lake/Pond Reclaimed for Moose.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Food	Abundance of Water Lilies	1.0	V18 -% of waterbody area supporting water lilies	<5%	0.2
				5-<25%	0.4
				25-<50%	0.6
				50-<5%	0.8
				75-<95%	1.0
				≥95%	1.0

Habitat Suitability Index (HSI) = [1.0 x V18 SI]

Table 13b. Habitat Evaluation Criteria and Scoring for Lake/Pond Reclaimed for Beaver.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Food/ Cover	Water Depth	0.5	V13 -Average water depth (September)	<0.5 m	0.2
				0.5-<1.0 m	0.5
				1.0-<1.5 m	1.0
				1.5-<2.0 m	1.0
				≥2.0 m	1.0
	Bank Characteristics	0.5	V14 -Bank height/ slope	<0.5 m and/or <15°	1.0
				0.5-<1.5 m and/or 15-<30°	0.8
				1.5-<2.5 m and/or 30-<45°	0.4
				≥2.5 m and/or ≥45°	0.2
	Abundance of Water Lilies	0.2	V18 -% of waterbody area supporting water lilies	<5%	0.2
				5-<25%	0.4
				25-<50%	0.6
				50-<75%	0.8
				75-<95%	1.0
				≥95%	1.0

Habitat Suitability Index (HSI) = [(0.5 x V13 SI) + (0.5 x V14 SI)] + [0.2 x V18 SI]

N.B. - Where average waterbody depth is <1.0 m, HSI = 0.0 unless a dammable outlet is present.
- HSI value cannot exceed 0.49 where lake/pond is more than 30 m from deciduous tree/shrub mix or shrubland habitat with HSI value of 0.5 or more.
- Where calculated HSI > 1.0, final HSI = 1.0

Table 13c. Habitat Evaluation Criteria and Scoring for Lake/Pond Reclaimed for Muskrat.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
	Water Depth	1.0	V13 -Average water depth (September)	<0.5 m	N/A
				0.5-<1.0 m	N/A
				1.0-<1.5 m	N/A
				1.5-<2.0 m	1.0
				≥2.0 m	0.5
	Abundance of Emergent Vegetation	0.7	V19 -% of shoreline with emergent band	<5%	0.0
				5-<25%	0.2
				25-<50%	0.5
				50-<75%	0.7
				75-<95%	0.9
Food/ Cover				≥95%	1.0
	Abundance of Submergent Vegetation	0.3	V16 -% of waterbody area supporting submergent cover	<5%	0.2
				5-<25%	0.6
				25-<50%	1.0
				50-<75%	1.0
				75-<95%	0.6
				≥95%	0.2
	Abundance of Herbaceous Terrestrial Vegetation	0.2	V17 -Herbaceous ground cover within 10 m of shore	<5%	0.2
				5-<25%	0.4
				25-<50%	0.6
				50-<75%	0.8
				75-<95%	1.0
				≥95%	1.0

Habitat Suitability Index (HSI) = {(1.0 x V13 SI) x [(0.7 x V19 SI) + (0.3 x V16 SI)]} + (0.2 x V17 SI)

N.B. - Where calculated HSI > 1.0, final HSI = 1.0

6.13.1.7 Other factors. In addition to those variables described above, the suitability value of lake/pond habitat can be influenced by its position relative to other habitat types. For example, lake/pond habitat developed for beaver must be near a suitable source of food and building materials (i.e., deciduous tree/shrub mix or shrubland habitat). Because decisions on appropriate habitat interspersion and juxtaposition should have been resolved during the initial reclamation planning stages, these factors are not incorporated directly into the assessment models. However, a qualifier has been developed for the beaver model to limit the calculated HSI value of lakes/ponds that are too far removed from suitable tree or shrub habitats for optimum utilization.

6.13.2 Explanation of Model Formula

6.13.2.1 Moose. In the moose model, the Habitat Suitability Index (HSI) value is equivalent to the assigned SI value for V18 (Abundance of Water Lilies).

6.13.2.2 Beaver. Lake/pond water depth (V13) and bank characteristics (V14) are considered to contribute equally (i.e., significance weightings of 0.5) to the provision of food and cover for beaver, and their weighted SI values are summed to provide a suitability value. Because water lilies provide a secondary source of food in this habitat, the weighted SI value for the abundance of water lilies (V18) is added to the calculated value above as a compensatory factor. The model is structured in such a way that the presence of such vegetation can add to, but its absence cannot detract from, the value of the habitat. The calculated HSI value is reduced as appropriate, depending on the location of the lake/pond relative to suitable deciduous tree/shrub mix or shrubland habitats, to derive the final HSI value.

6.13.2.3 Muskrat. The abundance of both emergent and submergent vegetation (V19 and V16, respectively) directly influences the food and cover value of this habitat for muskrat, and the weighted SI values for these two variables are summed to provide a suitability rating. Unfavourable water depth (V13) can only detract from this food and cover value. Consequently, the food/cover value is modified (multiplied) by the SI value for water depth. Because shoreline herbaceous vegetation provides a secondary source of food in this habitat, the weighted SI value for herbaceous vegetation is added to the calculated value above as a compensatory factor. The model is structured in such a way that the presence of such vegetation can add to, but its absence cannot detract from, the value of the habitat.

6.14 CLIFF

6.14.1 Important Assessment Variables

Cliff habitats provide important escape and/or reproductive cover for bighorn sheep, mountain goat, some raptors (e.g., golden eagle), corvids (e.g., ravens) and small mammals (e.g., Columbian ground squirrels), although only bighorn sheep, mountain goats and golden eagles have been selected as the key species. Six major factors that directly govern the habitat suitability value of cliffs have been selected as evaluation criteria and, hence, model components. These are 1) cliff height, 2) cliff slope, 3) ledge availability (sheep and goat models only), 4) nest site availability (eagle model only), 5) cliff face configuration and 6) dominant aspect of cliff. Although cliff length is an additional factor influencing cliff suitability, it has been incorporated as part of the criteria defining cliffs, rather than as a model variable. By definition, cliffs must be at least 100 m in length to provide an adequate amount of escape terrain and must not exceed 400 m in length unless a travel route up the cliff with a slope of less than 45° is provided within that distance. This latter restriction prevents the cliff from becoming a significant barrier to species not well suited to cliff travel (e.g., deer).

6.14.1.1 Cliff height. Height is considered to be one of the more significant habitat evaluators for cliffs as it directly influences the area of escape terrain and the degree of security provided by the habitat. With higher cliff profiles, there are also more predictable thermal currents for raptors and the potential for greater numbers of nest and perching sites. By definition, a cliff must have a vertical rise of at least 8 m to be acceptable. Habitat suitability is considered to increase with increasing height over and above 8 m (Tables 14a, b and c).

6.14.1.2 Cliff slope. Slope largely dictates a cliff's effectiveness as escape terrain. Cliffs must be steep enough to discourage predator travel and yet navigable to the key wildlife species of interest. By definition, cliffs must have a minimum slope of 50°, and slope intervals above this value have been arbitrarily selected for evaluation purposes. The optimal slopes for sheep and goat are considered to be 61-70° and 71-80°, respectively, while even steeper slopes (> 80°) are considered appropriate for golden eagles because of their ability to access such slopes in flight.

6.14.1.3 Ledge availability. Ledges within cliff faces are essential for cliff dwelling ungulates, as they provide the animals with travel lanes, resting areas and even localized feeding areas. In their absence, cliffs have limited habitat value. For the purposes of evaluation, ledges are defined as relatively flat (within 20° of the horizontal) pathways at least 0.5 m in width and accessible from the perimeter of the cliff face or from other accessible ledges. To be considered for evaluation, ledges must be at least 5 m from the top or bottom of the cliff face.

The number of meters of suitable ledges per 1000 m^2 of cliff face has been selected as the measurement for this variable. Arbitrarily selected variable categories and associated SI values are listed in Tables 14a and b. It has been assumed that habitat suitability increases with increasing ledge length.

6.14.1.4 Nest site availability. Cliffs are of particular value to eagles where small ledges or holes in the cliff face are available for nest sites and viewing perches. By definition, these structures must have a relatively flat, usable surface area of at least 0.5 m^2 and must be inaccessible and at least 5 m from the cliff face perimeter. The number of suitable ledges/holes per 1000 m^2 of cliff face has been used as the measure of this variable. Habitat suitability for eagles is considered to increase with increasing ledge/hole availability (to facilitate their propensity to maintain multiple nests within their nesting territory) up to eight structures per 1000 m^2 (Table 14c). A greater abundance of potential nest sites may lead to unfavourable nesting densities of a variety of cliff nesters and increased territorial disputes.

6.14.1.5 Cliff face configuration. Cliffs with a variety of inward and outward projections (i.e., different aspects) along their face are preferred over flat profiles. Irregular cliff faces provide visual barriers between different parts of the cliff and increase the security value

Table 14a. Habitat Evaluation Criteria and Scoring for Cliffs Reclaimed for Bighorn Sheep.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Cover	Ledge Availability	0.35	V25 -Length (m) of accessible ledges per 1000 m^2 of cliff face	0 m >0-<20 m 20-<40 m 40-<60 m 60-<80 m ≥80 m	0.0 0.2 0.4 0.6 0.8 1.0
	Cliff Height	0.25	V7 -Vertical rise of the exposed cliff face	<8 m 8-<15 m 15-<25 m ≥25 m	N/A 0.5 0.8 1.0
	Cliff Slope	0.25	V8 -Average slope of the cliff face	<50° 50-<60° 60-<70° 70-<80° ≥80°	N/A 0.5 1.0 0.8 0.6
	Cliff Face Configuration	0.15	V24 -Number of major aspects of cliff face (i.e., > 20% of cliff face)	1 2 ≥ 3	0.5 0.8 1.0

Table 14a.....continued

Table 14a.....continued

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
	Dominant Aspect	0.20	V28 -Dominant aspect of cliff face	N	0.0
				NE	0.0
				E	0.3
				SE	0.7
				S	1.0
				SW	1.0
				W	0.5
				NW	0.3

Habitat Suitability Index (HSI) = [(0.35 x V25 SI) + (0.25 x V7 SI) + (0.25 x V8 SI) + (0.15 x V24 SI)] + (0.20 x V28 SI)

N.B. - HSI value cannot exceed 0.49 where a portion of cliff base is not immediately adjacent to a meadow or aquatic habitat with an HSI value of 0.5 or more.
- Where calculated HSI > 1.0, final HSI = 1.0.

Table 14b. Habitat Evaluation Criteria and Scoring for Cliffs Reclaimed for Mountain Goat.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Cover	Ledge Availability	0.35	V25 -Length (m) of accessible ledges per 1000 m^2 of cliff face	0 m	0.0
				>0-<20 m	0.2
				20-<40 m	0.4
				40-<60 m	0.6
				60-<80 m	0.8
				≥80 m	1.0
	Cliff Height	0.25	V7 -Vertical rise of the exposed cliff face	<8 m	N/A
				8-<15 m	0.5
				15-<25 m	0.8
				≥25 m	1.0
	Cliff Slope	0.25	V8 -Average slope of the cliff face	<50°	N/A
				50-<60°	0.4
				60-<70°	0.8
				70-<80°	1.0
				≥80°	0.7
	Cliff Face Configuration	0.15	V24 -Number of major aspects of cliff face (i.e., > 20% of cliff face)	1	0.5
				2	0.8
				≥ 3	1.0

Table 14b......continued

Table 14b......continued

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
	Dominant Aspect	0.20	V28 -Dominant aspect of cliff face	N	0.0
				NE	0.0
				E	0.3
				SE	0.7
				S	1.0
				SW	1.0
				W	0.5
				NW	0.3

Habitat Suitability Index (HSI) = [(0.35 x V25 SI) + (0.25 x V7 SI) + (0.25 x V8 SI) + (0.15 x V24 SI)] + (0.20 x V28 SI)

N.B. - HSI value cannot exceed 0.49 where a portion of cliff base is not immediately adjacent to a meadow or aquatic habitat with an HSI value of 0.5 or more.
- Where calculated HSI > 1.0, final HSI = 1.0.

Table 14c. Habitat Evaluation Criteria and Scoring for Cliffs Reclaimed for Golden Eagle.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Cover	Nest Site Availability	0.35	V26 -Number of isolated ledges or holes per 1000 m^2 of cliff face	0	0.0
				1-2	0.2
				3-4	0.4
				5-6	0.6
				7-8	0.8
				8-9	1.0
				>9	0.5
	Cliff Height	0.25	V7 -Vertical rise of the exposed cliff face	<8 m	N/A
				8-<15 m	0.5
				15-<25 m	0.8
				≥25 m	1.0
	Cliff Slope	0.25	V8 -Average slope of the cliff face	<50°	N/A
				50-<60°	0.4
				60-<70°	0.6
				70-<80°	0.8
				≥80°	1.0
	Cliff Face Configuration	0.15	V24 -Number of major aspects of cliff face (i.e., > 20% of cliff face)	1	0.5
				2	0.8
				≥ 3	1.0

Table 14c......continued

Table 14c......continued

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
	Dominant Aspect	0.20	V28 -Dominant aspect of cliff face	N	0.0
				NE	0.0
				E	0.3
				SE	0.7
				S	1.0
				SW	1.0
				W	0.5
				NW	0.3

Habitat Suitability Index (HSI) = [(0.35 x V26 SI) + (0.25 x V7 SI) + (0.25 x V8 SI) + (0.15 x V24 SI)] + (0.20 x V28 SI)

N.B. - HSI value cannot exceed 0.49 where a portion of cliff base is not immediately adjacent to a meadow with an HSI value of 0.5 or more.
- Where calculated HSI > 1.0, final HSI = 1.0.

and number of useable sites of such habitats. Surface irregularities also provide better protection from wind, rain and snow. The number of dominant aspects of a cliff (i.e., aspects covering more than 20% of the cliff) is used as the measure of this variable, with three or more aspects being considered optimal for all three key species.

6.14.1.6 Dominant aspect. Although a variety of aspects are used by cliff dwellers, southerly aspects are generally preferred because of their microclimatic advantages, particularly during the reproductive period. Consequently, a cliff's dominant aspect is used as a compensatory variable in all of the models, designed to enhance but not detract from the value of a cliff, where appropriate. Variable categories and associated SI values are presented in Tables 14a, b and c.

6.14.1.7 Other factors. In addition to those variables described above, the suitability value of cliff habitat can be influenced by its position relative to other habitat types. For example, cliffs offer limited forage resources and will only be of value to wildlife if they are in close proximity to feeding/hunting or watering areas. Because decisions on appropriate habitat interspersion and juxtaposition should have been resolved during the initial reclamation planning stages, these factors are not incorporated directly into the assessment models. However, a qualifier has been developed for the models to limit the calculated HSI value of cliffs that are too far removed from suitable meadow or aquatic habitats for optimum utilization.

6.14.2 Explanation of Model Formula

6.14.2.1 Bighorn sheep, mountain goats. Cliff height (V7), cliff slope (V8), ledge availability (V25) and cliff face configuration (V24) all contribute to the provision of cover for sheep and goats in a cliff habitat. Consequently, the weighted SI values of these variables are summed to estimate cliff suitability. Because dominant aspect can enhance the thermal value of this habitat, the weighted SI value for dominant aspect (V28) is added to the calculated value above as a compensatory factor. The model is structured in such a way that the presence of a favourable aspect can add to, but its absence cannot detract from, the value of the habitat. The calculated HSI value is reduced as appropriate, depending on the location of the cliff relative to suitable meadow or aquatic habitats, to derive the final HSI value.

6.14.2.2 Golden eagle. Cliff height (V7), cliff slope (V8), nest site availability (V26) and cliff face configuration (V24) all contribute to the provision of cover for golden eagles in a cliff habitat. Consequently, the weighted SI values of these variables are summed to estimate cliff suitability. Because dominant aspect can enhance the thermal value of this habitat, the weighted SI value for dominant aspect (V28) is added to the calculated value above as a compensatory factor. The model is structured in such a way that the presence of a favourable aspect can add to, but its absence cannot detract from, the value of the habitat. The calculated HSI value is reduced as appropriate, depending on the location of the cliff relative to suitable meadow (i.e., hunting habitats), to derive the final HSI value.

6.15 TALUS

6.15.1 Important Assessment Variables

Talus habitats provide important escape and/or reproductive cover for bighorn sheep, mountain goats and white-tailed ptarmigan, in addition to a variety of rodents (e.g., pika, marmots). They can also function as access ramps onto cliff habitat. Two major factors that directly govern the habitat suitability of talus have been selected as evaluation criteria and, hence, model components. These are 1) size of talus fragments and 2) talus slope. Although talus length and width are additional factors influencing talus suitability, they have been incorporated as part of the criteria defining talus, rather than as model variables. By definition, talus slopes must be at least 100 m in width at their toe to provide an adequate amount of escape terrain and must not exceed 400 m in width unless interrupted by a vegetated slope within that distance. This latter restriction prevents the habitat from becoming a significant barrier to species not well suited to talus travel (e.g., deer). Talus must also extend for a minimum of 10 m upslope to be considered adequate in size.

6.15.1.1 Size of talus fragments. For sheep and goats, talus fragment size influences the effectiveness of talus as escape terrain. Fine-grained talus can be better negotiated by predators and, hence, offers reduced escape terrain value for sheep and goats. Talus with large unconsolidated fragments is much more treacherous to travel, giving sheep and goats distinct travel advantages over predators. Moderately coarse-grained talus provides an abundance of suitable interstitial spaces for nesting cover for ptarmigan.

Mean fragment volume is used as the measure of this variable. Habitat suitability for sheep and goats is considered to increase with fragment volume. For ptarmigan, optimal fragment size is considered to be 0.5 - 1.0 m^3. The spaces between larger fragments are too large to provide adequate cover and, consequently, fragments exceeding 1.0 m^3 have been assigned reduced suitability ratings (Tables 15a and b).

6.15.1.2 Talus slope. Slope influences both the effectiveness of talus as escape terrain and the long term stability of the habitat. Ideally, talus should be steep enough to discourage predator travel and yet stable to prevent the constant shifting and settling of rock fragments. The angle of repose (i.e., steepest angle at which a material remains stable) for coarse-grained rock particles is generally 30-40° and this range of values has been rated as optimal in the models.

6.15.1.3 Other factors. In addition to those variables described above, the suitability value of talus habitat can be influenced by its position relative to other habitat types. For example, talus offers limited forage resources and will only be of value to wildlife if it is in close proximity to feeding or watering areas. Because decisions on appropriate habitat interspersion and juxtaposition should have been resolved during the initial reclamation planning stages, these factors have not been incorporated directly into the assessment models. However, a qualifier has been developed for the models to limit the calculated HSI value of talus that is too far removed from suitable meadow or aquatic habitats for optimum utilization.

Table 15a. **Habitat Evaluation Criteria and Scoring for Talus Reclaimed for Bighorn Sheep or Mountain Goat.**

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
	Size of Talus Fragments	0.50	V9 -Average volume of talus fragments	<0.5 m^3	0.5
				$0.5-<1.0$ m^3	0.7
				$1.0-<2.0$ m^3	0.9
				≥ 2.0 m^3	1.0
Cover	Talus Slope	0.50	V27 -Average slope of talus pile	$<10°$	0.0
				$10-<20°$	0.6
				$20-<30°$	0.8
				$30-<40°$	1.0
				$40-<50°$	0.7
				$\geq 50°$	0.4

Habitat Suitability Index (HSI) = (0.50 x V9 SI) + (0.50 x V27 SI)

N.B. - HSI value cannot exceed 0.49 where a portion of the talus is not immediately adjacent to a meadow or aquatic habitat with an HSI value of 0.5 or more.

Table 15b. Habitat Evaluation Criteria and Scoring for Talus Reclaimed for White-tailed Ptarmigan.

LIFE REQUISITE PROVIDED	HABITAT VARIABLES USED AS ASSESSMENT CRITERIA	SIGNIFICANCE WEIGHTING	VARIABLE MEASUREMENT	VARIABLE CATEGORIES	SUITABILITY INDEX (SI)
Cover	Size of Talus Fragments	0.70	V9 -Average volume of talus fragments	$<0.5\ m^3$	0.4
				$0.5\text{-}<1.0\ m^3$	1.0
				$1.1\text{-}<2.0\ m^3$	0.8
				$\geq 2.0\ m^3$	0.5
	Talus Slope	0.30	V27 -Average slope of talus pile	<10°	0.0
				10-<20°	0.6
				20-<30°	0.8
				30-<40°	1.0
				40-<50°	0.7
				≥50°	0.4

Habitat Suitability Index (HSI) = (0.70 x V9 SI) + (0.30 x V27 SI)

N.B. - HSI value cannot exceed 0.49 where a portion of the talus is not immediately adjacent to a meadow or aquatic habitat with an HSI value of 0.5 or more.

6.15.2 Explanation of Model Formula

6.15.2.1 Bighorn sheep, mountain goats, and white-tailed ptarmigan. The cover value of talus is influenced by both size of fragments (V9) and talus slope (V27). Consequently, the weighted SI values of these variables are summed to provide a rating for this habitat. The calculated HSI value is reduced as appropriate, depending on the location of the talus relative to suitable meadow or aquatic habitats, to derive the final HSI value.

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Appendix I/
Assessment Handbook

APPENDIX I

A PROPOSED EVALUATION SYSTEM FOR WILDLIFE HABITAT RECLAMATION IN THE MOUNTAIN AND FOOTHILLS BIOMES OF ALBERTA:

ASSESSMENT HANDBOOK

Prepared for

The
Mountain Foothills Reclamation
Research Program

by
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J.E. Green

The Delta Environmental Management Group Ltd.
Calgary, Alberta

April 1988

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CHAPTER 1

INTRODUCTION

Mining developments in the Mountains and Foothills of Alberta inevitably result in the disruption of some wildlife habitat, either during site development or through clearing of linear rights-of-way (as during road construction or drill testing). Recent feasibility studies and several ongoing reclamation programs have shown that wildlife habitat can be created through reclamation and habitat enhancement, using existing technology applicable to the environmental conditions and wildlife species found in these regions (Green et al. 1986). Although the capability currently exists to reclaim disturbed areas as wildlife habitat, no guidelines have been developed for evaluating success of wildlife habitat reclamation efforts. The development of guidelines for the reclamation of wildlife habitat was the primary objectives of the wildlife component of the Mountains and Foothills Reclamation Research Program (MFRRP).

The Mountain Foothills Reclamation Research Program is a joint industry/government program, consisting of representatives from the Coal Association of Canada, Alberta Environment and Alberta Forestry, Lands and Wildlife. Initiated in 1984, the primary objectives of MFRRP were to summarize current information on operational aspects of reclamation for forestry and wildlife, and soil re-establishment, and to develop an appropriate method (or methods) for measuring reclamation success in the Mountain and Foothills biomes of Alberta. Because new and improved techniques for reclamation of disturbed sites are becoming available each year, the ability of industrial and government reclamation programs to achieve specific reclamation objectives is also improving. The summarization of operational techniques and development of assessment systems for such techniques is therefore a dynamic process that must be flexible to a continually improving information base.

A two phase study on wildlife habitat reclamation was begun by MFRRP in 1984, with the aim of delineating appropriate operational techniques (Phase I) and assessment methodology (Phase II). Phase I of the program involved a synthesis of information on techniques relevant to wildlife habitat reclamation in the Mountains and Foothills biomes of Alberta, and a review of habitat requirements of key wildlife species in these regions (Green et al. 1986). Phase II of the program, begun in June 1986, involved the development of an assessment methodology for evaluating the success of wildlife habitat reclamation programs (Eccles et al. 1987), and the development of an assessment handbook describing the evaluation system (this report).

The handbook is intended for use primarily by site operators and reclamation officers, and focuses on procedures for the evaluation and certification of reclaimed wildlife habitat in the Mountains and Foothills regions of the province. It is not designed to be a decision making tool for the selection of habitat types and configurations (the selection of appropriate habitats for a given project should be made during the preparation of the development and reclamation plan for the project, early in the regulatory process). The handbook functions solely as a tool for determining how well the stated reclamation objectives have been met. Basic information necessary for evaluating wildlife habitat reclamation is provided, including evaluation scoresheets for 15 different reclamation habitats, standard methodologies for measuring habitat features used as evaluation criteria, and minimum requirements for certification as acceptable wildlife habitat. Documentation of the proposed system for evaluation of wildlife habitat reclamation areas is provided in Eccles et al. (1987).

Although personnel conducting a habitat evaluation need not have prior knowledge of the site, or detailed knowledge of wildlife habitat requirements, a basic familiarity with the essential elements of wildlife reclamation planning and implementation will facilitate the evaluation process. Wildlife habitat reclamation begins with the identification of the type and location of landforms that will be present on the reclamation site following project development. For each of the landforms, appropriate reclamation habitats (defined by botanical composition [e.g., meadows and shrublands], water form type [e.g., watercourses and lakes/ponds] or physical characteristics [e.g., cliffs and talus slopes]) are chosen which will enhance the capability of the area to support a key wildlife species (defined as a locally occurring bird or mammal species of high management importance, which represents the general habitat requirements of a number of other wildlife species). The development of reclamation habitats, and the extent to which they provide the habitat needs of the selected key species, provides the basis for subsequent habitat evaluation and certification.

CHAPTER 2

HANDBOOK OBJECTIVES

The basic objective of this handbook is to provide a standard, easily applied and suitably accurate methodology for evaluating and certifying reclaimed wildlife habitat in the Mountains and Foothills regions of Alberta. The handbook is designed to provide specific evaluation criteria for each type of reclamation habitat that may be developed within these regions, to provide a means of quantifying reclamation success in relation to previously established reclamation goals, and to provide a means of identifying deficiencies should habitat development be insufficient for successful certification.

CHAPTER 3

USING THE HANDBOOK

To ensure that reclamation assessments are undertaken in a consistent fashion, standardized evaluation checksheets have been prepared for each appropriate combination of reclamation habitat and key wildlife species (see Chapter 6). These checksheets have been developed with the underlying assumption that one or more key measurable habitat variables or features can be used to assess the suitability of reclaimed habitats for wildlife. Each habitat feature selected for use is considered to be strongly related to the ability of the habitat to provide food and/or cover (hiding and/or thermal cover) for wildlife, and is practical to measure, either in the field or from remotely-sensed data sources such as air photos.

The final product of the evaluation checksheets is a species-specific habitat suitability index (HSI) for the wildlife habitat in question. HSI values range from 0.0 (unsuitable habitat conditions) to 1.0 (optimal habitat conditions), and are proposed as a basis for certification of wildlife habitat reclamation areas.

Employing the proposed evaluation system and scoresheets in this handbook, certification of a reclamation area would involve five basic tasks:

1. Review the approved reclamation plan for the site and subsequent amendments to the plan, identifying the reclamation habitats and key wildlife species of interest;

2. Review descriptions of and minimum requirements for each reclamation habitat on-site, in addition to the habitat features considered important for evaluating each (see Eccles et al. 1987);

3. Using sampling methods described in this handbook, collect average on-site values of the important habitat features discussed above for each habitat. Such information could be obtained as part of the annual reporting process to the Alberta Land Conservation and Reclamation Council.

4. Incorporate the on-site habitat measures into the appropriate evaluation checksheet for each habitat/key wildlife species combination (see Appendix 3) and calculate HSI values; and

5. Compare HSI values with pre-established standards for certification. These standards could be established specifically for each reclamation area during the reclamation planning process, or could be a provincially accepted standard. In either case, it is assumed that industry and the regulatory agencies would negotiate appropriate standards.

This handbook is designed to facilitate the completion of the certification process described above. Chapter 4 provides the necessary information on reclamation habitats required for the completion of Step 2 above, while Chapter 5 details the sampling procedures to be followed for collecting on-site measurements of each habitat feature considered important for evaluating reclamation habitats (Step 3). Chapter 6 discusses the evaluation checksheets to be used to calculate HSI values (Step 4), and presents instructions on the interpretation of such values, depending on the reclamation requirements in the approved reclamation plan (Step 5).

During the preparation of this handbook, it was the intent of the authors to produce a field-oriented guide to reclamation certification, with minimal technical back-up material. The reader is referred to Eccles et al. (1987) for a more a detailed discussion on the development of this certification procedure.

CHAPTER 4

DESCRIPTION OF RECLAMATION HABITATS

A total of 15 habitat types have been identified for reclamation and evaluation purposes in the Mountains and Foothills regions of Alberta. They can be broadly characterized as vegetation-based, water-based, or relief-based habitats:

Vegetation-Based Habitats:
- Alpine meadow
- Upland meadow
- Lowland/riparian meadow
- Upland shrubland
- Lowland/riparian shrubland
- Shrub meadow
- Deciduous tree/shrub mix
- Deciduous-coniferous tree/shrub mix
- Upland coniferous tree/shrub mix
- Lowland coniferous tree/shrub mix (muskeg)

Water-based Habitats:
- Watercourse
- Wetland
- Lake/pond

Relief-based Habitats:
- Cliff
- Talus

Vegetation-based habitats are defined by their botanical composition and structure (i.e., meadow, shrubland, shrub meadow, or tree/shrub mix), and in some cases by their elevation (i.e., lowland, upland or alpine). Trees are defined as single-stemmed woody species, and shrubs as multi-stemmed woody species (with the exception of rose and some willows, which may sometimes be single-stemmed but are always classed as shrubs). To facilitate measurements for evaluation purposes, all vegetation-based habitats, with the exception of streamside riparian habitats, must have a minimum area of 3 ha and must have a width of at least 100 m at one point along their length. Because of their linear configuration, the size requirements for streamside riparian habitats have been reduced, and include a minimum width of 10 m and a minimum length of 100 m. Additional evaluation criteria specific to individual habitat types are outlined in the descriptions below.

Water-based reclamation habitats include watercourses, wetlands (shallow marshes) or lakes/ponds that are constructed or altered during development of a site. Water-based reclamation habitats extend to the high water mark of a watercourse or waterbody, and consequently consist of both the open water and emergent vegetation zones. Size and depth requirements for individual habitat types are outlined below.

Relief-based reclamation habitats consist of steep, largely unvegetated cliffs and talus piles, and are generally developed from the headwalls of open pit operations. Cliffs must have slopes exceeding 50° and must also satisfy minimum height and length requirements (see descriptions below). Talus is defined as an unconsolidated apron of rock, and is usually associated with the base of a cliff.

In the remainder of this chapter, each of the 15 reclamation habitats is described in terms of its predominant vegetation species, water characteristics, and/or topography. Key wildlife species for each habitat and important evaluation features (used in the species-specific scoresheets for the habitat) are also described.

VEGETATION-BASED HABITATS

Alpine Meadow

Alpine meadows are defined as grass or sedge-dominated habitats occupying sites above 2000 m in elevation. The combined ground cover of grasses, sedges, mosses/lichens, forbs and low (<0.2 m) shrubs must average more than 25% within a minimum habitat area of 3 ha. More than 40% of the total ground cover must consist of grasses and sedges.

Alpine meadows can be developed and evaluated for bighorn sheep, caribou, elk, mountain goat or white-tailed ptarmigan. Features used for evaluating this habitat are forage abundance, forage composition, topographic diversity, and availability of unconsolidated rock cover. To be suitable for use by the key wildlife species, alpine meadows must be within 250 m of suitable escape habitat (i.e., talus or cliffs for bighorn sheep/mountain goat, and shrublands for caribou/elk).

Upland Meadow

Upland meadows are defined as grass or sedge-dominated habitats occupying relatively dry, well-drained sites up to 2000 m in elevation. The combined ground cover of grasses, sedges, mosses/lichens, forbs and low (<0.2 m) shrubs and trees must average more than 25% within a minimum habitat area of 3 ha. More than 60% of the total ground cover must consist of grasses and sedges. In addition, the canopy cover of trees and shrubs > 0.2 m must not exceed 10% and 5%, respectively.

Upland meadows can be developed and evaluated for four key wildlife species: bighorn sheep, mountain goat, caribou, or elk. Features used for evaluating this habitat are forage abundance, forage composition, and topographic diversity. To be suitable for use by these key wildlife species, upland meadows must be within 250 m of suitable escape habitat (i.e., talus or cliffs for bighorn sheep/mountain goat, and shrublands or tree/shrub mix for caribou/elk).

Lowland/Riparian Meadow

Lowland/riparian meadows are defined as grass or sedge-dominated habitats occupying sites with moderately wet to water-saturated soils. They generally occur in valley bottoms, but can also be established in localized depressions and catch basins up to subalpine (1500 m) elevations. The combined ground cover of grasses, sedges, mosses/lichens, forbs and low (<0.2 m) shrubs and trees must average more than 25% within a minimum habitat area of 3 ha. More than 60% of the total ground cover must consist of grasses and sedges. In addition, the canopy cover of shrubs and trees > 0.2 m must not exceed 10% and 5%, respectively.

Lowland/riparian meadows can be developed and evaluated for two key wildlife species: caribou or elk. Features used for evaluating this habitat are forage abundance, forage composition, and horsetail abundance. To be suitable for use by caribou or elk, lowland/riparian meadows must be within 250 m of suitable escape habitat (i.e., shrublands or tree/shrub mix).

Upland Shrubland

Upland shrublands are defined as shrub-dominated habitats occupying well-drained to moderately well-drained sites, ranging from lower valley slopes up to 2000 m elevation. The canopy cover of shrubs must average more than 25%, and tree canopy cover must not exceed 5%, within a minimum habitat area of 3 ha.

Upland shrublands can be developed and evaluated for four key wildlife species: elk, moose, snowshoe hare or white-tailed ptarmigan. Features used for evaluating this habitat are shrub abundance, shrub canopy height, shrub composition, and topographic diversity.

Lowland/Riparian Shrubland

Lowland/riparian shrublands are defined as shrub-dominated habitats occupying sites with poorly drained or wet soils. They generally occur in valley bottoms, but can also be established along drainage courses up to subalpine (1500 m) elevation. The canopy cover of shrubs must average more than 25%, and tree canopy cover must not exceed 5%, within a minimum habitat area of 3 ha.

Lowland/riparian shrublands can be developed and evaluated for three key wildlife species: beaver, moose or snowshoe hare. Features used for evaluating this habitat are shrub abundance, shrub canopy height, and shrub composition. To be suitable for use by beaver, lowland/riparian shrublands must be within 30 m of a suitable waterbody or watercourse.

Shrub Meadow

Shrub meadows are defined as a mosaic of shrubland and grass or sedge-dominated meadow areas. They generally are associated with valley bottoms. The canopy cover of shrubs must average from 10 to <25%, and tree canopy cover must not exceed 5%, within a minimum habitat area of 3 ha. In addition, the combined ground cover of grasses, sedges, mosses/lichens, forbs and low (<0.2 m) shrubs and trees must average more than 25%. More than 60% of the total ground cover must consist of grasses and sedges.

Elk are the only key evaluation species for this habitat. Habitat features used for evaluation are shrub abundance, shrub canopy height, shrub composition, forage abundance, forage composition, and topographic diversity.

Deciduous Tree/Shrub Mix

This habitat type includes all deciduous-dominated treed vegetation. Deciduous tree/shrub mix usually occurs on dry, warm slopes, but can also be developed on flat areas. The canopy cover of trees must average more than 5% within a minimum habitat area of 3 ha, and more than 80% of the tree cover must consist of broad-leaved deciduous trees.

Deciduous tree/shrub mix can be developed and evaluated for two key wildlife species: beaver or snowshoe hare. Features used for evaluating this habitat are tree abundance, tree composition, shrub abundance, and shrub canopy height. To be suitable for use by beaver, deciduous tree/shrub mix must be within 30 m of a suitable waterbody or watercourse.

Deciduous-Coniferous Tree/Shrub Mix

Deciduous-coniferous tree/shrub mix includes all mixedwood vegetation with a tree canopy cover averaging more than 5% within a minimum habitat area of 3 ha. Broad-leaved deciduous trees and coniferous trees must each make up 20-80% of the total tree cover.

Deciduous-coniferous tree/shrub mix can be developed and evaluated for three key wildlife species: moose, elk or snowshoe hare. Features used for evaluating this habitat are tree abundance, tree composition, shrub abundance, and shrub canopy height.

Upland Coniferous Tree/Shrub Mix

This habitat type includes all coniferous-dominated treed vegetation occurring on imperfectly to rapidly drained mineral soils. The canopy cover of trees must average more than 5% within a minimum habitat area of 3 ha, and more than 80% of the tree cover must consist of coniferous trees.

Upland coniferous tree/shrub mix can be developed and evaluated for four key wildlife species: caribou, moose, elk, snowshoe hare or spruce grouse. Features used for evaluating this habitat are tree abundance, tree composition, abundance and composition of the successional understory, shrub abundance, and shrub canopy height.

Lowland Coniferous Tree/Shrub Mix (Muskeg)

Muskeg includes all treed vegetation developed on wet organic soils. Tree canopy cover must average more than 5% within a minimum habitat area of 3 ha, and more than 80% of the tree cover must consist of coniferous trees and/or tamarack.

Muskeg can be developed and evaluated for two key wildlife species: moose or snowshoe hare. Features used for evaluating this habitat are tree abundance, shrub abundance, shrub canopy height, shrub composition and forage abundance.

WATER-BASED HABITATS

Watercourse

Watercourses are defined as linear drainage channels containing flowing water for all or part of the year. They must be at least 200 m in length for evaluation purposes.

Watercourses can be developed and evaluated for two key wildlife species: beaver or muskrat. Features used for evaluating this habitat are stream gradient, water depth, bank characteristics, abundance of emergent vegetation, and abundance of herbaceous terrestrial vegetation (on adjacent stream banks). To be suitable for use by beaver, a watercourse must be located within 30 m of suitable foraging habitat (i.e., deciduous tree/shrub mix or shrubland).

Wetland

Wetlands are defined as small waterbodies with depths of less than 1.5 m throughout most (more than 80%) of their area, and consisting of both open water areas and emergent vegetation. Total habitat area within the high water mark must be 0.2 ha or more.

Muskrat are the only key evaluation species for this habitat. Habitat features used for evaluation are water depth, abundance of emergent vegetation, abundance of submergent vegetation, and abundance of herbaceous terrestrial vegetation (on adjacent banks).

Lake/Pond

Lakes and ponds are defined as waterbodies with average water depths greater than 1.5 m, with open water comprising more than 80% of the surface area, and with small areas of emergent plant growth. They differ from wetlands primarily in terms of greater water depth and less extensive emergent growth. Total habitat area within the high water mark must be 0.2 ha or more.

Lakes and ponds can be developed and evaluated for three key wildlife species: moose, beaver or muskrat. Features used for evaluating this habitat are water depth, bank characteristics, abundance of water lilies, abundance of emergent vegetation, abundance of submergent vegetation, and abundance of herbaceous terrestrial vegetation (on adjacent banks). To be suitable for use by beaver, a lake or pond must be located within 30 m of suitable foraging habitat (i.e., deciduous tree/shrub mix or shrubland).

RELIEF-BASED HABITATS

Cliff

Cliffs are defined as exposed rock faces of with a slope of 50° or more, a vertical rise of at least 8 m, and a minimum length of 100 m.

Cliffs can be developed and evaluated for three key wildlife species: mountain goat, bighorn sheep or golden eagle. Features used for evaluating this habitat are cliff height, cliff slope, ledge availability, nest site availability, cliff face configuration, and dominant aspect. To be suitable for use by bighorn sheep and mountain goat, a portion of the cliff base must be adjacent to suitable foraging habitat (i.e., meadow) or a water source.

Talus

Talus is defined as an apron of unconsolidated rock pieces, with variable slopes and a minimum length of 100 m. Talus is usually (but not always) associated with cliff habitat.

Talus can be developed and evaluated for three key wildlife species: bighorn sheep, mountain goat or white-tailed ptarmigan. Features used for evaluating this habitat are size of talus fragments and talus slope. To be suitable for use by bighorn sheep, mountain goat or white-tailed ptarmigan, a portion of the talus must be adjacent to suitable foraging habitat (i.e., meadow) or a water source.

CHAPTER 5

FIELD TECHNIQUES FOR ON-SITE MEASUREMENTS OF RECLAIMED HABITATS

GENERAL SAMPLING METHODS

As discussed in Chapter 4, the 15 reclamation habitats to be used in the Mountains and Foothills regions are either vegetation-based, water-based or relief-based habitats. Sampling methods for collecting on-site measurements of important habitat features in each of these habitat classes are summarized below.

Vegetation-Based Habitats

Vegetation-based reclamation habitats are evaluated through selected vegetation measurements, although a measure of surface relief and rock cover is also used for some of the habitats. Paired transects, each 100 m in length and spaced 50 m apart are used as the sampling unit for collecting such measurements (see Figure 1). These transect pairs are located randomly within the habitat of interest and should be straight, except in long narrow habitats (such as riparian shrublands) where the configuration of the habitat must be followed to accommodate the entire transect pair. A minimum of one transect pair is required for any habitat less than 10 ha in area. For larger reclamation habitats (i.e., >10 ha), a sampling intensity of one transect pair per 10 ha is required, and each 10 ha area is considered separately for certification. Both the starting point and the direction of the transects should be randomly selected, either on air photos or planning maps of the site prior to field measurements, or in the field at the time of assessment.

For one time assessments, a transect can consist of a 100 m tape stretched along the ground during the actual sampling period. However, where multiple assessments of a habitat are required, a more permanent transect should be established using wooden or metal stakes to mark its start and end points.

Water-Based Habitats

Sampling procedures for water-based habitats are variable. Watercourses are divided into 1 km long segments (actual stream distance, not straight line distance) and each segment may be evaluated separately for certification. Two 100 m long, randomly selected sample reaches are evaluated in each 1 km long segment. Three 100 m long transects (running the full length of the sample reach) are then established, one at mid-channel, one along the emergent zone of one shoreline, and one along a streambank, approximately 5 m inland from the stream's high water mark (Figure 2).

For wetlands and lakes/ponds, two straight-line transects are used for water depth and submergent cover measurements. These transects will follow the two axes of the waterbody, extending from shoreline to shoreline and passing through the approximate center of the waterbody. One hundred meter long, randomly-located transects following the shoreline of the waterbody approximately 5 m inland from the high water mark are

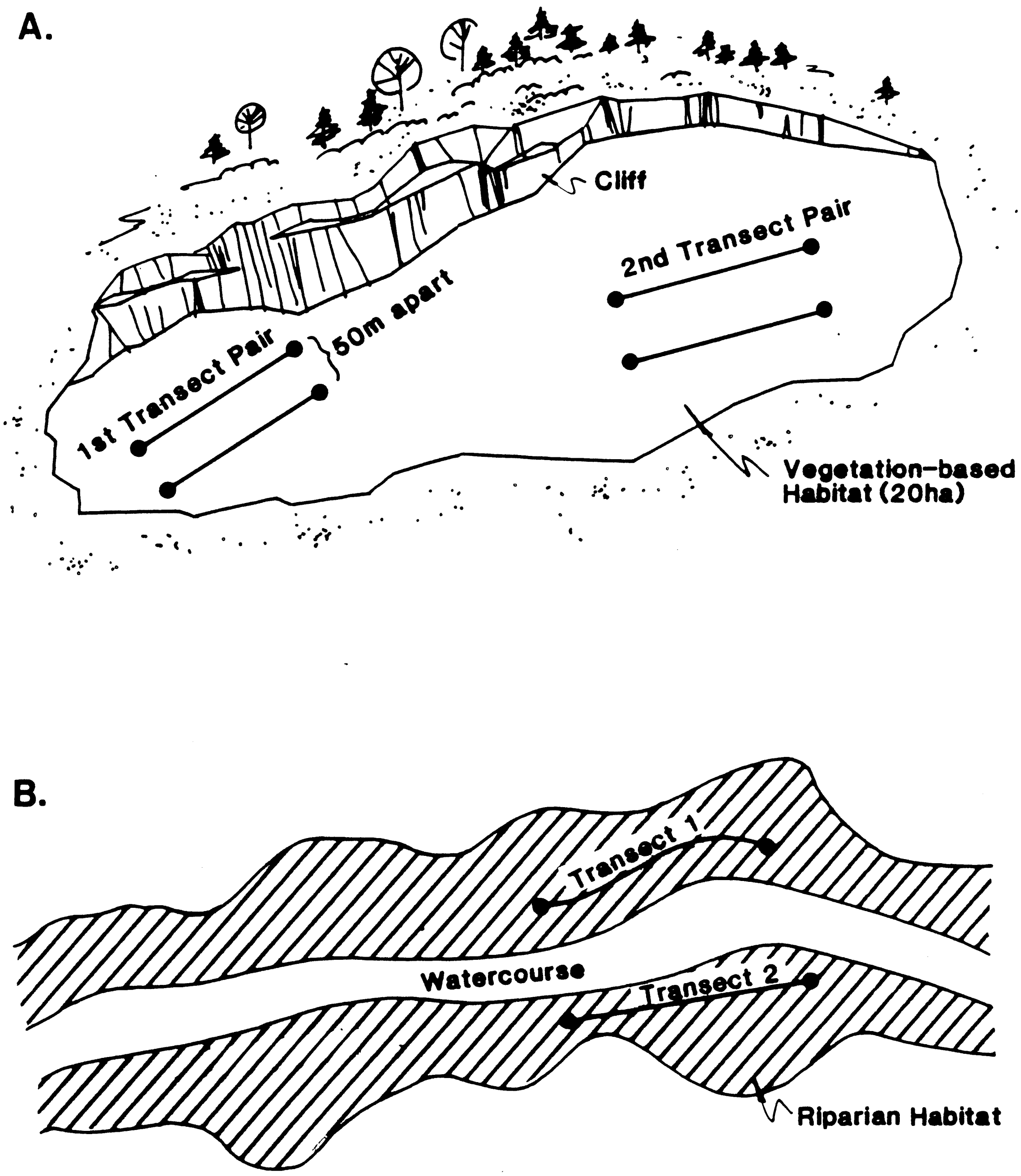

Figure 1. Illustration of the location and configuration of sample transect pairs for vegetation-based habitats (A: Block-shaped vegetation-based habitat areas and B: Linear vegetation-based habitats).

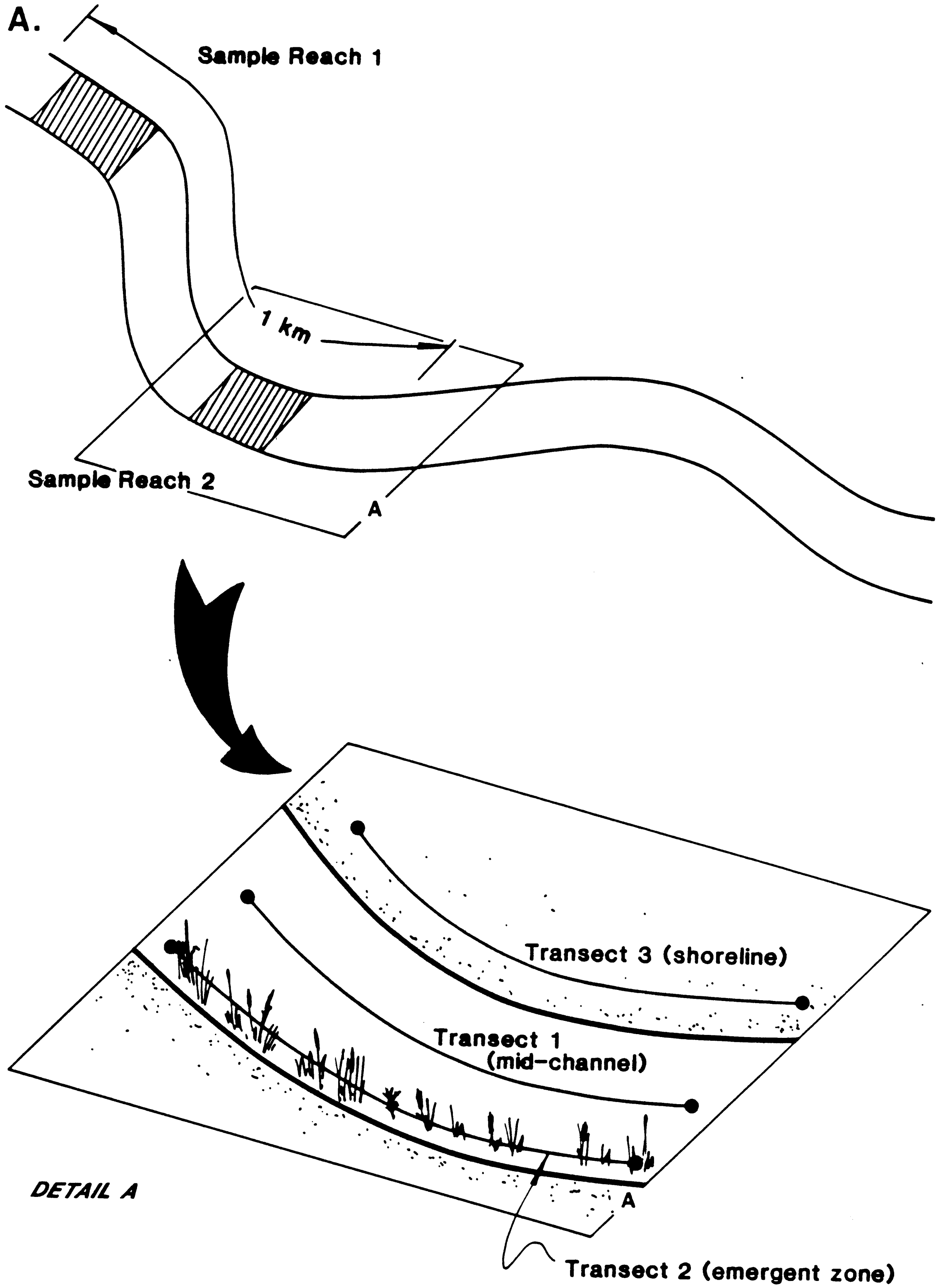

Figure 2. Illustration of the location and configuration of sample reaches and sample transects (within one sample reach) in a watercourse habitat.

used for the collection of data on shoreline herbaceous vegetation (Figure 3). At least two transects are required per km of shoreline.

For smaller wetlands and lakes/ponds, recent air photos of the waterbody taken during the peak growing period (i.e., July - mid-August) can be used for measuring emergent cover and, in the case of lake/pond habitat, bank characteristics. Alternatively, these features can be visually estimated from on the waterbody or from an adjacent vantage point. For larger lakes/ponds where sampling is required, information on emergent cover and bank characteristics is collected along 100 m long randomly-located transects (two transects per km of shoreline) following the waterline of the waterbody. These transects would be established in conjunction with the inland transects discussed above for the collection of data on herbaceous vegetation (Figure 4).

Relief-Based Habitats

Both talus and cliff habitats are largely evaluated visually, eliminating the need for a specific sampling procedure. However, to facilitate certain measurements, large cliffs and talus should be divided into 100 m segments along their base. Values generated for these segments are then averaged to produce a final value.

RECOMMENDED TECHNIQUES FOR MEASUREMENT OF HABITAT FEATURES

All vegetation measurements for vegetation-based and water-based habitats should be obtained during the peak growing season (July to mid-August in most areas within the Mountains and Foothills regions). Measurement of physical features such as bank characteristics, cliff height, and talus size can be completed at any time during the snow-free season, with the exception of water depth. Measurements for this latter feature should be made in September to adequately reflect overwintering values.

Methods for measurement of habitat features are presented below, beginning with variables relating to the tree, shrub and ground cover/composition and relief variables for vegetation-based habitats (in that order). These are followed by variables for water-based habitats and variables for relief-based habitats.

Tree Abundance

Tree abundance refers to the percent of the ground shaded by the combined canopy (i.e., leaves and branches) of all trees (i.e., all woody single stemmed plants > 0.2 m in height) within a given site, assuming the sun is directly overhead. It reflects the amount of food and/or cover available to particular key wildlife species.

Abundance values are calculated separately along each of the 100 m long transects which have been established within the habitat. Using a tape measure extended along the full length of the transect, a sampler moves along the tape and projects tree canopies vertically onto the tape, recording the length of the line segment covered and the type of tree involved (i.e., line intercept method; see Figure 5). The recording of tree type is important for estimating tree composition (see section below). Where two or more canopies overlap, each canopy is projected onto the tape and measured separately. Vertical projections are

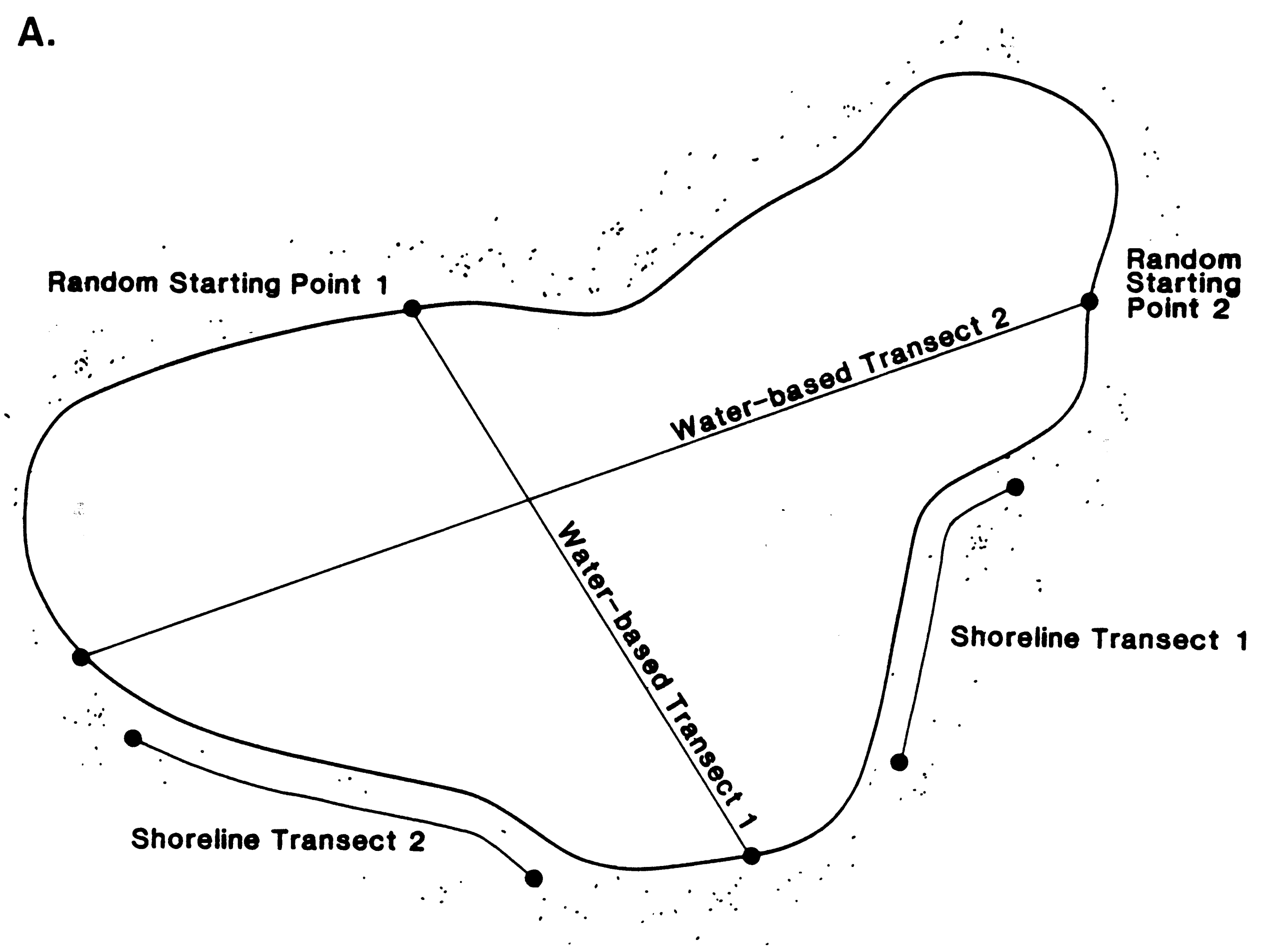

Figure 3. Illustration of the location and configuration of sample transects for a wetland habitat.

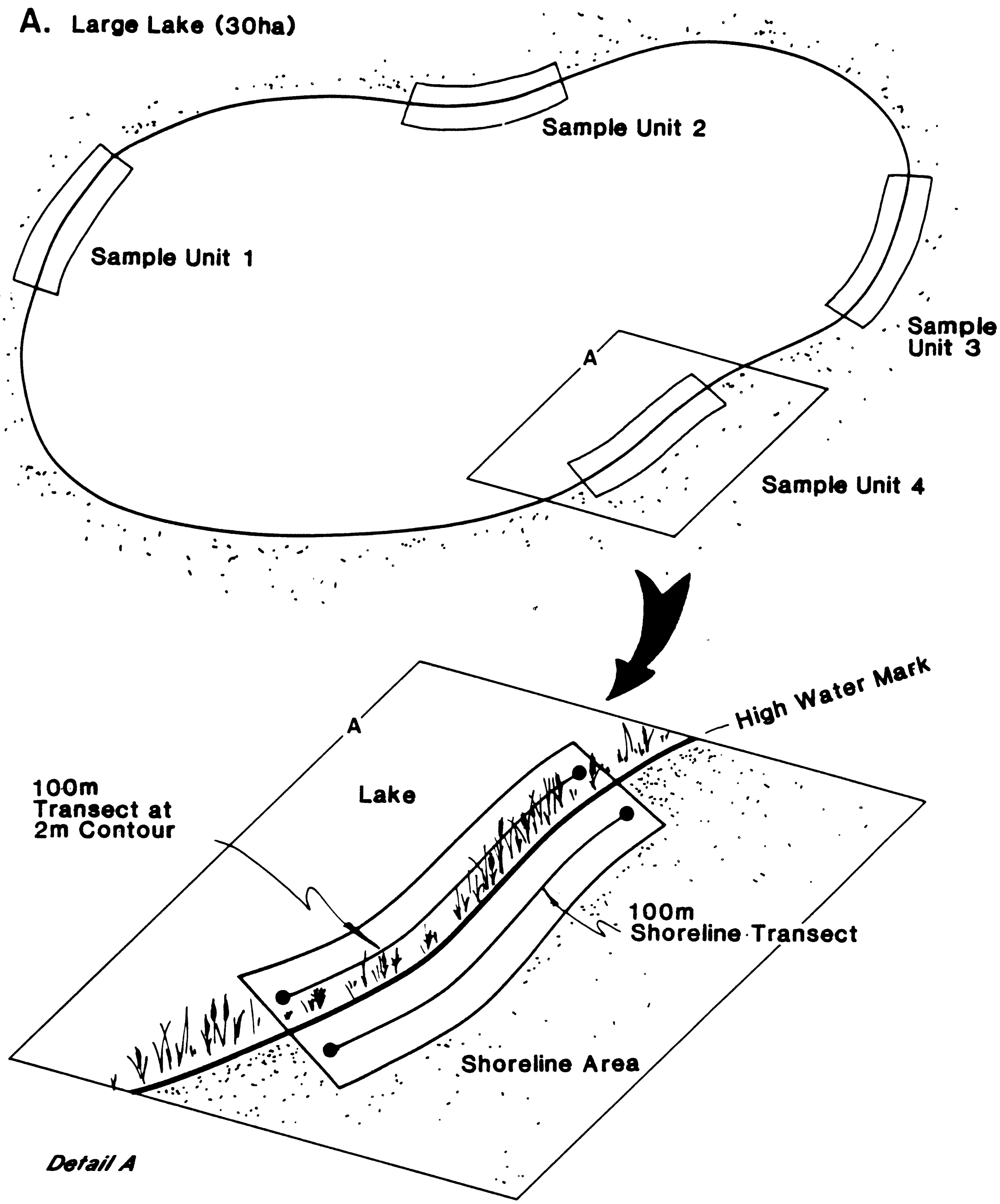

Figure 4. Illustration of the location and configuration of sample units and sample transects (within one sample unit) for a lake/pond habitat.

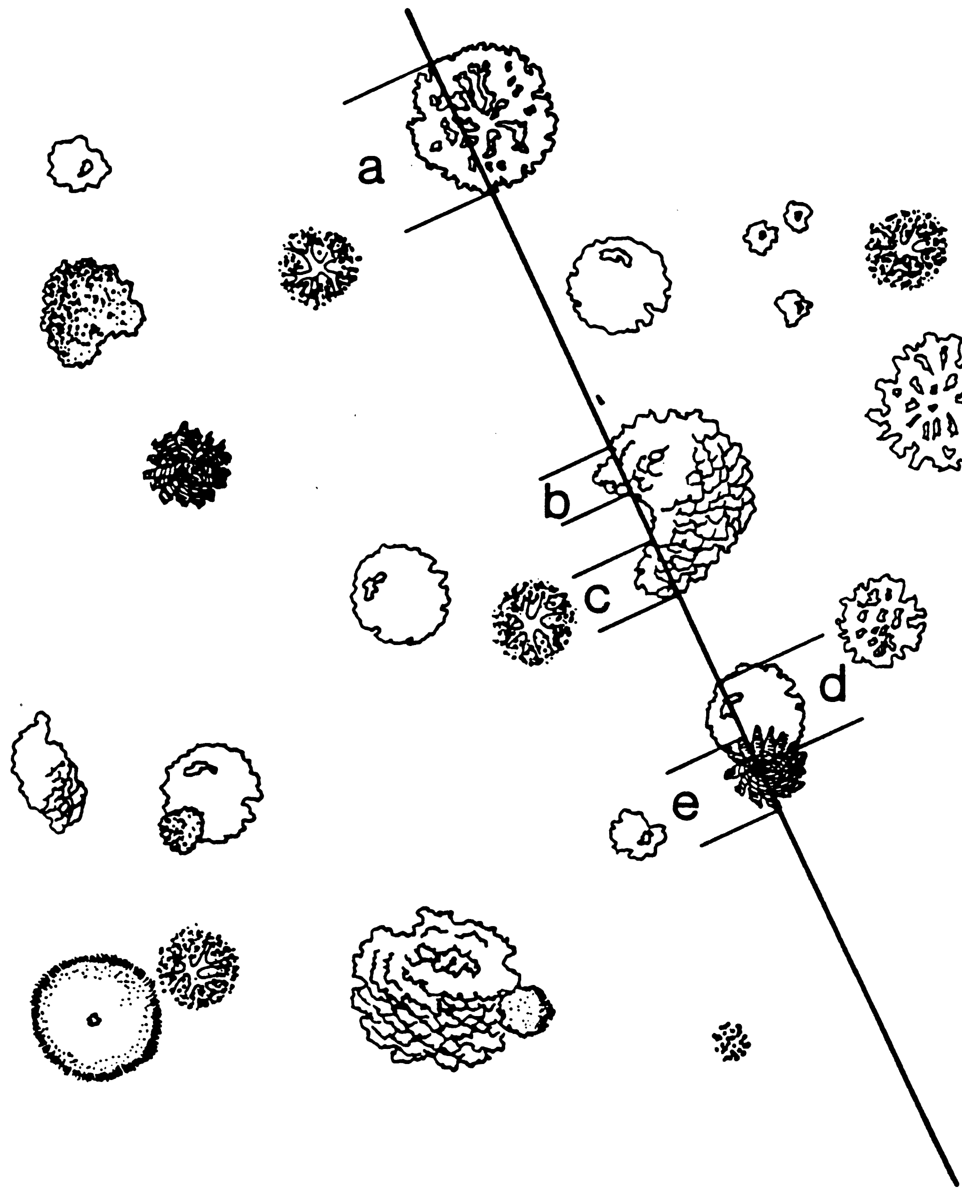

Figure 5. Vertical view of the Line Intercept technique, showing a transect line with intercepts of trees and shrubs (from Hays et al. 1981). (Percent tree cover would be equal to the percentage of the 100 m transect occupied by segments a and e. Percent shrub cover would be equal to the percentage of the 100 m transect line represented by segments b, c and d.)

easily conducted visually for canopies extending close to the ground (i.e., within 2 m). However, for canopies farther from the ground, a vertical rod 3-4 m in length should be used to improve projection accuracy. The rod is held vertically above the transect line and moved along the line until the outer edge of the canopy is encountered. The lower tip of the rod is then dropped onto the transect line to permit the intercept point to be read.

To estimate tree abundance (cover), the lengths (m) of individual line segments covered by tree canopies are summed and this value is expressed as a percent of the total transect length (100 m). Values generated from the transects are then averaged to produce the final abundance value. Data Form 1 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values.

Tree Composition *(For Beaver Only)*

This habitat feature refers to the percent of the total tree canopy which is comprised of tree species preferred by the key wildlife species, beaver, as a food source (i.e., aspen and balsam poplar). It reflects the amount of food available to beavers in a given treed habitat.

To estimate tree composition, the lengths (m) of those transect line segments covered by canopies of preferred tree species are summed for each transect (Figure 5) and this value is expressed as a percent of the total line length covered by all trees (from Data Form 1). Values generated from the transects are then averaged to produce the final composition estimate. Data Form 1 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values.

Tree Composition *(For Spruce Grouse Only)*

This habitat feature refers to the percent of the total tree canopy which is comprised of tree species preferred by spruce grouse as food and cover, including lodgepole pine and white spruce. It reflects the amount of food and cover available to spruce grouse in a given treed habitat.

To estimate tree composition, the lengths (m) of those transect line segments covered by canopies of preferred tree species are summed for each transect (Figure 5) and this value is expressed as a percent of the total line length covered by all trees (from Data Form 1). Values generated from the transects are then averaged to produce the final composition estimate. Data Form 1 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values.

Successional Understory Abundance

Successional understory abundance refers to the percent of the total tree canopy comprised of all Engelmann spruce and subalpine fir over 0.2 m in height within a given site. This feature reflects the types of trees (and, hence, the quality of habitat) which will be present in a given reclaimed forest stand several decades into the future, and is important as a habitat feature for the key wildlife species, caribou.

To estimate successional understory abundance, the lengths (m) of those transect line segments covered by canopies of Engelmann spruce and subalpine fir are summed for each transect and this value is expressed as a percent of the total line length covered by all trees (from Data Form 1). Values generated from the transects are then averaged to produce the final composition estimate. Data Form 1 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values.

Predominance of Coniferous Trees

This habitat feature refers to the percent of the total tree canopy which is comprised of coniferous tree species, including pine, fir and spruce. It influences the amount of thermal cover available to key ungulate species in a given treed habitat.

To estimate conifer dominance, the lengths (m) of those transect line segments covered by canopies of conifer trees are summed for each transect and this value is expressed as a percent of the total line length covered by all trees (Tree Abundance from Data Form 1). Values generated from the transects are then averaged to produce the final composition estimate. Data Form 1 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values.

Shrub Abundance

Shrub abundance refers to the percent of the ground shaded by the combined canopy (i.e., leaves and branches) of all shrubs (i.e., all multi-stemmed woody plants over 0.20 m in height) within a given site, assuming the sun is directly overhead. It reflects the amount of food and/or cover available to particular key wildlife species

Abundance values are calculated along each of the 100 m long transects which have been randomly located within the habitat. Using a tape measure extended along the full length of the transect, a sampler moves along the tape and projects shrub canopies vertically onto the tape, recording the length of the line segment covered and the type of shrub involved. The recording of shrub type is important for estimating shrub composition (see section below) Where two or more canopies overlap, each canopy is projected onto the tape and measured separately. Vertical projections can be easily conducted visually for canopies extending close to the ground (i.e., within 2 m). However, for canopies farther from the ground, a vertical rod 3-4 m in length should be used to improve projection accuracy. The rod is held vertically above the transect line and moved along the line until the outer edge of the canopy is encountered. The lower tip of the rod is then dropped onto the transect line to permit the intercept point to be read.

To estimate shrub abundance (cover), the lengths (m) of those line segments covered by shrub canopies are summed and this value is expressed as a percent of the total transect length (100 m). Values generated from the transects are then averaged to produce the final abundance value. Data Form 2 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values.

Shrub Composition *(For Ungulates Only)*

This habitat feature refers to the percent of the total shrub canopy which is comprised of shrub species preferred by key ungulate species as browse, including red-osier dogwood, saskatoon and willows (or otherwise specified in the approved reclamation plan). It reflects the amount of food available to ungulates in a given shrubland habitat.

To estimate shrub composition, the lengths (m) of those transect line segments covered by canopies of preferred shrub species are summed for each transect and this value is expressed as a percent of the total line length covered by all shrubs (Shrub Abundance from Data Form 2). Values generated from the transects are then averaged to produce the final composition estimate. Data Form 2 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values.

Shrub Composition *(For Beaver and White-tailed Ptarmigan Only)*

This habitat feature refers to the percent of the total shrub canopy which is comprised of willows (i.e., shrub species which are preferred by the key wildlife species, beaver and white-tailed ptarmigan, as food). It influences the amount of food available to beaver and ptarmigan in a given shrubland habitat.

To estimate shrub composition, the lengths (m) of those transect line segments covered by canopies of willow species are summed for each transect and this value is expressed as a percent of the total line length covered by all shrubs (Shrub Abundance from Data Form 2). Values generated from the transects are then averaged to produce the final composition estimate. Data Form 2 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values.

Shrub Canopy Height

This feature directly influences the accessibility of shrubs to a variety of key wildlife species. For example, shrubs which are too tall may support the majority of their browsable material above the feeding range of wildlife and will offer few branches and leaves at lower levels for cover. Similarly, low lying shrubs may be unavailable as food or cover during the winter months because of snow cover.

Height measurements are conducted along the 100 m long transects established for the site. At 5 m intervals, the height of the closest shrub within 2.5 m of the reference point is estimated to the nearest 0.5 m, either visually or with the aid of a graduated rod. If no shrub occurs within the designated distance, no height is entered for that sampling point. Average shrub heights are calculated for each transect by summing all of the shrub heights and dividing by the number of heights collected. Values generated from the transects are then averaged to produce the final height estimate. Given the shape of most shrubs, it is assumed that the majority of a shrub's browsable twigs occur at a height of approximately 2/3 that of the top of the shrub. Consequently, the final height estimate calculated above is multiplied by 0.67 for use in the habitat's assessment. Data Form 3 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values.

Forage Abundance

Forage abundance refers to the percent of the ground covered by the combined canopy (i.e., leaves and stems/branches) of all 1) grasses/sedges, 2) mosses/lichens, 3) forbs, 4) horsetail species and 5) low (<0.2 m) shrubs/trees within a given site. It reflects the amount of food and, to a lesser extent, cover available to particular key wildlife species.

Abundance values are calculated along each of the 100 m long transects which have been randomly located within the habitat. Using a tape measure extended along the full length of the transect, a sampler places a portable 0.5 m^2 frame or plot at each 5 m interval, centered on the transect line. One of six cover classes (<5%, 5-25%, 25-50%, 50-75%, 75-95% and >95%) is used to describe the percent of the ground within the plot which is covered by each of the five plant groups listed above (see Figure 6 for a visual aid in estimating cover) and the mid-point of the appropriate class (i.e., 2.5%, 15%, 37.5%, 67.5%, 87.5% and 97.5%) is assigned as the actual cover rating for each group. The mid-point values assigned at each plot are then summed for the entire transect and divided by 20 (i.e., the number of plots) to produce an average value for each plant group. Values generated from the transects are then averaged to produce the final cover estimate. Data Form 4 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values.

Forage Composition

This habitat feature refers to the percent of the total vegetative ground cover (discussed under forage abundance above) which is comprised of grasses and sedges. It reflects the amount of preferred year-round food resources available to key ungulate species in meadow habitats.

To estimate forage composition, the cover estimates for grasses/sedges from each sampling plot (i.e., 2.5%, 15%, 37.5%, 67.5%, 87.5% and 97.5%) are summed for each transect and this value is expressed as a percent of the total vegetative cover of all ground forages (Forage Abundance from Data Form 4). Values generated from the transects are then averaged to produce the final composition estimate. Data Form 4 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values.

Horsetail Abundance

Horsetail abundance refers to the percent of the ground covered by the canopy (i.e., leaves and stems/branches) of all horsetail species within a given site. It reflects the amount of highly preferred food available to particular key wildlife species utilizing lowland meadow communities.

To estimate horsetail abundance, the mid-point percent cover estimates for horsetails from each sampling plot (i.e., 2.5%, 15%, 37.5%, 67.5%, 87.5% and 97.5%) are summed for each transect and divided by 20 (i.e., the number of plots) to produce an average cover value. This value is expressed as a percent of the total vegetative cover of all ground forages (Forage Abundance from Data Form 4). Values generated from the transects are then averaged to produce the final cover estimate. Data Form 4 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values.

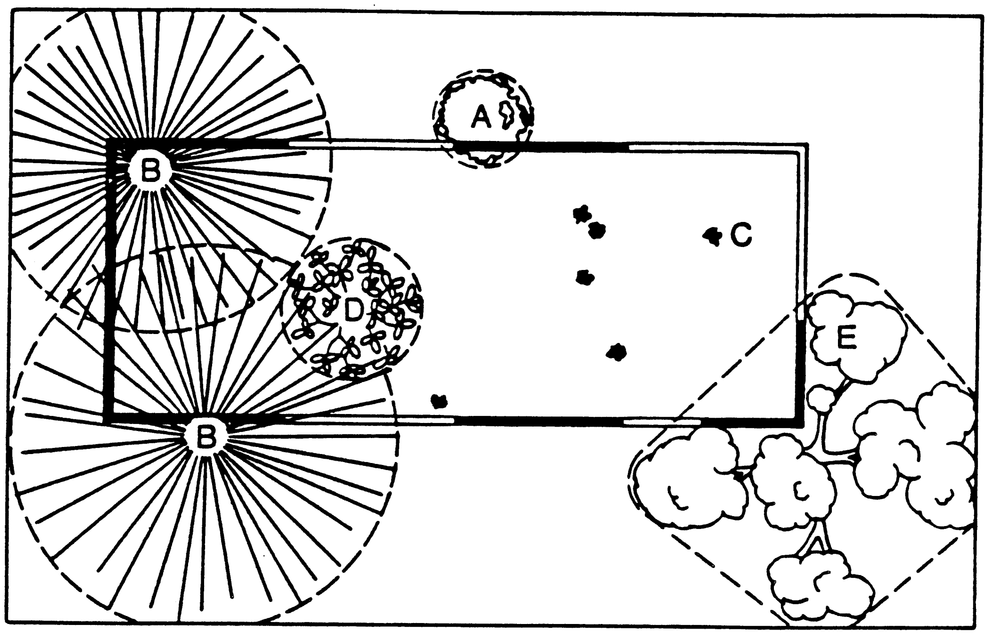

Figure 6. The grid technique of Ocular Estimation of Cover (redrawn from Daubenmire 1973)(from Hays et al. 1981). (Note the marks along the sides of the frame which lay out areas of 5, 25, 50, 75, and 95%. Cover classes of species shown are: A, <5%; B, 25-50%; C, <5%; D, 5-25% and E, <5%.)

Unconsolidated Rock Cover

This feature refers to the percent of the ground covered by unconsolidated rock fragments (> 0.5 m^3 in volume) within a given site. It reflects the amount of escape/nesting cover available to particular key wildlife species utilizing alpine meadow communities.

To estimate the amount of unconsolidated rock cover, the mid-point percentage cover estimates for the amount of ground within each sampling plot which consists of unconsolidated rock (i.e., 2.5%, 15%, 37.5%, 67.5%, 87.5% and 97.5%) are summed for each transect and divided by 20 (i.e., the number of plots) to produce an average cover value. Values generated from the transects are then averaged to produce the final cover estimate. Data Form 4 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values.

Topographic Diversity

This feature refers to the amount of localized surface relief occurring within a given site. It reflects the amount of escape and thermal cover available to particular key wildlife species utilizing alpine and upland meadow and upland shrubland habitats.

Topographic diversity is visually estimated along each of the 100 m long sampling transects which have been randomly located within the habitat. It is defined as the maximum vertical relief of surface irregularities encountered along the transect (i.e., maximum vertical drop in metres from the top to the bottom of a localized surface feature such as a mound or a pit). It does not pertain to the elevational change associated with ascending or descending the dominant slope of a habitat (i.e., it is assumed that the plane of habitat is always horizontal). Values generated from the transects are then averaged to produce the final relief estimate. Data Form 4 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values.

Abundance of Emergent Vegetation (Wetlands)

This feature refers to the percent of a wetland's surface area which supports emergent vegetation. For evaluation purposes, the presence of any leaves or stems of an emergent species (e.g., cattail, bulrush, sedge, etc.) within a m^2 of surface area constitutes emergent cover. This feature reflects the amount of food and cover available to particular key wildlife species utilizing wetland habitats.

The abundance of emergent vegetation is estimated visually for the wetland as a whole, either from the water, from an elevated vantage point adjacent to the wetland or from recent large-scale (i.e., 1:15,000 or larger) summer air photos of the wetland. Data Form 6 (Appendix 1) should be employed in the field for the recording of such values.

Abundance of Emergent Vegetation (Watercourses and Lakes/Ponds)

This feature refers to the percent of the shoreline of a watercourse or lake/pond which supports a band of emergent vegetation 1 m in width or greater. For evaluation purposes, the presence of any rooted emergent plant (e.g., cattail, bulrush, sedge, etc.)

within a m^2 of surface area constitutes emergent cover. This feature reflects the amount of food and cover available to particular key wildlife species utilizing watercourse and lake/pond habitats.

Unlike wetland habitats, emergent growth in watercourses and larger lakes/ponds is generally restricted to shoreline fringes. In watercourses, current scour prevents such growth from occurring away from the stream edges while, in lakes/ponds, excessive water depths away from shore eliminates emergent cover. Consequently, measures of emergent vegetation are made along randomly located 100 m long shoreline transects. At 5 m intervals along each transect, the 'presence' or 'absence' of emergent growth is recorded and the percent of the sampling points supporting such growth is used as the measure of abundance. As previously discussed in this chapter, two transects are to be established per km of shoreline and values generated from the transects are averaged to produce the final cover estimate. Data Form 7 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values. (**N.B.**: For smaller habitats, it may be possible to estimate shoreline emergent cover for the watercourse or lake/pond as a whole, similar to wetland habitats [see Abundance of Emergent Vegetation above].)

Abundance of Water Lilies

This feature refers to the percent of a lake/pond surface area which supports water lilies. For evaluation purposes, the presence of any leaves, stems or flowers of this plant within a m^2 of surface area constitutes water lily cover. This feature reflects the amount of food available to particular key wildlife species utilizing lake/pond habitats.

The abundance of water lilies is estimated visually for the wetland as a whole, either from the water, from an elevated vantage point adjacent to the wetland or from recent large-scale (i.e., 1:15,000 or larger) summer air photos of the wetland. Data Form 7 (Appendix 1) should be employed in the field for the recording of such values.

Abundance of Herbaceous Terrestrial Vegetation

This feature refers to the percent of the ground adjacent to shorelines which is covered by the combined canopy (i.e., leaves and stems/branches) of all 1) grasses/sedges, 2) forbs and 3) horsetail species. It reflects the amount of food available to particular key wildlife species which utilize watercourses, wetlands or lakes/ponds.

Abundance values are calculated along 100 m long transects which have been randomly located within 5 m of the high water mark of the reclaimed watercourse or waterbody. As previously discussed in this chapter, two randomly located transects are to be established per km of shoreline. Using a tape measure extended along the full length of the transect, a sampler places a portable 0.5 m^2 frame or plot at each 5 m interval, centered on the transect line. One of six cover classes (<5%, 5-25%, 25-50%, 50-75%, 75-95% and >95%) is used to describe the percent of the ground within the plot which is covered by each of the three plant groups listed above (see Figure 6) and the mid-point of the appropriate class (i.e., 2.5%, 15%, 37.5%, 67.5%, 87.5% and 97.5%) is assigned as the actual cover rating for each group. The mid-point values assigned at each plot are then summed for the entire transect and divided by 20 (i.e., the number of plots/transect) to produce an average value for each plant group. Values generated from the transects are then averaged to produce the final cover estimate. Data Form 4 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values.

Abundance of Submergent Vegetation

This feature refers to the percent of a wetland's subaqueous area which supports submergent vegetation. For evaluation purposes, the presence of any submergent plants (e.g., pondweed, stonewort, etc.) within a m^2 of surface area constitutes submergent cover. This feature reflects the amount of food available to particular key wildlife species utilizing wetland and lake/pond habitats.

The presence or absence of submergent growth is noted at 20 sampling points along each of the two major axes of the waterbody. For each axis (transect), the sampling points are spaced an equal distance apart (i.e., transect length ÷ 20), using a hipchain for open water distance measurements. The percent cover for each axis is calculated by totalling the number of sampling points with submergent cover and dividing by 20. Values generated from the transects are then averaged to produce the final cover estimate. Data Form 6 or 7 (depending on the habitat) (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values.

Water Depth

This feature refers to the average late summer depths of reclaimed watercourses and waterbodies. It reflects the overwintering suitability of these habitats for two key wildlife species: beaver and muskrat. Measurements for this feature should be made in September to adequately reflect overwintering values.

For watercourses, mid-channel depths are collected at 5 m intervals along each randomly selected 100 m long sampling reach (i.e., 20 depths) using a graduated rod. As previously discussed in this chapter, two transects are to be established per km of reclaimed watercourse. For each transect, mean water depth is calculated by summing all measured depths and dividing by 20. Depths calculated from the transects are then averaged to produce the final value. Data Form 5 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values.

For wetlands and lakes/ponds, depth is measured at 20 sampling points along each of the two major axes of the waterbody, using a graduated rod or a weight attached to a graduated cord. For each axis (transect), the sampling points are spaced an equal distance apart (i.e., transect length ÷ 20), using a hipchain for open water distance measurements. The mean depth along each axis is calculated by summing all depths and dividing by 20. Values generated from the transects are then averaged to produce the final depth estimate. Data Form 6 or 7 (depending on the habitat) (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values.

Bank Characteristics

This feature refers to the steepness and height of banks bordering watercourses and lakes/ponds. It reflects the degree to which terrestrial forage resources are accessible to particular key wildlife species utilizing these habitats.

One or both of these features will be measured for assessment purposes. For steeply incised watercourses or lakes/ponds, both bank height and bank steepness may be required to properly assess bank suitability. However, for those waterbodies with gradual shorelines and no definite bank, adjacent slope steepness is the only required measure.

For both watercourses (one bank only) and lakes/ponds, bank characteristics (height and/or steepness) are visually estimated at 5 m intervals along each randomly selected 100 m long sampling transect. As previously discussed in this chapter, two transects are to be established per km of reclaimed watercourse/shoreline. Because site-specific heights are moderately easy to estimate accurately (using a graduated rod or other aid), mean bank height is calculated by simply summing all estimates and dividing by 20. However, actual slopes are often more difficult to visualize. Where this is the case, one of four slope classes (0-15°, 16-30°, 31-45°, >45°) can be used to describe bank steepness, with the mid-point of the selected class (i.e., 7.5°, 23°, 38°, 68°) being assigned as the actual slope value. The mid-point values are then summed for the entire transect and divided by 20 (i.e., the number of sample points) to produce an overall value for the transect. For both features, values calculated from transects are averaged to produce the final value. Data Form 5 or 7 (depending on the habitat) (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values.

Stream Gradient

Stream gradient refers to the change in elevation along a given reach of stream. It reflects current velocity and the suitability of a watercourse for beaver activity.

Gradient estimates are made for each 100 m sampling reach established for the watercourse, using contour information from the plan profile maps of the mine site or one of a variety of hand-held instruments for determining slope (e.g., clinometer). Data Form 5 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values. The handbook user is referred to Appendix 2 for details on the use of contour information or a clinometer for estimating slope.

Cliff Slope

This feature refers to the steepness of reclaimed cliff habitat. It reflects the effectiveness of such habitats as escape terrain for particular key wildlife species.

The dominant slope is estimated for each 100 m segment of reclaimed cliff habitat, using contour information from the plan profile maps of the mine site or using a clinometer. Values calculated for all sampled segments are averaged to produce the final value. Data Form 8 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values. The handbook user is referred to Appendix 2 for details on the use of contour information or a clinometer for estimating slope.

Talus Slope

This feature refers to the steepness of reclaimed talus habitat. It reflects the effectiveness of such habitats as escape terrain for particular key wildlife species.

The dominant slope is estimated for each 100 m segment of reclaimed talus habitat, using contour information from the plan profile maps of the mine site or using a clinometer. Values calculated for all sampled segments are averaged to produce the final value. Data Form 9 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values. The handbook user is referred to Appendix 2 for details on the use of contour information or a clinometer for estimating slope.

Cliff Height

Cliff height reflects the effectiveness of such habitats as escape terrain for particular key wildlife species, with higher cliffs offering more and generally better escape cover..

The dominant height is estimated for each 100 m segment of reclaimed cliff habitat, either visually, using contour information from the plan profile maps of the mine site or using a clinometer and simple trigonometric functions. Values calculated for all sampled segments are averaged to produce the final value. Data Form 8 (Appendix 1) can be employed in the field to facilitate the recording of data and calculation of values. The handbook user is referred to Appendix 2 for details on the use of trigonometry and a clinometer for estimating height.

Cliff Face Configuration

This feature refers to the number of major aspects occurring within a cliff habitat. For the purposes of evaluation, a major aspect must cover more than 20% of the entire cliff habitat and must be located in a single continuous section of the cliff. This feature reflects the amount of visual cover provided within a given cliff habitat for several key wildlife species.

This feature is estimated for the cliff face as a whole, either visually with the aid of a compass or using plan profile maps of the mine site. Data Form 8 (Appendix 1) can be employed in the field to facilitate the recording of values.

Dominant Aspect of The Cliff

Dominant aspect refers to the direction faced by the majority of the cliff. It reflects the thermal properties of the cliff habitat, with warmer southern exposures generally being preferred by several cliff-dwelling key wildlife species during the winter and reproductive periods.

This feature is estimated for the cliff face as a whole, either visually with the aid of a compass or using plan profile maps of the mine site. Data Form 8 (Appendix 1) can be employed in the field to facilitate the recording of values.

Ledge Availability

This feature refers to the length of usable ledges available within a cliff habitat for several cliff-dwelling key wildlife species. For the purposes of evaluation, usable ledges are defined as flat to moderately sloped (<40°) pathways at least 0.5 m in width and accessible from the perimeter of the cliff or from other accessible ledges. Ledges are considered important habitat components of cliffs since they provide animals with travel lanes, resting areas and even localized feeding areas.

Ledge availability is measured as metres of ledge per 1000 m^2 of cliff face. Therefore, to facilitate its measurement, it is recommended that a cliff be divided into sections 100 m in width by 10 m in height, either visually or with the aid of flagging or marking posts. Lengths of usable ledges can be visually estimated from a distant vantage point for each section and averaged for the cliff as a whole. Data Form 8 (Appendix 1) can be employed in the field to facilitate the recording of values.

Nest Site Availability

This feature refers to the number of usable nesting ledges available within a cliff habitat for one cliff nesting key wildlife species: golden eagle. For the purposes of evaluation, usable nest sites are defined as flat inaccessible ledges with a surface area of at least 0.5 m^2. These ledges must be at least 5 m from the perimeter of the cliff face.

This feature is measured as the number nest sites per 1000 m^2 of cliff face. Therefore, to facilitate its measurement, it is recommended that a cliff be divided into sections 100 m in width by 10 m in height, either visually or with the aid of flagging or marking posts. Numbers of usable nest sites can be visually estimated from a distant vantage point for each section and averaged for the cliff as a whole. Data Form 8 (Appendix 1) can be employed in the field to facilitate the recording of values.

Size of Talus Fragments

This feature refers to the size (volume) of rock fragments comprising a reclaimed talus habitat. It reflects the availability and size of interstitial spaces between rock fragments and, hence, the availability of nesting and escape cover for one key wildlife species: white-tailed ptarmigan. It also reflects the ruggedness of the habitat and its resulting effectiveness as escape terrain for two key wildlife species: bighorn sheep and mountain goat.

For the purpose of evaluating this feature, a randomly selected 100 m wide segment of talus is sampled. Where talus fragments are very homogeneous in size, this feature can be estimated visually from the toe of the slope. However, where fragments are variable in size, a single transect will be established across the full width of the talus segment approximately 5 m upslope from the toe of the talus. At 5 m intervals, the fragment encountered by the transect line will be sized (visually), using one of four size classes (<0.5 m^3, 0.5-1.0 m^3, 1.1-2.0 m^3, >2.0 m^3). The mid-point of the selected class (i.e., 0.25 m^3, 0.75 m^3, 1.55 m^3, 3 m^3) is assigned as the actual fragment size and these values are then summed for the entire transect and divided by 20 (i.e., the number of sample points) to produce an overall value for the transect. Values generated for each of the transects are averaged to produce the final size estimate. Data Form 9 (Appendix 1) can be employed in the field to facilitate the recording of values.

CHAPTER 6

CERTIFYING RECLAMATION HABITATS

THE CALCULATION AND USE OF HSI VALUES

An evaluation checksheet for each appropriate combination of key wildlife species and reclamation habitat is presented in Appendix 3. These checksheets describe to the handbook user the steps and calculations required for generating an HSI value for the reclamation habitat of interest. Each checksheet has three major components, falling under the headings Habitat Feature, Categories and Suitability Index (SI).

Under the Habitat Feature heading, those features and associated measurements used as assessment criteria for the habitat are identified. The appropriate Data Form used for the collection of such measurements is also identified.

Under the 'Categories' heading, the ranges or 'categories' of values which may be encountered for each habitat feature in the field are listed. Each category is associated with a unique level of habitat suitability and, consequently, a suitability index (SI) or rating [ranging from 0.0 (poorest habitat) to 1.0 (best habitat)] is assigned to each (under the 'Suitability Index' heading).

Based on actual data from the reclamation site of interest, the handbook user selects the value (and associated SI rating) which best reflects on-site conditions for each feature. The SI ratings are then combined through the simple arithmetic formula presented at the bottom of each checksheet to produce the HSI rating.

Evaluating Reclamation Success Based On HSI Values

The major function of the HSI values generated from the checksheets is to provide a numerical basis for the evaluating a reclamation habitat. For the purpose of this study, a value of 0.5 has been adopted as the minimum standard for any given reclamation habitat at the time of final assessment. However, a different HSI value may be negotiated during the approval process for the reclamation plan, or an alternate value may be adopted by industry and government as a provincial standard for the Mountains and Foothills regions.

The use of just HSIs as certification criteria is best suited to reclamation sites with relatively few reclamation habitats. Where a large number of different habitats are being reclaimed, controversy may arise where some habitats satisfy HSI requirements while others do not, and the certification of the site as a whole may be in jeopardy because of a limited area of unsuitable habitat development. An alternative certification procedure which avoids such a situation is discussed below.

Evaluating Reclamation Success Based On Reclaimed Habitat Availability

A standardized measure of habitat availability [i.e., the Habitat Unit (HU)], reflecting both habitat quality and quantity, can be generated for any given reclamation habitat by simply multiplying the area of that habitat by its calculated HSI value. On a reclamation site with many different reclaimed habitats, total habitat availability can be readily calculated with the following formula:

$$HUs = \sum_{i=1}^{n}(HSI_i \times A_i)$$

where HSI_i = the HSI value for reclamation habitat i
A_i = the area of reclamation habitat i
n = the number of individual reclamation habitats on site.

HUs offer a second means of assessing the success of a reclamation site for certification purposes. By determining the amount of habitat lost from project development (i.e., from pre-development assessments of habitat availability, using the HSI checksheets presented in this document), the reclamation planner and regulatory agency have a quantitative basis for designing the reclamation program. For example, a threshold number of HUs for a given wildlife species, and acceptable to both the developer and the Land Conservation and Reclamation Council, could be negotiated and used as the certification standard for a reclamation site.

The use of HUs, rather than just HSIs, represents more of an averaging system for site evaluation. Insufficient HUs generated from one or two smaller areas demonstrating poor reclamation success may be compensated for by larger areas which exceed their HU requirements, thus permitting overall site approval.

TIMING OF ASSESSMENTS

Most mine developers implementing a habitat reclamation approach would prefer to see site assessments undertaken within 5 years of the implementation of the approved reclamation plan for the site. However, the time required to develop a habitat to acceptable standards is highly dependent on site conditions and the habitat involved. While such habitats as headwalls/cliffs and talus can be evaluated immediately after their development, meadows and aquatic habitats will require several years to stabilize, while shrubland and treed habitat will require an even longer assessment period. Because almost no information on vegetation community development in reclaimed areas is available, it is currently not possible to predict community conditions at maturity based on one or several habitat features at an earlier stage of development. For example, it is currently not possible to predict using on one or several habitat features within 5 years of tree and shrub establishment that a deciduous-coniferous tree/shrub mix habitat will be sufficiently developed after 20-25 years of growth to meet the suggested standards for this habitat.

Although such predictive habitat evaluation is not yet possible, we have recommended milestone HSI values for the slower developing habitats, to permit the monitoring of habitat progression, the detection of deficiencies at an early date, and the implementation of necessary corrective measures to achieve certification by the final assessment date. Such milestone HSI values may also provide some flexibility into the certification process, allowing final assessment periods to be negotiated between the developer and regulatory agencies. (As more information on vegetation community development in reclamation areas becomes available, our ability to decrease the duration of the final assessment period will also improve.). Table 1 summarizes possible assessment milestones and final assessment dates and associated threshold HSI values for each reclamation habitat.

As discussed by Eccles et al. (1987), certification of wildlife habitat reclamation areas could involve several stages, linked to the successful establishment of landforms, water forms, soil bases and vegetation. In the development of a reclamation area for wildlife habitat, reclamation operations generally will involve four steps:

1. The establishment of the final landform for the area (this may involve recontouring or specialized development of the site to create specific types of landforms such a swales, ridges, or knob and kettle terrain);

2. The optional development of water forms (e.g., watercourses, wetlands and lake/ponds) to complement the landforms;

3. The establishment of a soil base that is compatible with the landforms and/or water forms within the reclamation area, and is capable of supporting the proposed plant communities for the habitat unit or reclamation area; and

4. Revegetation of each habitat unit and, if necessary, the development of special habitat features.

The first three steps are generally completed within a short-time period (e.g., several months to a year) following completion of the site development, and represent a major portion of the total reclamation costs and manpower requirements. The fourth task, revegetation, may require periods of up to 25-30 years before the vegetation community is well established. In a multi-staged certification process, partial certification of a site could be granted following successful reclamation of landforms, water forms and soils, as per the approved reclamation plan. The first stage of certification could involve a separate inspection and evaluation for each step (three in total) or a single inspection and evaluation for the three steps combined. Final certification would involve assessment and approval of the revegetation program. Because a multi-staged certification program may reduce the period of time in which a major portion of the reclamation security bond is retained by the government, such a program may make wildlife habitat reclamation more attractive to project proponents, and encourage project proponents to include more complex wildlife habitats (e.g., tree/shrub mix habitats, conifer habitats, cliff and talus habitats) in the reclamation plan.

Table 1. Suggested assessment periods and possible milestone HSI values for reclamation habitats.

Reclamation Habitat	Milestone Assessment Periods and Suggested HSI Values		Final Assessment Period and Suggested HSI Values[1]
	Milestone 1	Milestone 2	
Alpine Meadow	N/A	N/A	5 years
Upland Meadow	N/A	N/A	3 years
Lowland/Riparian Meadow	N/A	N/A	3 years
Upland Shrubland	4 years (HSI = 0.3)	N/A	7 years
Lowland/Riparian Shrubland	3 years (HSI = 0.3)	N/A	5 years
Shrub Meadow	N/A	N/A	3 years
Deciduous Tree/ Shrub Mix (beaver)	4 years (HSI = 0.3)	N/A	7 years
Deciduous Tree/ Shrub Mix (hare)	N/A	N/A	5 years
Deciduous-Coniferous Tree/Shrub Mix (elk/moose)	4 years (HSI = 0.3)	N/A	7 years
Deciduous-Coniferous Tree/Shrub Mix (hare)	N/A	N/A	5 years
Upland Coniferous Tree/Shrub Mix (ungulates, spruce grouse)	4 years (HSI = 0.3)	7 years (HSI = 0.4)	10 year
Upland Coniferous Tree/Shrub Mix (hare)	N/A	N/A	5 years
Lowland Coniferous Tree/Shrub Mix (moose)	4 years (HSI = 0.3)	N/A	7 years
Lowland Coniferous Tree/Shrub Mix (hare)	N/A	N/A	5 years
Watercourses (beaver)	(N.B. Suitable shrubland or treed habitat must be within 30 m of watercourse)		5 years
Watercourse (muskrat)	N/A	N/A	3 years
Wetland	N/A	N/A	3 years
Lake/Pond (muskrat/moose)	N/A	N/A	3 years
Lake/Pond (beaver)	(N.B. Suitable shrubland or treed habitat must be within 30 m of shoreline)		5 years
Cliff	N/A/	N/A	Immediately
Talus	N/A/	N/A/	Immediately

[1] For the purpose of this report, we have assumed that an HSI of 0.5 would be adequate for the final assessment.

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APPENDIX 1. Data Forms for the recording of on-site measurements of habitat features.

Data Form 1: Measurement of Tree Abundance and Composition

Part A: Transect Data. Measure length of transect line segments covered by individual tree canopies.

Transect 1				Transect 2			
Species	(1) Canopy start point (m)	(2) Canopy end point (m)	(3) Canopy length [(2)-(1)]	Species	(4) Canopy start point (m)	(5) Canopy end point (m)	(6) Canopy length [(5)-(4)]

Part B: Data Summary. Sum transect segment lengths (Columns (3) and (6) above) covered by designated species groups.

Species Groups	% (i.e., length) of transect covered by canopy (7) Transect 1	(8) Transect 2	(9) Total [(7)+(8)]	(10) Percent [(9)/2]
Poplar, aspen	____	____	____	____ Line 1
Pine, spruce	____	____	____	____ Line 2
All coniferous (pine, spruce, fir)	____	____	____	____ Line 3
Engelmann spruce/subalpine fir	____	____	____	____ Line 4
All species combined	____	____	____	____ Line 5

Data Form 2: Measurement of Shrub Abundance and Composition

Part A: Transect Data. Measure length of transect line segments covered by individual shrub canopies.

Transect 1				Transect 2			
Species	(1) Canopy start point (m)	(2) Canopy end point (m)	(3) Canopy length [(2)-(1)]	Species	(4) Canopy start point (m)	(5) Canopy end point (m)	(6) Canopy length [(5)-(4)]

Part B: Data Summary. Sum transect segment lengths (Columns (3) and (6) above) covered by designated species groups.

Species Groups	% (i.e., length) of transect covered by canopy (7) Transect 1	(8) Transect 2	(9) Total [(7)+(8)]	(10) Percent [(9)/2]	
Willows, saskatoon and red-osier dogwood	_____	_____	_____	_____	Line 1
Willows	_____	_____	_____	_____	Line 2
All species combined	_____	_____	_____	_____	Line 3

Data Form 3: Measurement of Shrub Canopy Height

Part A: Transect Data. At 5 m intervals along each transect, measure the height of the closest shrub. If no shrubs occur within 2.5 m of the reference point, enter N/A.

Transect 1		Transect 2	
Sampling Point	Shrub Height (m)	Sampling Point	Shrub Height (m)
1	________	1	________
2	________	2	________
3	________	3	________
4	________	4	________
5	________	5	________
6	________	6	________
7	________	7	________
8	________	8	________
9	________	9	________
10	________	10	________
11	________	11	________
12	________	12	________
13	________	13	________
14	________	14	________
15	________	15	________
16	________	16	________
17	________	17	________
18	________	18	________
19	________	19	________
20	________	20	________

Part B: Data Summary

Sum of shrub height ÷ number of shrubs measured (Transect 1)	________	Line 1
Sum of shrub height ÷ number of shrubs measured (Transect 2)	________	Line 2
Mean shrub height $\frac{\text{Line 1} + \text{Line 2}}{2}$	________	Line 3
2/3 of mean shrub height (Line 3 x 2/3)	________	Line 4

Data Form 4: Measurement of ground cover characteristics.

<u>Part A: Transect Data</u>. Measure ground cover of individual plant groups and unconsolidated rock within sampling plots established at 5 m intervals along each transect. For each plot, select the mid-point of the cover class which best represents the coverage of each plant group and unconsolidated rock. Recognized cover classes and mid-points are presented below:

cover class	<5%;	5-25%;	25-50%;	50-75%;	75-95%;	>95%
mid-point	2.5%;	15%;	37.5%;	67.5%;	85%;	97.5%

TRANSECT 1							TRANSECT 2						
Plot #	(1) Grass/ Sedge	(2) Forb	(3) Moss/ Lichen	(4) Low (<0.2 m) Shrub/Tree	(5) Horse-Tail	(6) Rock	Plot #	(7) Grass/ Sedge	(8) Forb	(9) Moss/ Lichen	(10) Low(<0.2m) Shrub/Tree	(11) Horse Tail	(12) Rock
1							1						
2							2						
3							3						
4							4						
5							5						
6							6						
7							7						
8							8						
9							9						
10							10						
11							11						
12							12						
13							13						
14							14						
15							15						
16							16						
17							17						
18							18						
19							19						
20							20						
TOTAL:							TOTAL:						
MEAN:							MEAN:						
(Mean = Total / 20)							(Mean = Total / 20)						

.... Data Form 4 continued

Data Form 4 concluded.

Part B: Data Summaries

1) Forage Abundance:
   - Transect 1: Add mean values from Columns 1-5 ________ Line 1
   - Transect 2: Add mean values from Columns 7-11 ________ Line 2
   - Average value: (Line 1 + Line 2) ÷ 2 ________ Line 3

2) Forage Composition
   - Transect 1: (Mean value from Column 1 ÷ Line 1) x 100% ________ Line 4
   - Transect 2: (Mean value from Column 7 ÷ Line 2) x 100% ________ Line 5
   - Average value: (Line 4 + Line 5) ÷2 ________ Line 6

3) Horsetail Abundance
   - Average value: (Mean value from Column 5 + mean value from Column 11) ÷ 2 ________ Line 7

4) Rock Cover (rock fragments must be > 0.5 m^3)
   - Average value: (Mean value from Column 6 + mean value from Column 12) ÷ 2 ________ Line 8

5) Abundance of Herbaceous Vegetation (Grasses/sedges, forbs, horsetails)
   - Transect 1: Add mean values from Columns 1, 2 and 5 ________ Line 9
   - Transect 2: Add mean values from Columns 7, 8 and 11 ________ Line 10
   - Average value: (Line 9 + Line 10) ÷ 2 ________ Line 11

6) Topographic Diversity
   - Maximum vertical relief of surface irregularities along Transect 1 ________ Line 12
   - Maximum vertical relief of surface irregularities along Transect 1 ________ Line 13
   - Average value: (Line 12 + Line 13) ÷ 2 ________ Line 14

Data Form 5: Measurement of watercourse characteristics.

Part A: Transect Data. -Measure mid-channel stream depths at 5 m intervals along 100 m long stream reach.
-Estimate bank characteristics (height/slope) at 5 m intervals along one shoreline of 100 m long stream reach.
-Record presence or absence of emergent vegetation (emergent band of at least 1 m in width) at 5 m intervals along one shoreline of 100 m long stream reach.

REACH 1				REACH 2			
Sampling Point	(1) Water Depth (m)	(2) Bank Height/ Slope (°)	(3) Abundance of Emergent Vegetation (Present (P) or Absent (A))	Sampling Point	(4) Water Depth (m)	(5) Bank Height/ Slope (°)	(6) Abundance of Emergent Vegetation (Present (P) or Absent (A))
1				1			
2				2			
3				3			
4				4			
5				5			
6				6			
7				7			
8				8			
9				9			
10				10			
11				11			
12				12			
13				13			
14				14			
15				15			
16				16			
17				17			
18				18			
19				19			
20				20			
TOTAL:	______	______	% Cover: ______	TOTAL:	______	______	% Cover ______
MEAN:	______	______	(i.e., % of sampling points with emergent vegetation)	MEAN:	______	______	(i.e., % of sampling points with emergent vegetation)
(Mean = Total / 20)				(Mean = Total / 20)			

Data Form 5 continued.....

Data Form 5......continued

Part B: Data Summaries

1) Water Depths:
   Average value: (Mean value for Column 1 + Mean value from Column 4) ÷ 2 _______ Line 1

2) Bank Height/Slope
   Average value: (Mean value from Column 2 + Mean value from Column 5) ÷ 2 _______ Line 2

3) Abundance of Emergent Vegetation
   Average value: (% cover from Column 3 + % cover from Column 6) ÷ 2 _______ Line 3

4) Stream Gradient
   Reach 1: Estimated gradient using contour information or clinometer _______ Line 4
   Reach 2: Estimated gradient using contour information or clinometer _______ Line 5
   Average value: (Line 4 + Line 5) ÷ 2 _______ Line 6

Data Form 6: Measurement of wetland characteristics.

Part A: Transect Data. -Measure 20 water depths at equally spaced intervals along each of the two major axes of the waterbody.
-Record presence or absence of submergent vegetation at 20 equally spaced intervals along each of the two major axes of the waterbody.

REACH 1			REACH 2		
Sampling Point	(1) Water Depth (m)	(2) Abundance of Emergent Vegetation (Present (P) or Absent (A))	Sampling Point	(3) Water Depth (m)	(4) Abundance of Emergent Vegetation [Present (P) or Absent (A)]
1			1		
2			2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
10			10		
11			11		
12			12		
13			13		
14			14		
15			15		
16			16		
17			17		
18			18		
19			19		
20			20		
	TOTAL: ______ MEAN: ______ (Mean = Total/20)	% Cover: ______ (i.e., % of sampling points with emergent vegetation)		TOTAL: ______ MEAN: ______ (Mean = Total/20)	% Cover ______ (i.e., % of sampling points with emergent vegetation)

Data Form 6 continued.....

Data Form 6.....continued

Part B: Data Summaries

1) Water Depths:
   Average value: (Mean value for Column 1 + Mean value from Column 3) ÷ 2 _______ Line 1

2) Abundance of Submergent Vegetation
   Average value: (Mean value from Column 2 + Mean value from Column 4) ÷ 2 _______ Line 2

3) Abundance of Emergent Vegetation
   Estimate emergent cover visually from vantage point or from recent air photos of the wetland _______ Line 3

Data Form 7: Measurement of lake/pond characteristics.

Part A: Transect Data. -Measure 20 water depths at equally spaced intervals along each of the two major axes of the waterbody.
-Record presence or absence of submergent vegetation at 20 equally spaced intervals along each of the two major axes of the waterbody.
-Estimate bank characteristics (height/slope) at 5 m intervals along 100 m long shoreline transects.
-Record presence or absence of emergent vegetation at 5 m intervals along 100 m long shoreline transects.

AXIS 1			SHORELINE TRANSECT 1		AXIS 2			SHORELINE TRANSECT 2	
Sample Points	(1) Water Depth (m)	(2) Abundance of Submerg. Veg. [Present (P) or Absent (A)]	(3) Bank Height/ slope	(4) Abundance of Emerg. Veg. [Present (P) or Absent (A)]	Sample Points	(5) Water Depth (m)	(6) Abundance of Submerg. Veg. [Present (P) or Absent (A)]	(7) Bank Height slope	(8) Abundance of Emerg. Veg. [Present (P) or Absent (A)]
1					1				
2					2				
3					3				
4					4				
5					5				
6					6				
7					7				
8					8				
9					9				
10					10				
11					11				
12					12				
13					13				
14					14				
15					15				
16					16				
17					17				
18					18				
19					19				
20					20				
TOTAL:	______	% Cover: ____	TOTAL: ____	% Cover______		TOTAL: ____	% Cover ____	TOTAL:____	% Cover ____
MEAN:	______	(i.e., % of sampling points with submerg-ent vegetation)	MEAN: ____	(i.e., % of sampling points with emergent vegetation)		MEAN: ____	(i.e., % of sampling points with submerg-ent vegetation)	MEAN: ____	(i.e.,.% of sampling points with emergent vegetation)

Data Form 7 continued.....

Data Form 7.....continued

Part B: Data Summaries

1) Water Depths:
   Average value: (Mean value for Column 1 + mean value from Column 5) ÷ 2 _______ Line 1

2) Abundance of Submergent Vegetation
   Average value: (Mean value from Column 2 + mean value from Column 6) ÷ 2 _______ Line 2

3) Bank Height/Slope
   Average value: (Mean value from Column 3 + mean value for Column 7) ÷ 2 _______ Line 3

4) Abundance of Emergent Vegetation
   Average value: (% cover from Column 4 + % cover from Column 8) ÷ 2 _______ Line 4
   (N.B. For smaller lakes/ponds, emergent cover can be estimated visually from vantage point adjacent to the waterbody or from recent air photos of the waterbody.)

5) Abundance of Waterlilies
   Visually estimate % of waterbody supporting waterlilies, either from a vantage point adjacent to the waterbody or from recent air photos of the waterbody _______ Line 5

Data Form 8: Measurement of Cliff Characteristics

Part A: Ledge/nest site availability

Measure ledge availability (m/1000m²) or nest site availability (#/1000m²) for sections of cliff face 100 m wide by 10 m high.

Section #	Ledge Availability (m/1000m²)	Nest site Availability (#/1000m²)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

TOTAL:

MEAN: _______ Line 1

(Mean = Total length of ledge / Number of cliff sections)

TOTAL:

MEAN: _______ Line 2

(Mean = Total number of nest sites / Number of cliff sections)

Part B: Physical Characteristics: Measure dominant height and slope of 100 m wide segments of cliff face

Segment #	Cliff Height (m)	Cliff Slope
1		
2		
3		
4		
TOTAL:	_____	_____
MEAN:	_____ Line 3	_____ Line 4

(Mean = Total ÷ # of cliff segments)

Part C: Aspect

1) Estimate dominant aspect of cliff face ______ Line 5

2) Estimate number of major aspects (i.e., occupying > 20% of total cliff area) ______ Line 6

Data Form 9 Measurement of Talus Characteristics

Part A: Size of Talus Fragments

-Estimate size (volume) of talus fragments encountered at 5 m intervals along a 100 m long transect, running horizontally 25 m upslope from the toe of the talus. Select mid-point of the size class which best represents the size of the fragment encountered. Recognized size classes and mid-points are presented below:

size class:	$<0.5\ m^3$	$0.5\text{-}1.0\ m^3$	$1.1\text{-}2.0\ m^3$	$>2.0\ m^3$
mid-point:	$0.25\ m^3$	$0.75\ m^3$	$1.5\ m^3$	$3.0\ m^3$

Sampling Point	Fragment Size (Volume m^3)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	______

TOTAL:

MEAN: ______ Line 1

(Mean = $\frac{\text{Total}}{20}$)

Part B: Talus Slope

-Estimate dominant slope of each 100 m wide talus segment, using contour information of the mine site or a clinometer.

Segment	Dominant Slope
1	
2	
3	
4	______

TOTAL:

MEAN: ______ Line 2

(Mean = $\frac{\text{Total}}{\text{\# of segments}}$)

APPENDIX 2. Detailed sampling procedures for slope and cliff height estimates (modified from Hays et al. 1981).

TRIGONOMETRIC HYPSOMETRY

Variable Estimated

Height of cliff face.

Description

A vantage point should be selected which is at least as far away as the height of the cliff being measured. From this vantage point, it must be possible to see both the top and the base of the cliff. From this point, one or more angles are measured from the horizontal to the cliff's top and base using a clinometer (see Figure 7). Next, the horizontal distance from the cliff to the vantage point must be measured by tape measure, pacing or Optical Range Finder. If the cliff is on a slope, it is possible to estimate the horizontal distance to the cliff by measuring the distance along the slope, plus the slope's angle from the horizontal. Calculations are shown in Figure 7.

If the clinometer used has a scale that reads percent slope, calculations can be avoided if the vantage point is exactly 100 m from the object. Under these conditions, the height is equal to the percent slope.

Accuracy

This technique is highly accurate. Measurements using hand held clinometers can be made to less than $\pm$ 3%. This degree of accuracy requires precise measurements of the distance from the vantage point to the cliff. Errors also increase for cliffs that are not vertical.

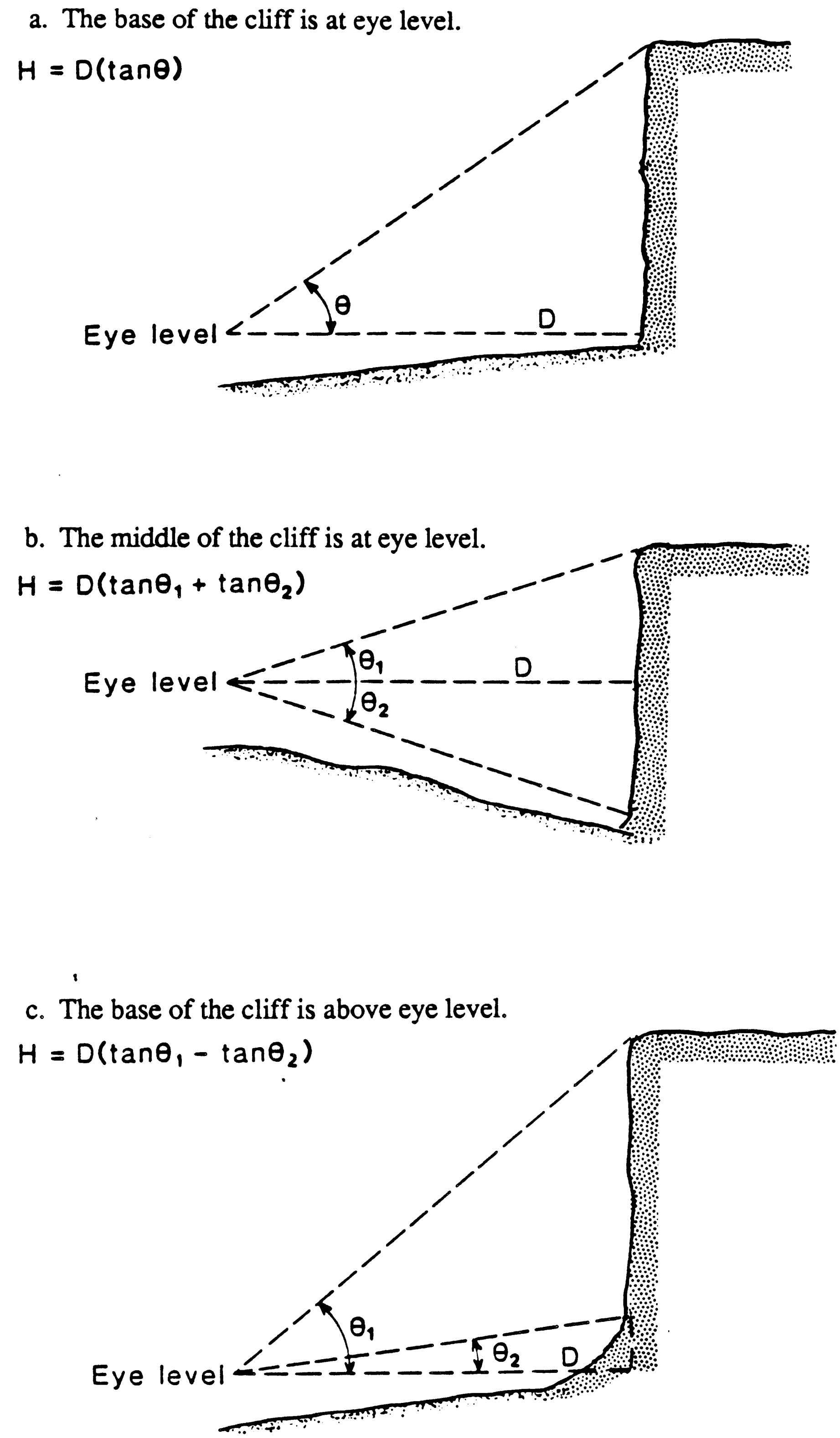


Figure 7. Estimating cliff height with Trigonometric Hypsometry (from Hays et al. 1981).

SLOPE (GRADIENT) AND ASPECT FROM TOPOGRAPHIC MAPS

Variables Estimated

Slope (gradient) and aspect.

Description

The location to be sampled must be selected and located on the topographic map. If this point falls precisely on top of a contour line, another point should be selected. If the point falls between contour lines that are farther than 2 to 3 mm apart, one can use a straight edge and rotate it slowly around the point until the shortest distance between the two contour lines is found. Measurements of the distance must be made so that no contour line is crossed (Figure 8). This distance is measured with a precise ruler and recorded. If aspect is desired, the direction of the straight edge should be converted to angular degrees using a protractor (Figure 8). When contour lines are close together, it is often desirable to use only the contours printed with a "heavier" or wider line (usually every fifth line).

Elevation between the contour lines is given as "contour interval" on the map. (If contour lines are close together, and one is using the heavier contour lines, the elevation difference is, of course, five times the stated contour interval.)

Slope is calculated by the following formulas:

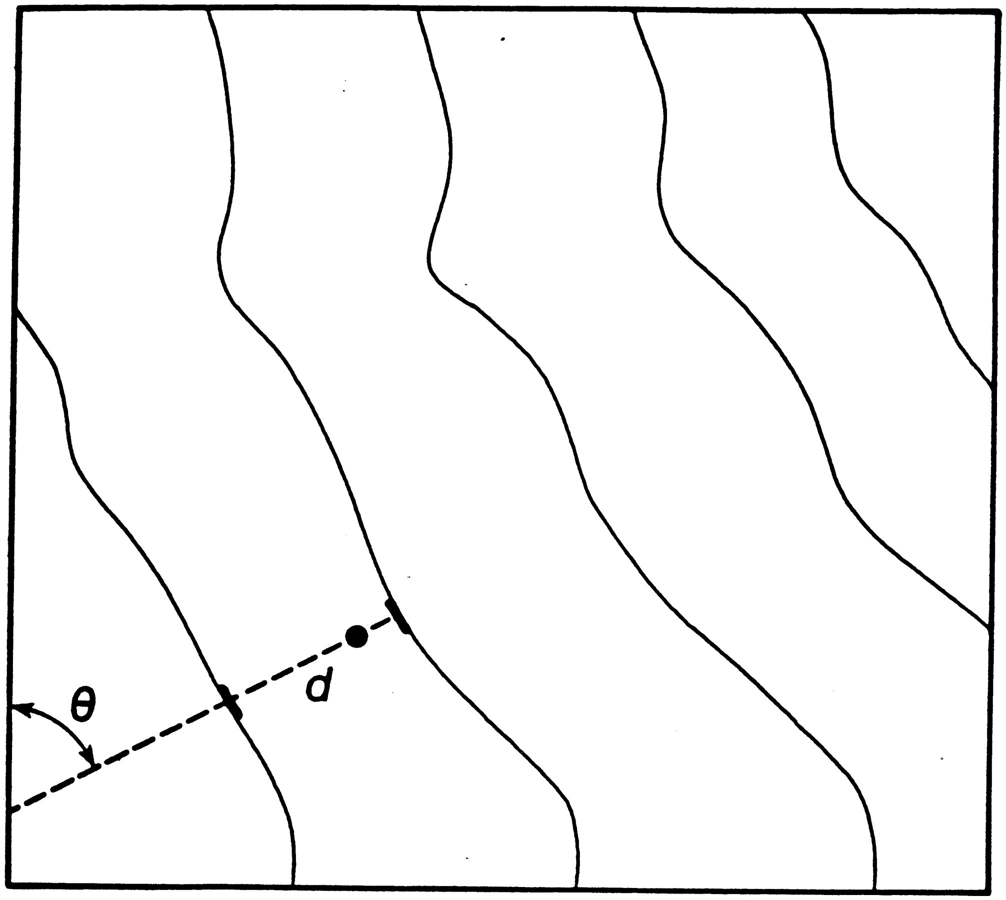
$$S = \frac{E\ m\ 100{,}000}{d} \quad \text{(metric)}$$

where S = slope (%)
E = difference in elevation on the ground between two points (m or ft)
m = the map scale (decimal fraction)
d = the distance on the map between the two points (mm or in)

If S is wanted in angular degrees, $S = \tan \frac{(S\%)}{100}$

Accuracy

This technique can be accurate if contour information is accurate. The technique introduces error if slope changes rapidly over the surface of the ground. Under these conditions, contour lines will clearly not parallel one another.



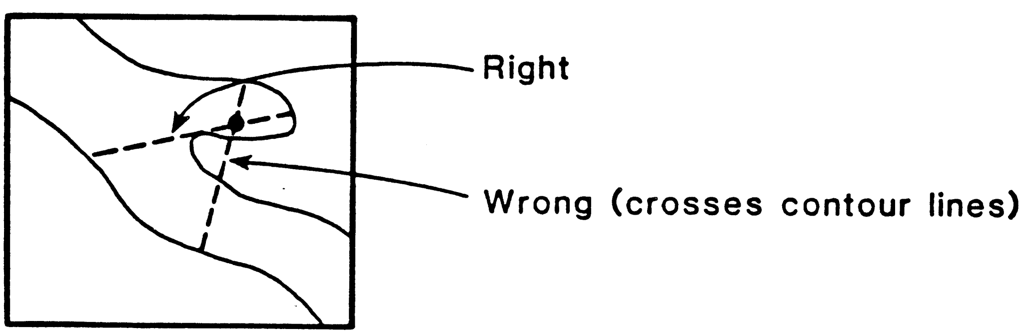


Figure 8. Estimating slope and aspect from topographic maps (d = measured distance between contour intervals on the map, 0 = angle from north)(from Hays et al. 1981).

CLINOMETER AND COMPASS

Variables Estimated

Slope (gradient) and aspect.

Description

From a randomly-selected sample point, two measuring locations should be identified, one directly down the aspect from the sampling point and the other directly above. Ideally, these locations should be approximately 60 m apart. Where visibility is restricted, or the slope angle changes rapidly, it may be necessary to use two locations that are closer together. One crew member holds a target at one of the sample points, and the other measures the angle of the target from the horizontal using the clinometer (Figure 9). The target should be a stick with a mark at the same height as the measuring crew member's eye level.

Aspect is measured with a compass, corrected for differences between magnetic north and true north.

Accuracy

Most clinometers can be read with a precision of approximately 1%, or 1°. Since slope is a statistical property that can usually be determined to only the nearest several percent or degrees due to the uneveness of the ground surface, it is not ordinarily meaningful to speak of accuracy at this level. Aspect can be measured to within $\pm$ 2° with most compasses.

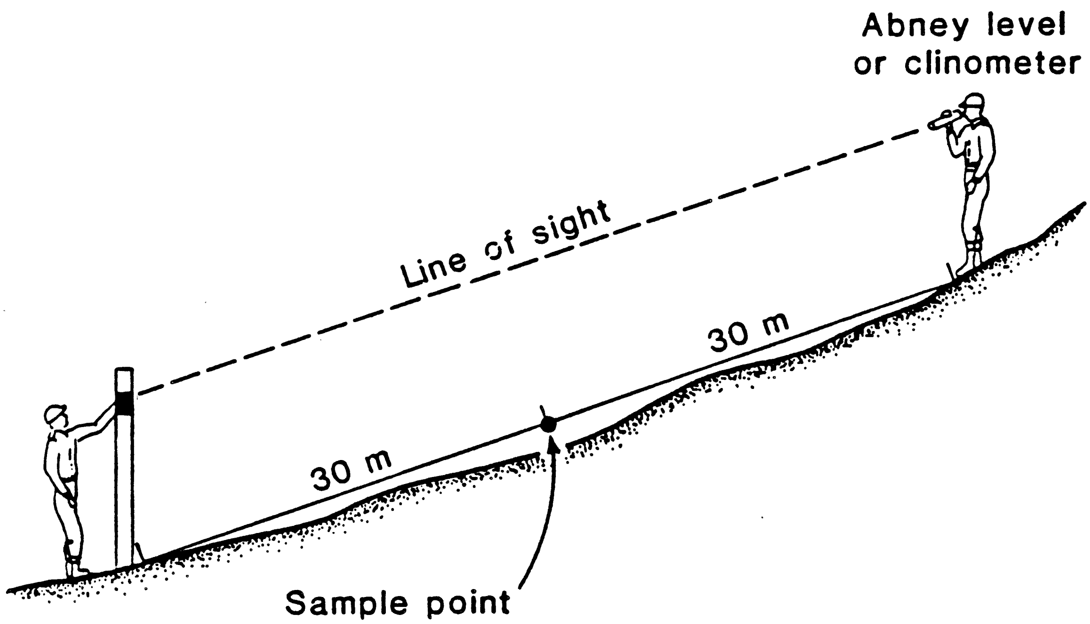


Figure 9. Measuring slope using a clinometer or Abney level. Aspect is measured over the same path using a compass (from Hays et al. 1981).

APPENDIX 3. Evaluation checksheets for the assessment of reclamation habitats.

Evaluation Checksheet 1a. Calculation of Habitat Suitability for Alpine Meadow Reclaimed for Bighorn Sheep or Mountain Goat.

Is total tree canopy cover 5% or less? (from Data Form 1)............. | |
Is total shrub canopy cover 10% or less? (from Data Form 2)........... | |

Proceed with the evaluation only if the answer to both of the above questions is YES.

Habitat Feature	Categories	Suitability Index (SI)
Forage Abundance: Determine combined ground cover of all herbaceous species and low (<0.5 m) shrubs from Data Form 4, and enter corresponding SI value from list opposite in Box 1.	<5%	N/A
	5-<25%	N/A
	25-<50%	0.5
	50-<75%	0.8
	75-<95%	1.0
	≥95%	1.0
	Enter SI value here:	1
Forage Composition: Determine percentage of total vegetative ground cover comprised of grasses and sedges from Data Form 4, and enter corresponding SI value from list opposite in Box 2.	<20%	N/A
	20-<40%	N/A
	40-<60%	0.5
	60-<80%	0.8
	≥80%	1.0
	Enter SI value here:	2
Topographic Diversity: Determine predominant topographic characteristics from Data Form 4, and enter corresponding SI value from list opposite in Box 3.	-flat/constant slope (<1 m variation in surface relief)	0.0
	-undulating (1-<2 m relief)	0.5
	-rolling (2-<5 m relief)	0.8
	-steeply rolling (≥5 m relief)	1.0
	Enter SI value here:	3

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 7 and do not proceed with the calculation).

Step 1: Multiply value in Box 1 by value in Box 2, and enter new value in Box 4.. | 4

Step 2: Multiply value in Box 3 by 0.2, and enter new value in Box 5.. | 5

Step 3: Add values in Boxes 4 and 5, and enter new value (HSI) in Box 6 (if >1.0, enter 1.0). Enter HSI value here: [ ] 6

Step 4: If alpine meadow is more than 250 m from certifiable talus or cliff habitat, enter value from Box 6 or 0.49, whichever is less, in Box 7. If within 250 m, enter value from Box 6. Enter final HSI value here: [ ] 7

Evaluation Checksheet 1b. Calculation of Habitat Suitability for Alpine Meadow Reclaimed for Caribou or Elk.

Is total tree canopy cover 5% or less? (from Data Form 1)..............| |
Is total shrub canopy cover 10% or less? (from Data Form 2)............| |

Proceed with the evaluation only if the answer to both of the above questions is YES.

Habitat Feature	Categories	Suitability Index (SI)
Forage Abundance: Determine combined ground cover of all herbaceous species and low (<0.5 m) shrubs from Data Form 4, and enter corresponding SI value from list opposite in Box 1.	<5%	N/A
	5-<25%	N/A
	25-<50%	0.5
	50-<75%	0.8
	75-<95%	1.0
	≥95%	1.0
	Enter SI value here:	1
Forage Composition: Determine percentage of total vegetative ground cover comprised of grasses and sedges from Data Form 4, and enter corresponding SI value from list opposite in Box 2.	<20%	N/A
	20-<40%	N/A
	40-<60%	0.8
	60-<80%	1.0
	≥80%	0.7
	Enter SI value here:	2
Topographic Diversity: Determine predominant topographic characteristics from Data Form 4, and enter corresponding SI value from list opposite in Box 3.	-flat/constant slope (<1 m variation in surface relief)	0.0
	-undulating (1-<2 m relief)	0.5
	-rolling (2-<5 m relief)	0.8
	-steeply rolling (≥5 m relief)	1.0
	Enter SI value here:	3

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 7 and do not proceed with the calculation).

<u>Step 1</u>: Multiply value in Box 1 by value in Box 2, and enter new value in Box 4..| 4

<u>Step 2</u>: Multiply value in Box 3 by 0.2, and enter new value in Box 5...| 5

<u>Step 3</u>: Add values in Boxes 4 and 5, and enter new value (HSI) in Box 6 (if >1.0, enter 1.0). Enter HSI value here: [ ] 6

<u>Step 4</u>: If alpine meadow is more than 250 m from certifiable shrubland habitat, enter value from Box 6 or 0.49, whichever is less, in Box 7. If within 250 m, enter value from Box 6. Enter final HSI value here: [ ] 7

Evaluation Checksheet 1c. Calculation of Habitat Suitability for Alpine Meadow Reclaimed for White-tailed Ptarmigan.

Is total tree canopy cover 5% or less? (from Data Form 1)............. | |
Is total shrub canopy cover 10% or less? (from Data Form 2)........... | |

Proceed with the evaluation only if the answer to both of the above questions is YES.

Habitat Feature	Categories	Suitability Index (SI)
Forage Abundance: Determine combined ground cover of all herbaceous species and low (<0.5 m) shrubs from Data Form 4, and enter corresponding SI value from list opposite in Box 1.	<5%	N/A
	5-<25%	N/A
	25-<50%	0.7
	50-<75%	1.0
	75-<95%	0.8
	≥95%	0.6
	Enter SI value here:	1
Forage Composition: Determine percentage of total vegetative ground cover comprised of grasses and sedges from Data Form 4, and enter corresponding SI value from list opposite in Box 2.	<20%	N/A
	20-<40%	N/A
	40-<60%	1.0
	60-<80%	0.8
	≥80%	0.5
	Enter SI value here:	2
Unconsolidated Rock Cover: Determine ground cover of unconsolidated rocks >0.5 m^3 in volume from Data Form 4, and enter corresponding SI value from list opposite in Box 3.	<5%	0.0
	5-<25%	0.8
	25-<50%	1.0
	50-<75%	0.7
	75-<95%	0.4
	≥95%	0.0
	Enter SI value here:	3

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 6 and do not proceed with the calculation).

<u>Step 1</u>: Multiply value in Box 1 by value in Box 2, and enter new value in Box 4... | 4

<u>Step 2</u>: Multiply value in Box 3 by 0.2, and enter new value in Box 5.. | 5

<u>Step 3</u>: Add values in Boxes 4 and 5, and enter new value (HSI) in Box 6 (if >1.0, enter 1.0). Enter HSI value here: | 6

Evaluation Checksheet 2a. Calculation of Habitat Suitability for Upland Meadow Reclaimed for Bighorn Sheep or Mountain Goat.

Is total tree canopy cover 5% or less? (from Data Form 1).............. | |
Is total shrub canopy cover 10% or less? (from Data Form 2)............ | |

Proceed with the evaluation only if the answer to both of the above questions is YES.

Habitat Feature	Categories	Suitability Index (SI)
Forage Abundance: Determine combined ground cover of all herbaceous species and low (<0.5 m) shrubs from Data Form 4, and enter corresponding SI value from list opposite in Box 1.	<5%	N/A
	5-<25%	N/A
	25-<50%	0.5
	50-<75%	0.7
	75-<95%	0.9
	≥95%	1.0
	Enter SI value here:	1
Forage Composition: Determine percentage of total vegetative ground cover comprised of grasses and sedges from Data Form 4, and enter corresponding SI value from list opposite in Box 2.	<20%	N/A
	20-<40%	N/A
	40-<60%	N/A
	60-<80%	0.7
	≥80%	1.0
	Enter SI value here:	2
Topographic Diversity: Determine predominant topographic characteristics from Data Form 4, and enter corresponding SI value from list opposite in Box 3.	-flat/constant slope (<1 m variation in surface relief)	0.0
	-undulating (1-<2 m relief)	0.5
	-rolling (2-<5 m relief)	0.8
	-steeply rolling (≥5 m relief)	1.0
	Enter SI value here:	3

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 7 and do not proceed with the calculation).

Step 1: Multiply value in Box 1 by value in Box 2, and enter new value in Box 4.. | 4

Step 2: Multiply value in Box 3 by 0.2, and enter new value in Box 5... | 5

Step 3: Add values in Boxes 4 and 5, and enter new value (HSI) in Box 6 (if >1.0, enter 1.0). Enter HSI value here: [ ] 6

Step 4: If upland meadow is more than 250 m from certifiable talus or cliff habitat, enter value from Box 6 or 0.49, whichever is less, in Box 7. If within 250 m, enter value from Box 6. Enter final HSI value here: [ ] 7

Evaluation Checksheet 2b. Calculation of Habitat Suitability for Upland Meadow Reclaimed for Caribou or Elk.

Is total tree canopy cover 5% or less? (from Data Form 1).............. | |
Is total shrub canopy cover 10% or less? (from Data Form 2)............ | |

Proceed with the evaluation only if the answer to both of the above questions is YES.

Habitat Feature	Categories	Suitability Index (SI)
Forage Abundance: Determine combined ground cover of all herbaceous species and low (<0.5 m) shrubs from Data Form 4, and enter corresponding SI value from list opposite in Box 1.	<5%	N/A
	5-<25%	N/A
	25-<50%	0.5
	50-<75%	0.7
	75-<95%	0.9
	≥95%	1.0
	Enter SI value here:	1
Forage Composition: Determine percentage of total vegetative ground cover comprised of grasses and sedges from Data Form 4, and enter corresponding SI value from list opposite in Box 2.	<20%	N/A
	20-<40%	N/A
	40-<60%	N/A
	60-<80%	1.0
	≥80%	0.7
	Enter SI value here:	2
Topographic Diversity: Determine predominant topographic characteristics from Data Form 4, and enter corresponding SI value from list opposite in Box 3.	-flat/constant slope (<1 m variation in surface relief)	0.0
	-undulating (1-<2 m relief)	0.5
	-rolling (2-<5 m relief)	0.8
	-steeply rolling (≥5 m relief)	1.0
	Enter SI value here:	3

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 7 and do not proceed with the calculation).

<u>Step 1</u>: Multiply value in Box 1 by value in Box 2, and enter new value in Box 4... | 4

<u>Step 2</u>: Multiply value in Box 3 by 0.2, and enter new value in Box 5... | 5

<u>Step 3</u>: Add values in Boxes 4 and 5, and enter new value (HSI) in Box 6 (if >1.0, enter 1.0). Enter HSI value here: [ ] 6

<u>Step 4</u>: If upland meadow is more than 250 m from certifiable shrubland or tree/shrub mix habitat, enter value from Box 6 or 0.49, whichever is less, in Box 7. If within 250 m, enter value from Box 6. Enter final HSI value here: [ ] 7

Evaluation Checksheet 3. Calculation of Habitat Suitability for Lowland/ Riparian Meadow Reclaimed for Caribou or Elk.

Is total tree canopy cover 5% or less? (from Data Form 1)..............| |
Is total shrub canopy cover 10% or less? (from Data Form 2)............| |

Proceed with the evaluation only if the answer to both of the above questions is YES.

Habitat Feature	Categories	Suitability Index (SI)
Forage Abundance: Determine combined ground cover of all herbaceous species and low (<0.5 m) shrubs from Data Form 4, and enter corresponding SI value from list opposite in Box 1.	<5%	N/A
	5-<25%	N/A
	25-<50%	0.5
	50-<75%	0.7
	75-<95%	0.9
	≥95%	1.0
	Enter SI value here:	| |1
Forage Composition: Determine percentage of total vegetative ground cover comprised of grasses and sedges from Data Form 4, and enter corresponding SI value from list opposite in Box 2.	<20%	N/A
	20-<40%	N/A
	40-<60%	N/A
	60-<80%	1.0
	≥80%	0.7
	Enter SI value here:	| |2
Horsetail Abundance: Determine ground cover of horsetails from Data Form 4, and enter corresponding SI value from list opposite in Box 3.	<5%	0.4
	5-<25%	1.0
	≥25%	0.7
	Enter SI value here:	| |3

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 7 and do not proceed with the calculation).

<u>Step 1</u>: Multiply value in Box 1 by value in Box 2, and enter new value in Box 4..| |4

<u>Step 2</u>: Multiply value in Box 3 by 0.2, and enter new value in Box 5..| |5

<u>Step 3</u>: Add values in Boxes 4 and 5, and enter new value (HSI) in Box 6 (if >1.0, enter 1.0). Enter HSI value here: [ ]6

<u>Step 4</u>: If lowland/riparian meadow is more than 250 m from certifiable shrubland or tree/shrub mix habitat, enter value from Box 6 or 0.49, whichever is less, in Box 7. If within 250 m, enter value from Box 6. Enter final HSI value here: [ ]7

Evaluation Checksheet 4a. Calculation of Habitat Suitability for Upland Shrubland Reclaimed for Elk or Moose.

Is total tree canopy cover 5% or less? (from Data Form 1).............| |

Proceed with the evaluation only if the answer to the above question is YES.

Habitat Feature	Categories	Suitability Index (SI)
Shrub Abundance: Determine percent canopy cover of shrubs (all species combined) from Column 10 on Data Form 2, and enter corresponding SI value from list opposite in Box 1.	<5%	N/A
	5-<25%	N/A
	25-<50%	0.7
	50-<75%	1.0
	75-<95%	0.9
	≥95%	0.7
	Enter SI value here:	| |1
Shrub Composition: Determine percentage of total shrub canopy cover comprised of browse species preferred by elk and moose (willow, red osier dogwood and saskatoon) from Data Form 2, and enter corresponding SI value from list opposite in Box 2.	<20%	0.2
	20-<40%	0.4
	40-<60%	0.6
	60-<80%	0.8
	≥80%	1.0
	Enter SI value here:	| |2
Shrub Canopy Height: Determine 2/3 of average shrub height (Line 4 on Data Form 3) and enter corresponding SI value from list opposite in Box 3.	<0.5 m	0.2
	0.5-<1.0 m	0.6
	1.0-<1.5 m	1.0
	1.5-<2.0 m	1.0
	2.0-<2.5 m	1.0
	2.5-<3.0 m	0.6
	≥3.0 m	0.2
	Enter SI value here:	| |3
Topographic Diversity: Determine predominant topographic characteristics from Data Form 4, and enter corresponding SI value from list opposite in Box 4.	-flat/constant slope (<1 m variation in surface relief)	0.0
	-undulating (1-<2 m relief)	0.5
	-rolling (2-<5 m relief)	0.8
	-steeply rolling (≥5 m relief)	1.0
	Enter SI value here:	| |4

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 10 and do not proceed with the calculation).

Step 1: Multiply value in Box 2 by 0.5, and enter new value in Box 5...| |5

Step 2: Multiply value in Box 3 by 0.5, and enter new value in Box 6...| |6

Step 3: Add values in Boxes 5 and 6, and enter new value in Box 7...| |7

Step 4: Multiply value in Box 1 by value in Box 7, and enter new value in Box 8..| |8

Step 5: Multiply value in Box 4 by 0.2, and enter new value in Box 9...| |9

Step 6: Add values in Boxes 8 and 9, and enter new value (HSI) in Box 10 (if >1.0, enter 1.0). Enter HSI value here: [ ]10

Evaluation Checksheet 4b. Calculation of Habitat Suitability for Upland Shrubland Reclaimed for Snowshoe Hare.

Is total tree canopy cover 5% or less? (from Data Form 1).............| |

Proceed with the evaluation only if the answer to the above question is YES.

Habitat Feature	Categories	Suitability Index (SI)
Shrub Abundance: Determine percent canopy cover of shrubs (all species combined) from Column 10 on Data Form 2, and enter corresponding SI value from list opposite in Box 1.	<5%	N/A
	5-<25%	N/A
	25-<50%	0.5
	50-<75%	0.7
	75-<95%	0.9
	≥95%	1.0
	Enter SI value here:	1
Shrub Canopy Height: Determine 2/3 of average shrub height (Line 4 on Data Form 3) and enter corresponding SI value from list opposite in Box 2.	<0.5 m	0.2
	0.5-<1.0 m	0.6
	1.0-<1.5 m	1.0
	1.5-<2.0 m	0.9
	2.0-<2.5 m	0.7
	2.5-<3.0 m	0.4
	≥3.0 m	0.2
	Enter SI value here:	2

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter X an in Box 3 and do not proceed with the calculation).

Multiply value in Box 1 by value in Box 2, and enter new value (HSI) in Box 3.

Enter HSI value here: [ ] 3

Evaluation Checksheet 4c. Calculation of Habitat Suitability for Upland Shrubland Reclaimed for White-tailed Ptarmigan.

Is total tree canopy cover 5% or less? (from Data Form 1)............. | |

Proceed with the evaluation only if the answer to the above question is YES.

Habitat Feature	Categories	Suitability Index (SI)
Shrub Abundance: Determine percent canopy cover of shrubs (all species combined) from Column 10 on Data Form 2, and enter corresponding SI value from list opposite in Box 1.	<5%	N/A
	5-<25%	N/A
	25-<50%	0.5
	50-<75%	0.7
	75-<95%	0.9
	≥95%	1.0
	Enter SI value here:	|1
Shrub Composition: Determine percentage of total shrub canopy cover comprised of browse species preferred by white-tailed ptarmigan (willows and rose) from Data Form 2, and enter corresponding SI value from list opposite in Box 2.	<20%	0.2
	20-<40%	0.4
	40-<60%	0.6
	60-<80%	0.8
	≥80%	1.0
	Enter SI value here:	|2
Shrub Canopy Height: Determine 2/3 of average shrub height (Line 4 on Data Form 3) and enter corresponding SI value from list opposite in Box 3.	<0.5 m	0.2
	0.5-<1.0 m	0.6
	1.0-<1.5 m	1.0
	1.5-<2.0 m	1.0
	2.0-<2.5 m	1.0
	2.5-<3.0 m	1.0
	≥3.0 m	1.0
	Enter SI value here:	|3

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 7 and do not proceed with the calculation).

<u>Step 1</u>: Multiply value in Box 2 by 0.5, and enter new value in Box 4.. | |4

<u>Step 2</u>: Multiply value in Box 3 by 0.5, and enter new value in Box 5.. | |5

<u>Step 3</u>: Add values in Boxes 4 and 5, and enter new value in Box 6.. | |6

<u>Step 4</u>: Multiply value in Box 1 by value in Box 6, and enter new value (HSI) in Box 7. Enter HSI value here: [ ]7

Evaluation Checksheet 5a. Calculation of Habitat Suitability for Lowland/ Riparian Shrubland Reclaimed for Beaver.

Is total tree canopy cover 5% or less? (from Data Form 1).............| |

Proceed with the evaluation only if the answer to the above question is YES.

Habitat Feature	Categories	Suitability Index (SI)
Shrub Abundance: Determine percent canopy cover of shrubs (all species combined) from Column 10 on Data Form 2, and enter corresponding SI value from list opposite in Box 1.	<5%	N/A
	5-<25%	N/A
	25-<50%	0.7
	50-<75%	1.0
	75-<95%	0.9
	≥95%	0.7
	Enter SI value here:	1
Shrub Canopy Height: Determine 2/3 of average shrub height (Line 4 on Data Form 3) and enter corresponding SI value from list opposite in Box 2.	<0.5 m	0.1
	0.5-<1.0 m	0.3
	1.0-<1.5 m	0.5
	1.5-<2.0 m	0.7
	2.0-<2.5 m	0.8
	2.5-<3.0 m	0.9
	≥3.0 m	1.0
	Enter SI value here:	2
Shrub Composition: Determine percentage of total shrub canopy cover comprised of browse species preferred by beaver (willows) from Data Form 2, and enter corresponding SI value from list opposite in Box 3.	<20%	0.2
	20-<40%	0.4
	40-<60%	0.6
	60-<80%	0.8
	≥80%	1.0
	Enter SI value here:	3

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 8 and do not proceed with the calculation).

Step 1: Multiply value in Box 1 by 0.5, and enter new value in Box 4...| 4

Step 2: Multiply value in Box 2 by 0.5, and enter new value in Box 5...| 5

Step 3: Add values in Boxes 4 and 5, and enter new value in Box 6...| 6

Step 4: Multiply value in Box 3 by value in Box 6, and enter new value (HSI) in Box 7. Enter HSI value here: [ ] 7

Step 5: If lowland/riparian shrubland is more than 30 m from certifiable watercourse or lake/pond, enter value from Box 7 or 0.49, whichever is less, in Box 8. If within 30 m, enter value from Box 7. Enter final HSI value here: [ ] 8

Evaluation Checksheet 5b. Calculation of Habitat Suitability for Lowland/ Riparian Shrubland Reclaimed for Moose.

Is total tree canopy cover 5% or less? (from Data Form 1)............. | |

Proceed with the evaluation only if the answer to the above question is YES.

Habitat Feature	Categories	Suitability Index (SI)
Shrub Abundance: Determine percent canopy cover of shrubs (all species combined) from Column 10 on Data Form 2, and enter corresponding SI value from list opposite in Box 1.	<5%	N/A
	5-<25%	N/A
	25-<50%	0.7
	50-<75%	1.0
	75-<95%	0.9
	≥95%	0.7
	Enter SI value here:	1
Shrub Composition: Determine percentage of total shrub canopy cover comprised of browse species preferred by moose (willow, red osier dogwood and saskatoon) from Data Form 2, and enter corresponding SI value from list opposite in Box 2.	<20%	0.2
	20-<40%	0.4
	40-<60%	0.6
	60-<80%	0.8
	≥80%	1.0
	Enter SI value here:	2
Shrub Canopy Height: Determine 2/3 of average shrub height (Line 4 on Data Form 3) and enter corresponding SI value from list opposite in Box 3.	<0.5 m	0.2
	0.5-<1.0 m	0.6
	1.0-<1.5 m	1.0
	1.5-<2.0 m	1.0
	2.0-<2.5 m	1.0
	2.5-<3.0 m	0.6
	≥3.0 m	0.2
	Enter SI value here:	3

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 7 and do not proceed with the calculation).

<u>Step 1</u>: Multiply value in Box 2 by 0.5, and enter new value in Box 4.. | 4

<u>Step 2</u>: Multiply value in Box 3 by 0.5, and enter new value in Box 5.. | 5

<u>Step 3</u>: Add values in Boxes 4 and 5, and enter new value in Box 6... | 6

<u>Step 4</u>: Multiply value in Box 1 by value in Box 6, and enter new value (HSI) in Box 7. Enter HSI value here: [ ] 7

Evaluation Checksheet 5c. Calculation of Habitat Suitability for Lowland/ Riparian Shrubland Reclaimed for Snowshoe Hare.

Is total tree canopy cover 5% or less? (from Data Form 1)........... | |

Proceed with the evaluation only if the answer to the above question is YES.

Habitat Feature	Categories	Suitability Index (SI)
Shrub Abundance: Determine percent canopy cover of shrubs (all species combined) from Column 10 on Data Form 2, and enter corresponding SI value from list opposite in Box 1.	<5%	N/A
	5-<25%	N/A
	25-<50%	0.5
	50-<75%	0.7
	75-<95%	0.9
	≥95%	1.0
	Enter SI value here:	1
Shrub Canopy Height: Determine 2/3 of average shrub height (Line 4 on Data Form 3) and enter corresponding SI value from list opposite in Box 2.	<0.5 m	0.2
	0.5-<1.0 m	0.6
	1.0-<1.5 m	1.0
	1.5-<2.0 m	0.9
	2.0-<2.5 m	0.7
	2.5-<3.0 m	0.4
	≥3.0 m	0.2
	Enter SI value here:	2

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 3 and do not proceed with the calculation).

Multiply value in Box 1 by value in Box 2, and enter new value (HSI) in Box 3. Enter HSI value here: [ ] 3

Evaluation Checksheet 6. Calculation of Habitat Suitability for Shrub Meadow Reclaimed for Elk.

Is total tree canopy cover 5% or less? (from Data Form 1).............| |

Proceed with the evaluation only if the answer to the above question is YES.

Habitat Feature	Categories	Suitability Index (SI)
Shrub Abundance: Determine percent canopy cover of shrubs (all species combined) from Column 10 on Data Form 2, and enter corresponding SI value from list opposite in Box 1.	<5%	N/A
	5-<25%	1.0
	25-<50%	N/A
	50-<75%	N/A
	75-<95%	N/A
	≥95%	N/A
	Enter SI value here:	|1
Shrub Composition: Determine percentage of total shrub canopy cover comprised of browse species preferred by elk (willow, red osier dogwood and saskatoon) from Data Form 2, and enter corresponding SI value from list opposite in Box 2.	<20%	0.2
	20-<40%	0.4
	40-<60%	0.6
	60-<80%	0.8
	≥80%	1.0
	Enter SI value here:	|2
Shrub Canopy Height: Determine 2/3 of average shrub height (Line 4 on Data Form 3) and enter corresponding SI value from list opposite in Box 3.	<0.5 m	0.2
	0.5-<1.0 m	0.6
	1.0-<1.5 m	1.0
	1.5-<2.0 m	1.0
	2.0-<2.5 m	1.0
	2.5-<3.0 m	0.6
	≥3.0 m	0.2
	Enter SI value here:	|3
Forage Abundance: Determine combined ground cover of all herbaceous species and low (<0.5 m) shrubs from Data Form 4, and enter corresponding SI value from list opposite in Box 4.	<5%	N/A
	5-<25%	N/A
	25-<50%	0.5
	50-<75%	0.7
	75-<95%	0.9
	≥95%	1.0
	Enter SI value here:	|4
Forage Composition: Determine percentage of total vegetative ground cover comprised of grasses and sedges from Data Form 4, and enter corresponding SI value from list opposite in Box 5.	<20%	N/A
	20-<40%	N/A
	40-<60%	N/A
	60-<80%	1.0
	≥80%	0.7
	Enter SI value here:	|5
Topographic Diversity: Determine predominant topographic characteristics from Data Form 4, and enter corresponding SI value from list opposite in Box 6.	-flat/constant slope (<1 m variation in surface relief)	0.0
	-undulating (1-<2 m relief)	0.5
	-rolling (2-<5 m relief)	0.8
	-steeply rolling (≥5 m relief)	1.0
	Enter SI value here:	|6

continued......

Evaluation Checksheet 6. Calculation of Habitat Suitability for Shrub Meadow Reclaimed for Elk (concluded).

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 7 and do not proceed with the calculation).

<u>Step 1</u>: Multiply value in Box 1 by 0.3, and enter new value in Box 7		7
<u>Step 2</u>: Multiply value in Box 2 by 0.5, and enter new value in Box 8		8
<u>Step 3</u>: Multiply value in Box 3 by 0.5, and enter new value in Box 9		9
<u>Step 4</u>: Add values in Boxes 8 and 9, and enter new value in Box 10		10
<u>Step 5</u>: Multiply value in Box 7 by value in Box 10, and enter new value in Box 11		11
<u>Step 6</u>: Multiply value in Box 4 by 0.7, and enter new value in Box 12		12
<u>Step 7</u>: Multiply value in Box 5 by value in Box 12, and enter new value in Box 13		13
<u>Step 8</u>: Multiply value in Box 6 by 0.2, and enter new value in Box 14		14
<u>Step 9</u>: Add values in Boxes 11, 13 and 14, and enter new value (HSI) in Box 15 (if >1.0, enter 1.0). Enter HSI value here:		15

Evaluation Checksheet 7a. Calculation of Habitat Suitability for Deciduous Tree/Shrub Mix Reclaimed for Beaver.

Does more than 80% of the total tree canopy cover consist of broad-leaved deciduous species? (from Data Form 1)................................| |

Proceed with the evaluation only if the answer to the above question is YES.

Habitat Feature	Categories	Suitability Index (SI)
Tree Abundance: Determine percent canopy cover of trees (all species combined) from Column 10 on Data Form 1, and enter corresponding SI value from list opposite in Box 1.	<5%	N/A
	5-<25%	0.4
	25-<50%	0.7
	50-<75%	1.0
	75-<95%	0.9
	≥95%	0.7
	Enter SI value here:	| |1
Tree Composition: Determine percentage of total tree canopy cover comprised of browse species preferred by beaver (aspen and balsam poplar) from Data Form 1, and enter corresponding SI value from list opposite in Box 2.	<20%	0.2
	20-<40%	0.4
	40-<60%	0.6
	60-<80%	0.8
	≥80%	1.0
	Enter SI value here:	| |2
Shrub Abundance: Determine percent canopy cover of shrubs (all species combined) from Column 10 on Data Form 2, and enter corresponding SI value from list opposite in Box 3.	<5%	0.0
	5-<25%	0.4
	25-<50%	0.7
	50-<75%	1.0
	75-<95%	0.9
	≥95%	0.7
	Enter SI value here:	| |3

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 7 and do not proceed with the calculation).

Step 1: Multiply value in Box 1 by value in Box 2, and enter new value in Box 4..| |4

Step 2: Multiply value in Box 3 by 0.2, and enter new value in Box 5..| |5

Step 3: Add values in Boxes 4 and 5, and enter new value (HSI) in Box 6 (if >1.0, enter 1.0). Enter HSI value here: [ ]6

Step 4: If deciduous tree/shrub mix is more than 30 m from certifiable watercourse or lake/pond, enter value from Box 6 or 0.49, whichever is less, in Box 7. If within 30 m, enter value from Box 6. Enter final HSI value here: [ ]7

Evaluation Checksheet 7b. Calculation of Habitat Suitability for Deciduous Tree/Shrub Mix Reclaimed for Snowshoe Hare.

Is total tree canopy cover greater than 5% ? (from Data Form 1)........| |
Does more than 80% of the total tree canopy cover consist of broad-leaved deciduous species? (from Data Form 1)................................| |

Proceed with the evaluation only if the answer to both of the above questions is YES.

Habitat Feature	Categories	Suitability Index (SI)
Shrub Abundance: Determine percent canopy cover of shrubs (all species combined) from Column 10 on Data Form 2, and enter corresponding SI value from list opposite in Box 1.	<5%	0.0
	5-<25%	0.3
	25-<50%	0.5
	50-<75%	0.7
	75-<95%	0.9
	≥95%	1.0
	Enter SI value here:	| |1
Shrub Canopy Height: Determine 2/3 of average shrub height (Line 4 on Data Form 3) and enter corresponding SI value from list opposite in Box 2.	<0.5 m	0.2
	0.5-<1.0 m	0.6
	1.0-<1.5 m	1.0
	1.5-<2.0 m	0.9
	2.0-<2.5 m	0.7
	2.5-<3.0 m	0.4
	≥3.0 m	0.2
	Enter SI value here:	| |2

Habitat Suitability Index:

Multiply value in Box 1 by value in Box 2, and enter new value (HSI) in Box 3. Enter HSI value here: [ ]3

Evaluation Checksheet 8a. Calculation of Habitat Suitability for Deciduous-Coniferous Tree/Shrub Mix Reclaimed for Elk or Moose.

Habitat Feature	Categories	Suitability Index (SI)
Tree Abundance: Determine percent canopy cover of trees (all species combined) from Column 10 on Data Form 1, and enter corresponding SI value from list opposite in Box 1.	<5%	N/A
	5-<25%	0.4
	25-<50%	0.7
	50-<75%	1.0
	75-<95%	0.9
	≥95%	0.7
	Enter SI value here:	1
Predominance of Conifers: Determine percentage of total tree canopy comprised of conifers from Data Form 1, and enter corresponding SI value from list opposite in Box 2.	<20%	N/A
	20-<40%	0.4
	40-<60%	0.7
	60-<80%	1.0
	≥80%	N/A
	Enter SI value here:	2
Shrub Abundance: Determine percent canopy cover of shrubs (all species combined) from Column 10 on Data Form 2, and enter corresponding SI value from list opposite in Box 3.	<5%	0.2
	5-<25%	0.4
	25-<50%	0.7
	50-<75%	1.0
	75-<95%	0.9
	≥95%	0.7
	Enter SI value here:	3

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 6 and do not proceed with the calculation).

Step 1: Multiply value in Box 1 by value in Box 2, and enter new value in Box 4.. 4

Step 2: Multiply value in Box 3 by 0.2, and enter new value in Box 5.. 5

Step 3: Add values in Boxes 4 and 5, and enter new value (HSI) in Box 6 (if >1.0, enter 1.0). Enter HSI value here: 6

Evaluation Checksheet 8b. Calculation of Habitat Suitability for Deciduous-Coniferous Tree/Shrub Mix Reclaimed for Snowshoe Hare.

Is total tree canopy cover greater than 5% ? (from Data Form 1)........| |
Do broad-leaved deciduous trees and coniferous trees both make up 20-80% of the total tree canopy cover? (from Data Form 1).............| |

Proceed with the evaluation only if the answer to both of the above questions is YES.

Habitat Feature	Categories	Suitability Index (SI)
Shrub Abundance: Determine percent canopy cover of shrubs (all species combined) from Column 10 on Data Form 2, and enter corresponding SI value from list opposite in Box 1.	<5%	0.0
	5-<25%	0.3
	25-<50%	0.5
	50-<75%	0.7
	75-<95%	0.9
	≥95%	1.0
	Enter SI value here:	1
Shrub Canopy Height: Determine 2/3 of average shrub height (Line 4 on Data Form 3) and enter corresponding SI value from list opposite in Box 2.	<0.5 m	0.2
	0.5-<1.0 m	0.6
	1.0-<1.5 m	1.0
	1.5-<2.0 m	0.9
	2.0-<2.5 m	0.7
	2.5-<3.0 m	0.4
	≥3.0 m	0.2
	Enter SI value here:	2

Habitat Suitability Index:

Multiply value in Box 1 by value in Box 2, and enter new value (HSI) in Box 3. Enter HSI value here: [ ] 3

Evaluation Checksheet 9a. Calculation of Habitat Suitability for Upland Coniferous Tree/Shrub Mix Reclaimed for Caribou.

Does more than 80% of the total tree canopy cover consist of coniferous species? (from Data Form 1)................................| |

Proceed with the evaluation only if the answer to the above question is YES.

Habitat Feature	Categories	Suitability Index (SI)
Tree Abundance: Determine percent canopy cover of trees (all species combined) from Column 10 on Data Form 1, and enter corresponding SI value from list opposite in Box 1.	<5%	N/A
	5-<25%	0.4
	25-<50%	0.7
	50-<75%	1.0
	75-<95%	0.9
	≥95%	0.7
	Enter SI value here:	|1
Successional Understory Abundance: Determine percentage of total tree canopy cover comprised of Engelmann spruce/subalpine fir from Data Form 1, and enter corresponding SI value from list opposite in Box 2.	<20%	0.4
	20-<40%	0.6
	40-<60%	0.8
	60-<80%	1.0
	≥80%	1.0
	Enter SI value here:	|2
Shrub Abundance: Determine percent canopy cover of shrubs (all species combined) from Column 10 on Data Form 2, and enter corresponding SI value from list opposite in Box 3.	<5%	0.2
	5-<25%	0.4
	25-<50%	0.7
	50-<75%	1.0
	75-<95%	0.9
	≥95%	0.7
	Enter SI value here:	|3

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 6 and do not proceed with the calculation).

<u>Step 1</u>: Multiply value in Box 1 by value in Box 2, and enter new value in Box 4...| |4

<u>Step 2</u>: Multiply value in Box 3 by 0.2, and enter new value in Box 5...| |5

<u>Step 3</u>: Add values in Boxes 4 and 5, and enter new value (HSI) in Box 6 (if >1.0, enter 1.0). Enter HSI value here: | |6

Evaluation Checksheet 9b. Calculation of Habitat Suitability for Upland Coniferous Tree/Shrub Mix Reclaimed for Elk or Moose.

Does more than 80% of the total tree canopy cover consist of coniferous species? (from Data Form 1)................................| |

Proceed with the evaluation only if the answer to the above question is YES.

Habitat Feature	Categories	Suitability Index (SI)
Tree Abundance: Determine percent canopy cover of trees (all species combined) from Column 10 on Data Form 1, and enter corresponding SI value from list opposite in Box 1.	<5%	N/A
	5-<25%	0.4
	25-<50%	0.7
	50-<75%	1.0
	75-<95%	0.9
	≥95%	0.7
	Enter SI value here:	| |1
Shrub Abundance: Determine percent canopy cover of shrubs (all species combined) from Column 10 on Data Form 2, and enter corresponding SI value from list opposite in Box 2.	<5%	0.2
	5-<25%	0.4
	25-<50%	0.7
	50-<75%	1.0
	75-<95%	0.9
	≥95%	0.7
	Enter SI value here:	| |2

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 4 and do not proceed with the calculation).

Step 1: Multiply value in Box 2 by 0.2, and enter new value in Box 3...| |3

Step 2: Add values in Boxes 1 and 3, and enter new value (HSI) in Box 4 (if >1.0, enter 1.0). Enter HSI value here: [ ]4

Evaluation Checksheet 9c. Calculation of Habitat Suitability for Upland Coniferous Tree/Shrub Mix Reclaimed for Snowshoe Hare.

Is total tree canopy cover greater than 5% ? (from Data Form 1)........| |
Does more than 80% of the total tree canopy cover consist of coniferous species? (from Data Form 1)................................| |

Proceed with the evaluation only if the answer to both of the above questions is YES.

Habitat Feature	Categories	Suitability Index (SI)
Shrub Abundance: Determine percent canopy cover of shrubs (all species combined) from Column 10 on Data Form 2, and enter corresponding SI value from list opposite in Box 1.	<5%	0.0
	5-<25%	0.3
	25-<50%	0.5
	50-<75%	0.7
	75-<95%	0.9
	≥95%	1.0
	Enter SI value here:	1
Shrub Canopy Height: Determine 2/3 of average shrub height (Line 4 on Data Form 3) and enter corresponding SI value from list opposite in Box 2.	<0.5 m	0.2
	0.5-<1.0 m	0.6
	1.0-<1.5 m	1.0
	1.5-<2.0 m	0.9
	2.0-<2.5 m	0.7
	2.5-<3.0 m	0.4
	≥3.0 m	0.2
	Enter SI value here:	2

Habitat Suitability Index:

Multiply value in Box 1 by value in Box 2, and enter new value (HSI) in Box 3. Enter HSI value here: [ ] 3

Evaluation Checksheet 9d. Calculation of Habitat Suitability for Upland Coniferous Tree/Shrub Mix Reclaimed for Spruce Grouse.

Does more than 80% of the total tree canopy cover consist of coniferous species? (from Data Form 1)................................| |

Proceed with the evaluation only if the answer to the above question is YES.

Habitat Feature	Categories	Suitability Index (SI)
Tree Abundance: Determine percent canopy cover of trees (all species combined) from Column 10 on Data Form 1, and enter corresponding SI value from list opposite in Box 1.	<5%	N/A
	5-<25%	0.4
	25-<50%	0.7
	50-<75%	1.0
	75-<95%	0.7
	≥95%	0.4
	Enter SI value here:	|1
Tree Composition: Determine percentage of total tree canopy cover comprised of browse species preferred by spruce grouse (lodgepole pine and white spruce) from Data Form 1, and enter corresponding SI value from list opposite in Box 2.	<20%	0.2
	20-<40%	0.4
	40-<60%	0.6
	60-<80%	0.8
	≥80%	1.0
	Enter SI value here:	|2
Shrub Abundance: Determine percent canopy cover of shrubs (all species combined) from Column 10 on Data Form 2, and enter corresponding SI value from list opposite in Box 3.	<5%	0.2
	5-<25%	0.6
	25-<50%	1.0
	50-<75%	0.6
	75-<95%	0.2
	≥95%	0.0
	Enter SI value here:	|3

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 6 and do not proceed with the calculation).

Step 1: Multiply value in Box 1 by value in Box 2, and enter new value in Box 4...| |4

Step 2: Multiply value in Box 3 by 0.2, and enter new value in Box 5...| |5

Step 3: Add values in Boxes 4 and 5, and enter new value (HSI) in Box 6 (if >1.0, enter 1.0). Enter HSI value here: [ ]6

Evaluation Checksheet 10a. Calculation of Habitat Suitability for Lowland Coniferous Tree/Shrub Mix (Muskeg) Reclaimed for Moose.

Does more than 80% of the total tree canopy cover consist of coniferous species or tamarack? (from Data Form 1)....................| |

Proceed with the evaluation only if the answer to the above question is YES.

Habitat Feature	Categories	Suitability Index (SI)
Tree Abundance: Determine percent canopy cover of trees (all species combined) from Column 10 on Data Form 1, and enter corresponding SI value from list opposite in Box 1.	<5%	N/A
	5-<25%	0.4
	25-<50%	0.7
	50-<75%	1.0
	75-<95%	0.9
	≥95%	0.7
	Enter SI value here:	|1
Shrub Abundance: Determine percent canopy cover of shrubs (all species combined) from Column 10 on Data Form 2, and enter corresponding SI value from list opposite in Box 2.	<5%	0.2
	5-<25%	0.4
	25-<50%	0.7
	50-<75%	1.0
	75-<95%	0.9
	≥95%	0.7
	Enter SI value here:	|2
Shrub Composition: Determine percentage of total shrub canopy cover comprised of browse species preferred by moose (willow, red osier dogwood and saskatoon) from Data Form 2, and enter corresponding SI value from list opposite in Box 3.	<20%	0.2
	20-<40%	0.4
	40-<60%	0.6
	60-<80%	0.8
	≥80%	1.0
	Enter SI value here:	|3
Shrub Canopy Height: Determine 2/3 of average shrub height (Line 4 on Data Form 3) and enter corresponding SI value from list opposite in Box 4.	<0.5 m	0.2
	0.5-<1.0 m	0.6
	1.0-<1.5 m	1.0
	1.5-<2.0 m	1.0
	2.0-<2.5 m	1.0
	2.5-<3.0 m	0.6
	≥3.0 m	0.3
	Enter SI value here:	|4
Forage Abundance: Determine combined ground cover of all herbaceous species and low (<0.5 m) shrubs from Data Form 4 and enter corresponding SI value from list opposite in Box 5.	<5%	0.2
	5-<25%	0.4
	25-<50%	0.6
	50-<75%	0.8
	75-<95%	1.0
	≥95%	1.0
	Enter SI value here:	|5

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 13 and do not proceed with the calculation).

<u>Step 1</u>: Multiply value in Box 1 by 0.3, and enter new value in Box 6..| |6

<u>Step 2</u>: Multiply value in Box 3 by 0.5, and enter new value in Box 7..| |7

<u>Step 3</u>: Multiply value in Box 4 by 0.5, and enter new value in Box 8..| |8

<u>Step 4</u>: Add values in Boxes 7 and 8, and enter new value in Box 9..| |9

<u>Step 5</u>: Multiply value in Box 2 by value in Box 9, and enter new value in Box 10..| |10

<u>Step 6</u>: Multiply value in Box 10 by 0.7, and enter new value in Box 11...| |11

<u>Step 7</u>: Multiply value in Box 5 by 0.2, and enter new value in Box 12...| |12

<u>Step 8</u>: Add values in Boxes 6, 11 and 12, and enter new value (HSI) in Box 13 (if >1.0, enter 1.0). Enter HSI value here: | |13

Evaluation Checksheet 10b. Calculation of Habitat Suitability for Lowland Coniferous Tree/Shrub Mix (Muskeg) Reclaimed for Snowshoe Hare.

Is total tree canopy cover greater than 5% ? (from Data Form 1)........| |
Does more than 80% of the total tree canopy cover consist of coniferous species or tamarack? (from Data Form 1).....................| |

Proceed with the evaluation only if the answer to both of the above questions is YES.

Habitat Feature	Categories	Suitability Index (SI)
Shrub Abundance: Determine percent canopy cover of shrubs (all species combined) from Column 10 on Data Form 2, and enter corresponding SI value from list opposite in Box 1.	<5%	0.0
	5-<25%	0.3
	25-<50%	0.5
	50-<75%	0.7
	75-<95%	0.9
	≥95%	1.0
	Enter SI value here:	| |1
Shrub Canopy Height: Determine 2/3 of average shrub height (Line 4 on Data Form 3) and enter corresponding SI value from list opposite in Box 2.	<0.5 m	0.2
	0.5-<1.0 m	0.6
	1.0-<1.5 m	1.0
	1.5-<2.0 m	0.9
	2.0-<2.5 m	0.7
	2.5-<3.0 m	0.4
	≥3.0 m	0.2
	Enter SI value here:	| |2

Habitat Suitability Index:

Multiply value in Box 1 by value in Box 2, and enter new value (HSI) in Box 3. Enter HSI value here: [ ]3

Evaluation Checksheet 11a. Calculation of Habitat Suitability for Watercourse Reclaimed for Beaver.

Habitat Feature	Categories	Suitability Index (SI)
Stream Gradient: Determine mean stream gradient from Line 6 on Data Form 5, and enter corresponding SI value from list opposite in Box 1.	<5%	1.0
	5-<10%	0.5
	≥10%	0.0
	Enter SI value here:	1
Water Depth: Determine mean water depth from Line 1 on Data Form 5, and enter corresponding SI value from list opposite in Box 2.	<0.5 m	0.2
	0.5-<1.0 m	0.5
	1.0-<1.5 m	1.0
	1.5-<2.0 m	1.0
	≥2.0 m	1.0
	Enter SI value here:	2
Bank Characteristics: Determine predominant bank height and slope from Line 2 on Data Form 5, and enter corresponding SI value from list opposite in Box 3.	<0.5 m and/or <15°	1.0
	0.5-<1.5 m and/or 15-<30°	0.8
	1.5-<2.5 m and/or 30-<45°	0.4
	≥2.5 m and/or ≥45°	0.2
	Enter SI value here:	3

Habitat Suitability Index:

Step 1: Multiply value in Box 2 by 0.5, and enter new value in Box 4.. 4

Step 2: Multiply value in Box 3 by 0.5, and enter new value in Box 5.. 5

Step 3: Add values in Boxes 4 and 5, and enter new value in Box 6.. 6

Step 4: Multiply value in Box 1 by value in Box 6, and enter new value (HSI) in Box 7. Enter HSI value here: 7

Step 5: If watercourse is more than 30 m from certifiable deciduous tree/shrub mix or shrubland habitat, enter value from Box 7 or 0.49, whichever is less, in Box 8. If within 30 m, enter value from Box 7. Enter final HSI value here: 8

Evaluation Checksheet 11b. Calculation of Habitat Suitability for Watercourse Reclaimed for Muskrat.

Habitat Feature	Categories	Suitability Index (SI)
Water Depth: Determine mean water depth from Line 1 on Data Form 5, and enter corresponding SI value from list opposite in Box 1.	<0.5 m	0.2
	0.5-<1.0 m	1.0
	1.0-<1.5 m	1.0
	1.5-<2.0 m	0.8
	≥2.0 m	0.5
	Enter SI value here:	1
Abundance of Emergent Vegetation: Determine percentage of shoreline supporting emergent vegetation from Line 3 on Data Form 5, and enter corresponding SI value from list opposite in Box 2.	<5%	0.0
	5-<25%	0.2
	25-<50%	0.5
	50-<75%	0.7
	75-<95%	0.9
	≥95%	1.0
	Enter SI value here:	2
Abundance of Herbaceous Terrestrial Vegetation: Determine combined ground cover of grasses, sedges and forbs within 10 m of shore from Data Form 4, and enter corresponding SI value from list opposite in Box 3.	<5%	0.2
	5-<25%	0.4
	25-<50%	0.6
	50-<75%	0.8
	75-<95%	1.0
	≥95%	1.0
	Enter SI value here:	3

Habitat Suitability Index:

Step 1: Multiply value in Box 1 by value in Box 2, and enter new value in Box 4.. 4

Step 2: Multiply value in Box 3 by 0.2, and enter new value in Box 5.. 5

Step 3: Add values in Boxes 4 and 5, and enter new value (HSI) in Box 6 (if >1.0, enter 1.0). Enter HSI value here: 6

Evaluation Checksheet 12. Calculation of Habitat Suitability for Wetland Reclaimed for Muskrat.

Habitat Feature	Categories	Suitability Index (SI)
Water Depth: Determine mean water depth from Line 1 on Data Form 6, and enter corresponding SI value from list opposite in Box 1.	<0.5 m	0.2
	0.5-<1.0 m	1.0
	1.0-<1.5 m	1.0
	1.5-<2.0 m	0.8
	≥2.0 m	0.5
	Enter SI value here:	1
Abundance of Emergent Vegetation: Determine percentage of wetland area covered by emergent vegetation from Line 3 on Data Form 6, and enter corresponding SI value from list opposite in Box 2.	<5%	0.2
	5-<25%	0.6
	25-<50%	1.0
	50-<75%	1.0
	75-<95%	0.6
	≥95%	0.2
	Enter SI value here:	2
Abundance of Submergent Vegetation: Determine percentage of wetland area supporting submergent vegetation from Line 2 on Data Form 6, and enter corresponding SI value from list opposite in Box 3.	<5%	0.2
	5-<25%	0.6
	25-<50%	1.0
	50-<75%	1.0
	75-<95%	0.6
	≥95%	0.2
	Enter SI value here:	3
Abundance of Herbaceous Terrestrial Vegetation: Determine combined ground cover of grasses, sedges and forbs within 10 m of shore from Data Form 4, and enter corresponding SI value from list opposite in Box 4.	<5%	0.2
	5-<25%	0.4
	25-<50%	0.6
	50-<75%	0.8
	75-<95%	1.0
	≥95%	1.0
	Enter SI value here:	4

Habitat Suitability Index:

<u>Step 1</u>:	Multiply value in Box 2 by 0.7, and enter new value in Box 5	5
<u>Step 2</u>:	Multiply value in Box 3 by 0.3, and enter new value in Box 6	6
<u>Step 3</u>:	Add values in Boxes 5 and 6, and enter new value in Box 7	7
<u>Step 4</u>:	Multiply value in Box 1 by value in Box 7, and enter new value in Box 8	8
<u>Step 5</u>:	Multiply value in Box 4 by 0.2, and enter new value in Box 9	9
<u>Step 6</u>:	Add values in Boxes 8 and 9, and enter new value (HSI) in Box 10 (if >1.0, enter 1.0). Enter HSI value here:	10

Evaluation Checksheet 13a. Calculation of Habitat Suitability for Lake/Pond Reclaimed for Moose.

Habitat Feature	Categories	Suitability Index (SI)
Abundance of Water Lilies: Determine percentage of waterbody area covered by water lilies from Line 5 on Data Form 7, and enter corresponding SI value from list opposite in Box 1.	<5%	0.2
	5-<25%	0.4
	25-<50%	0.6
	50-<75%	0.8
	75-<95%	1.0
	≥95%	1.0
	Enter SI value here:	[ ] 1

Habitat Suitability Index:

Enter value from Box 1 in Box 2 as HSI value. Enter HSI value here: [ ] 2

Evaluation Checksheet 13b. Calculation of Habitat Suitability for Lake/Pond Reclaimed for Beaver.

Habitat Feature	Categories	Suitability Index (SI)
Water Depth: Determine mean water depth from Line 1 on Data Form 7, and enter corresponding SI value from list opposite in Box 1. (If mean water depth is <1.0 m and no dammable outlet is present, enter 0.0 in Box 8 and do not proceed with evaluation.)	<0.5 m	0.2
	0.5-<1.0 m	0.5
	1.0-<1.5 m	1.0
	1.5-<2.0 m	1.0
	≥2.0 m	1.0
	Enter SI value here:	1
Bank Characteristics: Determine predominant bank height and slope from Line 3 on Data Form 7, and enter corresponding SI value from list opposite in Box 2.	<0.5 m and/or <15°	1.0
	0.5-<1.5 m and/or 15-<30°	0.8
	1.5-<2.5 m and/or 30-<45°	0.4
	≥2.5 m and/or ≥45°	0.2
	Enter SI value here:	2
Abundance of Water Lilies: Determine percentage of waterbody area covered by water lilies from Line 5 on Data Form 7, and enter corresponding SI value from list opposite in Box 3.	<5%	0.2
	5-<25%	0.4
	25-<50%	0.6
	50-<75%	0.8
	75-<95%	1.0
	≥95%	1.0
	Enter SI value here:	3

Habitat Suitability Index:

<u>Step 1</u>: Multiply value in Box 1 by 0.5, and enter new value in Box 4.. 4

<u>Step 2</u>: Multiply value in Box 2 by 0.5, and enter new value in Box 5.. 5

<u>Step 3</u>: Add values in Boxes 4 and 5, and enter new value in Box 6.. 6

<u>Step 4</u>: Multiply value in Box 3 by 0.2, and enter new value in Box 7.. 7

<u>Step 5</u>: Add values in Boxes 6 and 7, and enter new value (HSI) in Box 8 (if >1.0, enter 1.0). Enter HSI value here: 8

<u>Step 6</u>: If waterbody is more than 30 m from certifiable deciduous tree/shrub mix or shrubland habitat, enter value from Box 8 or 0.49, whichever is less, in Box 9. If within 30 m, enter value from Box 8. Enter final HSI value here: 9

Evaluation Checksheet 13c. Calculation of Habitat Suitability for Lake/Pond Reclaimed for Muskrat.

Habitat Feature	Categories	Suitability Index (SI)
Water Depth: Determine mean water depth from Line 1 on Data Form 7, and enter corresponding SI value from list opposite in Box 1.	<0.5 m	N/A
	0.5-<1.0 m	N/A
	1.0-<1.5 m	N/A
	1.5-<2.0 m	1.0
	≥2.0 m	0.5
	Enter SI value here:	1
Abundance of Emergent Vegetation: Determine percentage of shoreline supporting emergent vegetation from Line 4 on Data Form 7, and enter corresponding SI value from list opposite in Box 2.	<5%	0.0
	5-<25%	0.2
	25-<50%	0.5
	50-<75%	0.7
	75-<95%	0.9
	≥95%	1.0
	Enter SI value here:	2
Abundance of Submergent Vegetation: Determine percentage of waterbody area supporting submergent vegetation from Line 2 on Data Form 7, and enter corresponding SI value from list opposite in Box 3.	<5%	0.2
	5-<25%	0.6
	25-<50%	1.0
	50-<75%	1.0
	75-<95%	0.6
	≥95%	0.2
	Enter SI value here:	3
Abundance of Herbaceous Terrestrial Vegetation: Determine combined ground cover of grasses, sedges and forbs within 10 m of shore from Data Form 4, and enter corresponding SI value from list opposite in Box 4.	<5%	0.2
	5-<25%	0.4
	25-<50%	0.6
	50-<75%	0.8
	75-<95%	1.0
	≥95%	1.0
	Enter SI value here:	4

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 10 and do not proceed with the calculation).

Step 1: Multiply value in Box 2 by 0.7, and enter new value in Box 5.. | 5

Step 2: Multiply value in Box 3 by 0.3, and enter new value in Box 6.. | 6

Step 3: Add values in Boxes 5 and 6, and enter new value in Box 7.. | 7

Step 4: Multiply value in Box 1 by value in Box 7, and enter new value in Box 8.. | 8

Step 5: Multiply value in Box 4 by 0.2, and enter new value in Box 9.. | 9

Step 6: Add values in Boxes 8 and 9, and enter new value (HSI) in Box 10 (if >1.0, enter 1.0). Enter HSI value here: [ ] 10

Evaluation Checksheet 14a. Calculation of Habitat Suitability for Cliffs Reclaimed for Bighorn Sheep.

Habitat Feature	Categories	Suitability Index (SI)
Ledge Availability: Determine length of accessible ledges from Data Form 8, and enter corresponding SI value from list opposite in Box 1.	0 m	0.0
	$>$0-$<$20 m	0.2
	20-$<$40 m	0.4
	40-$<$60 m	0.6
	60-$<$80 m	0.8
	$\geq$80 m	1.0
	Enter SI value here:	[ ] 1
Cliff Height: Determine cliff height from Data Form 8, and enter corresponding SI value from list opposite in Box 2.	$<$8 m	N/A
	8-$<$15 m	0.5
	15-$<$25 m	0.8
	$\geq$25 m	1.0
	Enter SI value here:	[ ] 2
Cliff Slope: Determine average cliff slope from Data Form 8, and enter corresponding SI value from list opposite in Box 3.	$<$50°	N/A
	50-$<$60°	0.5
	60-$<$70°	1.0
	70-$<$80°	0.8
	$\geq$80°	0.6
	Enter SI value here:	[ ] 3
Cliff Face Configuration: Determine cliff face configuration from Data Form 8, and enter corresponding SI value from list opposite in Box 4.	1	0.5
	2	0.8
	$\geq$3	1.0
	Enter SI value here:	[ ] 4
Dominant Aspect: Determine dominant aspect of cliff face from Data Form 8, and enter corresponding SI value from list opposite in Box 5.	N	0.0
	NE	0.0
	E	0.3
	SE	0.7
	S	1.0
	SW	1.0
	W	0.5
	NW	0.3
	Enter SI value here:	[ ] 5

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 12 and do not proceed with the calculation).

<u>Step 1</u>: Multiply value in Box 1 by 0.35, and enter new value in Box 6.. [ ] 6

<u>Step 2</u>: Multiply value in Box 2 by 0.25, and enter new value in Box 7.. [ ] 7

<u>Step 3</u>: Multiply value in Box 3 by 0.25, and enter new value in Box 8.. [ ] 8

<u>Step 4</u>: Multiply value in Box 4 by 0.15, and enter new value in Box 9.. [ ] 9

<u>Step 5</u>: Multiply value in Box 5 by 0.20, and enter new value in Box 10.. [ ] 10

<u>Step 6</u>: Add values in Boxes 6, 7, 8, 9 and 10, and enter new value (HSI) in Box 11 (if $>$1.0, enter 1.0). Enter HSI value here: [ ] 11

<u>Step 7</u>: If part of the cliff base is not adjacent to certifiable meadow or water-based habitat, enter value from Box 11 or 0.49, whichever is less, in Box 12. If adjacent to suitable habitat, enter value from Box 11. Enter final HSI value here: [ ] 12

Evaluation Checksheet 14b. Calculation of Habitat Suitability for Cliffs Reclaimed for Mountain Goat.

Habitat Feature	Categories	Suitability Index (SI)
Ledge Availability: Determine length of accessible ledges from Data Form 8, and enter corresponding SI value from list opposite in Box 1.	0 m	0.0
	>0-<20 m	0.2
	20-<40 m	0.4
	40-<60 m	0.6
	60-<80 m	0.8
	≥80 m	1.0
	Enter SI value here:	1
Cliff Height: Determine cliff height from Data Form 8, and enter corresponding SI value from list opposite in Box 2.	<8 m	N/A
	8-<15 m	0.5
	15-<25 m	0.8
	≥25 m	1.0
	Enter SI value here:	2
Cliff Slope: Determine average cliff slope from Data Form 8, and enter corresponding SI value from list opposite in Box 3.	<50°	N/A
	50-<60°	0.4
	60-<70°	0.8
	70-<80°	1.0
	≥80°	0.7
	Enter SI value here:	3
Cliff Face Configuration: Determine cliff face configuration from Data Form 8, and enter corresponding SI value from list opposite in Box 4.	1	0.5
	2	0.8
	≥3	1.0
	Enter SI value here:	4
Dominant Aspect: Determine dominant aspect of cliff face from Data Form 8, and enter corresponding SI value from list opposite in Box 5.	N	0.0
	NE	0.0
	E	0.3
	SE	0.7
	S	1.0
	SW	1.0
	W	0.5
	NW	0.3
	Enter SI value here:	5

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 12 and do not proceed with the calculation).

Step 1: Multiply value in Box 1 by 0.35, and enter new value in Box 6 6

Step 2: Multiply value in Box 2 by 0.25, and enter new value in Box 7 7

Step 3: Multiply value in Box 3 by 0.25, and enter new value in Box 8 8

Step 4: Multiply value in Box 4 by 0.15, and enter new value in Box 9 9

Step 5: Multiply value in Box 5 by 0.20, and enter new value in Box 10 10

Step 6: Add values in Boxes 6, 7, 8, 9 and 10, and enter new value (HSI) in Box 11 (if >1.0, enter 1.0). Enter HSI value here: [ ] 11

Step 7: If part of the cliff base is not adjacent to certifiable meadow or water-based habitat, enter value from Box 11 or 0.49, whichever is less, in Box 12. If adjacent to suitable habitat, enter value from Box 11. Enter final HSI value here: [ ] 12

Evaluation Checksheet 14c. Calculation of Habitat Suitability for Cliffs Reclaimed for Golden Eagle.

Habitat Feature	Categories	Suitability Index (SI)
Nest Site Availability: Determine number of ledges and holes available as nest sites from Data Form 8, and enter corresponding SI value from list opposite in Box 1.	0	0.0
	1-2	0.2
	3-4	0.4
	5-6	0.6
	7-8	0.8
	8-9	1.0
	>9	0.5
	Enter SI value here:	1
Cliff Height: Determine cliff height from Data Form 8, and enter corresponding SI value from list opposite in Box 2.	<8 m	N/A
	8-<15 m	0.5
	15-<25 m	0.8
	≥25 m	1.0
	Enter SI value here:	2
Cliff Slope: Determine average cliff slope from Data Form 8, and enter corresponding SI value from list opposite in Box 3.	<50°	N/A
	50-<60°	0.4
	60-<70°	0.6
	70-<80°	0.8
	≥80°	1.0
	Enter SI value here:	3
Cliff Face Configuration: Determine cliff face configuration from Data Form 8, and enter corresponding SI value from list opposite in Box 4.	1	0.5
	2	0.8
	≥3	1.0
	Enter SI value here:	4
Dominant Aspect: Determine dominant aspect of cliff face from Data Form 8, and enter corresponding SI value from list opposite in Box 5.	N	0.0
	NE	0.0
	E	0.3
	SE	0.7
	S	1.0
	SW	1.0
	W	0.5
	NW	0.3
	Enter SI value here:	5

Habitat Suitability Index: (N.B. If the SI value in any box above is listed as N/A, enter an X in Box 12 and do not proceed with the calculation).

<u>Step 1</u>: Multiply value in Box 1 by 0.35, and enter new value in Box 6.. | 6

<u>Step 2</u>: Multiply value in Box 2 by 0.25, and enter new value in Box 7.. | 7

<u>Step 3</u>: Multiply value in Box 3 by 0.25, and enter new value in Box 8.. | 8

<u>Step 4</u>: Multiply value in Box 4 by 0.15, and enter new value in Box 9.. | 9

<u>Step 5</u>: Multiply value in Box 5 by 0.20, and enter new value in Box 10.. | 10

<u>Step 6</u>: Add values in Boxes 6, 7, 8, 9 and 10, and enter new value (HSI) in Box 11 (if >1.0, enter 1.0). Enter HSI value here: [ ] 11

<u>Step 7</u>: If part of the cliff base is not adjacent to certifiable meadow habitat, enter value from Box 11 or 0.49, whichever is less, in Box 12. If adjacent to suitable habitat, enter value from Box 11. Enter final HSI value here: [ ] 12

Evaluation Checksheet 15a. Calculation of Habitat Suitability for Talus Reclaimed for Bighorn Sheep or Mountain Goat.

Habitat Feature	Categories	Suitability Index (SI)
Size of Talus Fragments. Determine average size of talus fragments from Data Form 9, and enter corresponding SI value from list opposite in Box 1.	<0.5 m3	0.5
	0.5-<1.0 m3	0.7
	1.0-<2.0 m3	0.9
	≥2.0 m3	1.0
	Enter SI value here:	1
Talus Slope: Determine average slope of talus pile from Data Form 9, and enter corresponding SI value from list opposite in Box 2.	<10°	0.0
	10-<20°	0.6
	20-<30°	0.8
	30-<40°	1.0
	40-<50°	0.7
	≥50°	0.4
	Enter SI value here:	2

Habitat Suitability Index:

Step 1: Multiply value in Box 1 by 0.5, and enter new value in Box 3... 3

Step 2: Multiply value in Box 2 by 0.5, and enter new value in Box 4... 4

Step 3: Add values in Boxes 3 and 4, and enter new value (HSI) in Box 5... 5

Step 4: If part of the talus is not adjacent to certifiable meadow or water-based habitat, enter value from Box 5 or 0.49, whichever is less, in Box 6. If adjacent to suitable habitat, enter value from Box 5. Enter final HSI value here: 6

Evaluation Checksheet 15b. Calculation of Habitat Suitability for Talus Reclaimed for White-tailed Ptarmigan.

Habitat Feature	Categories	Suitability Index (SI)
Size of Talus Fragments. Determine average size of talus fragments from Data Form 9, and enter corresponding SI value from list opposite in Box 1.	<0.5 m3	0.4
	0.5-<1.0 m3	1.0
	1.0-<2.0 m3	0.8
	≥2.0 m3	0.5
	Enter SI value here:	1
Talus Slope: Determine average slope of talus pile from Data Form 9, and enter corresponding SI value from list opposite in Box 2.	<10°	0.0
	10-<20°	0.6
	20-<30°	0.8
	30-<40°	1.0
	40-<50°	0.7
	≥50°	0.4
	Enter SI value here:	2

Habitat Suitability Index:

Step 1: Multiply value in Box 1 by 0.7, and enter new value in Box 3 3

Step 2: Multiply value in Box 2 by 0.3, and enter new value in Box 4 4

Step 3: Add values in Boxes 3 and 4, and enter new value (HSI) in Box 5 5

Step 4: If part of the talus is not adjacent to certifiable meadow or water-based habitat, enter value from Box 5 or 0.49, whichever is less, in Box 6. If adjacent to suitable habitat, enter value from Box 5. Enter final HSI value here: 6