

BIOPHYSICAL LAND CLASSIFICATION OF BANFF AND JASPER NATIONAL PARKS

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ABSTRACT

The Banff-Jasper biophysical team accepts the basic concepts of a biophysical land classification system. Modifications to existing biophysical inventory methodology are described, including problems with classification methodology, and recommendations. Four appendices describe operational methodology, results to-date, user contact and anticipated applications, and problem areas.

RÉSUMÉ

L'équipe biophysique des parcs de Banff et Jasper accepte les concepts fondamentaux d'un système de classification écologique du territoire. Le présent document explique les modifications apportées à la méthodologie existante l'inventaire biophysique, y compris les problèmes relatifs à la méthodologie de la classification et les recommandations. Quatre annexes décrivent la méthodologie opérationnelle, les résultats obtenus jusqu'ici, les contacts avec les usagers, les applications prévues et les domaines à problèmes.

INTRODUCTION

At the request of Parks Canada in 1973, a biophysical land classification was planned, in 1974, for Banff and Jasper National Parks and initiated by field activities in the Mt. Eisenhower-Lake Louise area of Banff National Park. The methodology of Lacate (1969) was adopted for trial. Field work was initiated in Jasper in 1975, and continued in Banff, with Lacate's methodology being modified and developed as described in this paper.

Detailed objectives of the Banff-Jasper inventory project are provided by Day *et al.* (1975) and reiterated in Progress Report No. 1 by Holland *et al.* (1975). The objectives of the project may be summarized as follows:

- 1) To quantitatively and qualitatively describe the landforms, soils and vegetation characteristics of both Parks - in map and report form.
- 2) To provide interpretation of data for Parks' purposes; eg. land use planning and management of land within the Parks.

The terms of reference (Day *et al.* 1975)

thoroughly outlines the basic data requirements in terms of a multi-disciplinary team approach to integrated resource inventory; thus, the adoption of a biophysical land classification system. They also provide for the inclusion of landform classification (Fulton *et al.* 1974); soil classification (Canada Soil Survey Committee 1970, 1973, 1974); wetlands classification (Zoltai *et al.* 1975); vegetation resource description and classification; wildlife resources. User requirements are described. Freedom is provided, however, to permit development of integrated land classification methodology; for example, in the vegetation component of the inventory and as dictated by the scale of 1:50,000.

The main emphasis of this paper is on the classification methodology that is being used in Banff-Jasper and the development of the methodology, logistics, problems, etc. is presented in four Appendices to this paper.

CLASSIFICATION METHODOLOGY

A. Background - The basic concept or aim of biophysical land classification--namely, "to

differentiate and classify ecologically significant segments of the land surface" (Lacate 1969)--is valid and quite acceptable. The hierarchical levels of generalization (Lacate 1969, Jurdant *et al.* 1975) also have merit but problems in applying them in the Banff-Jasper Land Inventory Project arise for the following reasons:

1. Flexibility of application designed into definitions (Zoltai 1970) promotes somewhat variable interpretations of the various classification levels between team members.

2. Variability of mountain terrain and environments is a main problem area. In particular, vertical zonation, produced by altitudinal macro-climates, necessitates more complex and areally smaller separations at highest levels of generalization than have been recognized in several other projects across Canada.

3. The approximate scales as established by Lacate (1969) for a hierarchical biophysical system are not entirely adequate in the mountains and do not include the required project scale of 1:50,000.

4. Many ecologists feel that there is insufficient collection of basic environmental data in biophysical inventory projects. These data are generally not available but are necessary to explain ecological relationships and will add integrity to most interpretations. For the most part, these relationships are now explained by hypotheses. In addition, vegetation scientists desire, in biophysical classification systems, more meaningful hierarchical structure in terms of *ecological significance*. Consequently, modification and refinement of land classification concepts to-date have resulted in the Banff-Jasper Biophysical Land Classification System as presented in the following section.

B. Banff-Jasper Biophysical Land Classification System (Table 1) - Table 1 presents a breakdown (hierarchical levels of generalization) of the biophysical land classification system being used, and proposed for use, in Banff and Jasper National Parks. Levels 1, 2, 4 and 5 are presently operational (e.g. Lake Louise Study Area, Walker *et al.* 1976). Level 3 is presently under consideration as a means of grouping, at an intermediate hierarchical level, those Land Systems that have apparently similar environments.

The general objective of this system is to promote holistic, repeating, map unit concepts through integration of landscape components (landform, soil, and vegetation) within an

ecologically sound framework.

1. *Bioclimate Zone* (Level 1) constitutes the highest level of abstraction in the Banff-Jasper Biophysical Land Classification System. Separations at this level depict macro-climates, as expressed by vegetation, that are controlled mainly by elevation and partly by latitude and general east-west physiography.

2. *Bioclimate Subzone* (Level 2) identifies subdivisions of macro-climate based primarily on elevation differences as reflected by vegetation. For example, Upper Subalpine encompasses Subalpine vegetation types (usually spruce/fir forests) that reflect, in this structure and species composition, near-Alpine conditions.

3. *Vegetation-Soil 'District'* (Level 3) is under consideration as an intermediate step for differentiating various environmental 'facies' within some of the more broadly defined Bioclimate Subzones. The basic concept for Level 3 was initiated when biophysical map units comprising the Lake Louise Study Area (Walker *et al.* 1976) were grouped for purposes of relating soil and vegetation development to inferred climatic trends existing in that area (see Figure 1). It is felt that adoption of this step for the overall inventory (1:50,000 scale) will add ecological integrity to the Banff-Jasper Biophysical Land Classification System. It must be pointed out, however, that the 'Districts' listed in Level 3 (Table 1) are highly tentative and reflect experience gained over one year in limited areas of both Parks.

Conceivably, Vegetation-Soil 'Districts' will depict trends in soil and vegetation development as influenced by *meso-climate* (or physiographic modification of macro-climate) interacting with latitudinal, elevational, and broad material (reaction and calcareousness) variations. Controlling physiographic parameters are east-west orography (Foothills versus Front Ranges versus Main Ranges) and, to a lesser extent, slope aspect in broad valleys. Specifically, climatic features such as snowfall (amount and duration), total precipitation, evapo-transpiration, and temperature can be qualitatively defined, on a relative basis, through an evaluation of trends in soil and vegetation development.

4. *Land System* (Level 4) is the basic conceptual level in the Banff-Jasper biophysical land inventory because Land Systems are the most consistent, repeating map concepts observable using air photos. Units that group or subdivide (above and below in the hierarchy) Land Systems are interpreted or identified as a

Table 1: Banff-Jasper Biophysical Land Classification (tentative)

LEVEL OF GENERALIZATION	1 BIOCLIMATIC ZONE	2 BIOCLIMATIC SUBZONE	3 VEGETATION-SOIL 'DISTRICT'	4 LAND SYSTEM	5 BIOPHYSICAL MAP UNIT
	ALPINE	Upper	Rock and lichen	Separations at this level are presently made within each Bioclimatic Subzone and are based on landform and major drainage features. Consequently, each Land System encompasses map units: <ol style="list-style-type: none"> 1. on similar geologic materials (consideration of origin, texture, and reaction); 2. of similar terrain surface form^{4,5} (eg. aprons & fans vs. steep & inclined slopes vs. hummocky & ridged, etc.); and 3. having dominant soils of either: <ol style="list-style-type: none"> a) moderate to very rapid drainage - or - b) imperfect to very poor drainage. More variability is allowed in alluvial (recent) material characteristics than in other geomorphic materials. In addition, alluvial areas dominated by Regosolic soils (resulting from frequent flooding) are separated from alluvial areas with more advanced soils. 	Each Land System is subdivided according to variations in soil and vegetation components as follows: <ul style="list-style-type: none"> - significant landform modifications (eg. inclusions of other materials, erosional processes); - significant variations in the proportions of component soils (phase of subgroups) and representative vegetation types; - significant inclusions of extraneous soils and vegetation types that influence overall use potential
		Middle & Lower ²	<i>Cassiope/Phyllodoce</i> --Brunisol/Regosol		
	SUBALPINE	Upper Subalpine	Spruce/fir- <i>Cassiope</i> --Brunisol/Podzol Larch/fir-Brunisol/Podzol Spruce/fir- <i>Vaccinium</i> --Brunisol/Podzol		
		Lower Subalpine	Spruce/fir- <i>Menziesia</i> --Podzol Spruce/fir- <i>Menziesia</i> --Podzol/Brunisol Pine (Spruce) - <i>Shepherdia</i> --Brunisol/Luvisol		
		MONTANE	(Middle & Lower) ² White spruce/Douglas fir--Brunisol/Luvisol Grassland--Brunisol/Regosol		
	BOREAL	Upper Foothills ³	?		
BIO-PHYSICAL LAND CLASSIFICATION EQUIVALENTS ¹	LAND REGION (?)	SUBDIVISION OF LAND REGION	?	LAND SYSTEM (?)	SUBDIVISION OF LAND SYSTEM
1. Lacate 1969 2. La Roi <i>et al.</i> 1975 3. Rowe 1972 4. Fulton <i>et al.</i> 1974 5. Acton 1975					

secondary stage.

Separations at this level are based on the descriptive landform classification system initiated by Fulton *et al.* (1974) and modified by Acton (1975). Materials category (origin) and terrain surface form are the basic elements of landform classification considered in Level 4. However, texture, reaction, and calcareousness are also considered. Because of use implications in the mountain National Parks, areas dominated by poorly and very poorly drained (wet) soils are also separated, at Level 4, from areas dominated by better drained soils. Table 1 lists the criteria by which Land System separations are made.

At the present time, Land Systems are differentiated within Bioclimatic Subzone (Level 2) units. If Level 3 is accepted as part of the hierarchy, Land Systems will be

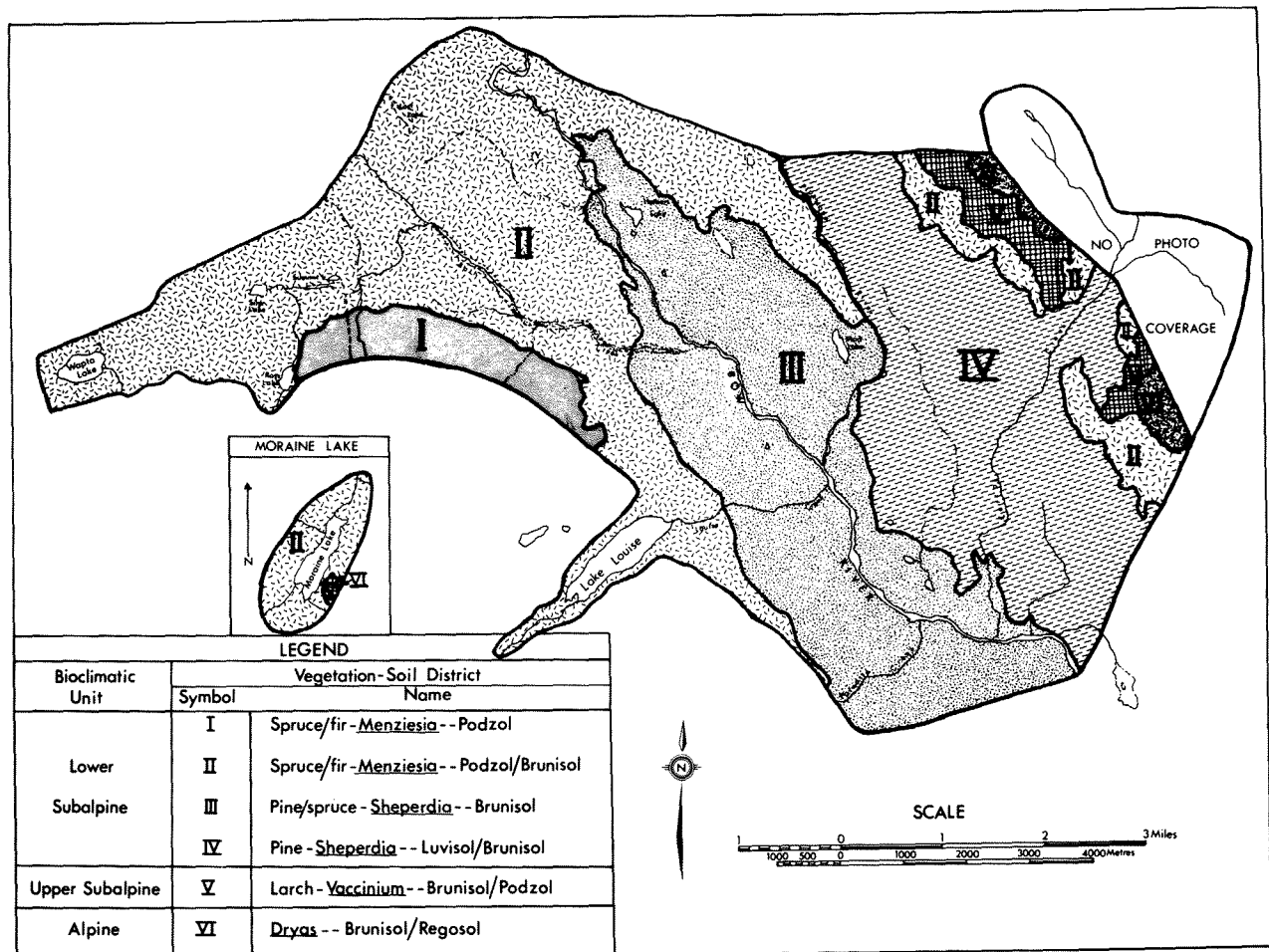
defined as occurring within Vegetation-Soil 'District'. Each Land System is identified by a geographic place name and, on maps, by a two-letter symbol.

5. *Biophysical Map Unit* (Level 5) is the main mapping level for the Banff-Jasper biophysical land inventory. Each map unit is identified by a two-letter symbol (indicating the Land System in which it belongs) plus a number.

Each Biophysical Map Unit indicates a pattern of soils and vegetation allowable within the geologic and environmental limits imposed by higher hierarchical levels in the classification system. Table 1 further specifies the criteria used to make map units separations.

The component soil (or soils) of biophysical Map Unit is recognized to be *subgroup phase*.

Figure 1: Vegetation-Soil "Districts" of the Lake Louise Study Area (from Walker et al. 1976)



Representative vegetation type (or types) constitutes the vegetation element of a biophysical map unit definition and is based on a taxonomic entity - the vegetation type. A vegetation type is the smallest vegetation unit discriminable floristically and environmentally and is comparable to *plant association* (*sensu* Braun-Blanquet as modified by Krajina 1960) or *biogeocoenosis type* (*sensu* Sukachev 1958, 1960).

Representative vegetation type is a new concept introduced as a mapping device (legend) in the Lake Louise Study Area (Walker *et al.* 1976). Since most map units are somewhat heterogeneous in terms of vegetative cover, one taxonomic vegetation type is selected to represent or characterize, in the legend, the vegetation of each map unit. This is the representative vegetation type of that unit. In most cases, representative vegetation type is the dominant type providing it is stabilized or mature and reflects model habitat conditions

of the map unit. Potential climax types need not be used as representative vegetation types. Short-term early or young succession stages (following disturbances) and introduced vegetation are not used. Types other than the representative vegetation type may in most cases be regarded as inclusions in a map unit. Some map units may be vegetationally characterized by up to three representative vegetation types. These are generally associated with complex landforms and habitats where landscape segments (e.g. north- versus south-facing slopes, dry versus wet portions) are defined in the legend or situations in which more than one vegetation type occupy nearly equal portions of the map unit.

C. Problem Areas - Problems other than logistics problems, but sometimes logistics-related, remain in the Banff-Jasper Biophysical Land Classification System concepts and their application.

1. *Cartographic Problems* - If rock, ice, and permanent snow fields are included within the concept of *Alpine*, Bioclimatic Zones (Level 1) are mappable at a scale of 1:500,000 and, perhaps, smaller scales. However, a major cartographic problem occurs in Level 2 because some bioclimatic subzones--namely Alpine areas exclusive of rock and ice and Upper Subalpine areas--are not mappable at scales smaller than 1:50,000. Nevertheless, bioclimate subzones (Level 2) are ecologically important areas and are used as an organizational tool to group units from lower levels in the hierarchy.

Vegetation-soil 'districts' (Level 3) should be mappable at 1:125,000 to 1:250,000 because they span material and landform boundaries. However, they occur within bioclimatic subzones (Level 2 units), some of which are unmappable at the smaller scales (see preceding paragraph).

The cartographic problem pertaining to Level 2 also descends to Level 4 (Land System). In addition, land systems, as used in the Banff-Jasper biophysical land inventory, are conceptual rather than cartographic groupings of biophysical map units (Level 5 units). In other words, map units belonging to a land system seldom occur together in the landscape but are frequently separated by map units of other land systems.

Biophysical map units (Level 5) are utilized in the mapping and work reasonably well at scales of 1:20,000 to 1:50,000 in the mountain terrain.

2. *Data Requirements* - As previously mentioned in the *Background* subsection, most ecologists express a need for more intensive data gathering for purposes of identifying and explaining ecological relationships. In particular, vegetation scientists desire an intensive sampling program (amenable to statistical analysis) to adequately characterize and define limits for vegetation types. Beyond this, ecological (climate-vegetation-soil-geologic material) relationships, and resulting interpretations, could be more confidently established.

Although intensive sampling and characterization of vegetation is both necessary and desirable, time and monetary constraints limit such an approach and necessitate compromises in sampling intensity.

3. *Waterbodies and Wetlands* - To-date, operational mapping procedures within Banff and Jasper National Parks have not included detailed characterization of lakes and streams. The relatively small areal extent of waterbodies in sections mapped to-date has probably

been the main reason for this reduced concern. Recent contact with limnologists, hydrologists, and wildlife biologists suggests that more attention be given to aquatic ecosystems.

Present operational mapping in the mountain Parks recognizes waterbodies and associated wetlands only as accessory features of biophysical map unit (Level 5) definitions. However, guidelines for open water and wetland classification as outlined by Adams and Zoltai (1969) and modified by Jurdant *et al.* (1972) may be tested in the Banff-Jasper Biophysical Land Classification System in the near future.

4. *Classification System Problems* - Main problems in the Banff-Jasper Biophysical Land Classification System center around Level 3 and include naming of this category (use of 'District' may create confusion relative to Lacate's 1969 Land District definition) and its implementation within the hierarchical structure. Regarding the latter problem, several options are under consideration.

- a) Level 3 may be retained as a district category as shown in Table 1. Land System separations would be made according to the specified criteria (Table 1) but within each vegetation-soil 'district'.
- b) Levels 1,2,4 and 5 (Table 1) may remain operational and Level 3 will be used outside the system's hierarchy to group various soil and vegetation trends for discussion purposes. This option would necessitate mapping of Level 3 units to show climatic and distributional relationships.
- c) Levels 2 and 3 (Table 1) may be integrated into a single hierarchical category with less emphasis on the vertical (altitudinal) zonation imposed by Level 2. Such a move may alleviate, in part, the mapping problems associated with the Bioclimatic Subzone Level (see discussion under *Cartographic Problems*).
- d) Levels 2 and 4 (Table 1) may be integrated into one hierarchical category. Cartographic problems at such a level would, however, be compounded.

Some of the options will be subjected to testing and evaluation during the 1976 field season. In addition, more stringent criteria for Level 3 separations will be developed in the following year.

D. Summary Discussion and Recommendations - The Banff-Jasper biophysical team accepts the basic concepts of a biophysical land classifi-

cation system. It strongly feels, however, that many definitions of terms, taxonomic criteria, and hierarchical structure be made more rigorous. The trial, and/or adoption, of a restructured hierarchical classification methodology that provides for a category approaching Vegetation-Soil 'District' as described in the above text, is also considered very important.

Recommendations from the Banff-Jasper biophysical team are summarized as follows:

1. Development of more rigorous terms, definitions, taxonomic criteria, hierarchical classification structure throughout the entire biophysical system.
2. The Level 3 concept of Vegetation-Soil 'District' be further developed and adopted for trial.
3. Investigate methods of obtaining extra input from vegetation scientists into biophysical inventory by aiming their efforts towards further development and/or adoption of a unified framework for vegetation classification in Canada.
4. Exploration be made whereby basic data-gathering for vegetation and soils be made more extensive in order to identify and explain ecologically significant relationships that may be used to verify and strengthen interpretations.
5. Efforts be made to develop climatic data input into biophysical land classification methodology in order to assist in differentiation to the Vegetation-Soil 'District' Level (Level 3, Table 1).
6. Biophysical team members continue to develop user contacts and maintain some involvement with site-specific problems and studies as a self-training tool (refer to Appendix C).
7. Efforts be made towards upgrading of user skills in understanding inventory methodology, resource analysis, and interpretative results by development and sale of a

Benchmark Training Manual for Biophysical Land Classification Users (refer to Appendices C and D).

8. Research requirements be established in order of priority and methods of funding be investigated (refer to Appendix D).

9. Methods of providing publication assistance for biophysical projects be examined (refer to Appendix D).

ACKNOWLEDGEMENTS

The survey of Banff and Jasper National Parks is a joint project involving the Canadian Forestry Service, the Soil Research Institute and the Alberta Institute of Pedology.

Parks Canada is supplying the Major funding. Problem areas, data requirements, advice, and assistance have been, and are being received from Dave Day, C. Zinkan, and P. Benson, Western Region, Parks Canada, Calgary, and from Bruce Wilson, Tom Ross, the Warden Service and others in the respective Parks.

The project is receiving whole-hearted support from the Biophysical team members, namely:

Alberta Institute of Pedology:

Dr. Russ Well, Pedologist
 Bruce D. Walker, Pedologist
 Phil Epp, Pedologist
 Ian Corns, Vegetation Scientist
 Alan Westhaver, Vegetation Technician
 Joe Tajek, Soil Technician

Canadian Forestry Service:

Dr. S. Kojima, Vegetation Scientist
 Doug Allan, Soil Technician
 Jack Dyck, Vegetation Technician

Soil Research Institute:

Dr. G.M. Coen, Pedologist
 Dr. Julian Dumanski, Pedologist

The above personnel are all contributors, in one way or another, to reports emanating from the Banff-Jasper Project. The single name on the front of this document is convenient for referencing and queries.

APPENDIX A

OPERATIONAL METHODOLOGY

Inventory requirements for the overall program (scale 1:50,000) are outlined in the terms of reference (Day *et al.* 1975). The main procedural methodology is given in the Banff-Jasper Bio-Physical Land Inventory Progress Report No. 1:1974-1975 (Holland *et al.* 1975). These two bulky documents have limited availability; their main function is to outline some user requirements, point out the need for a biophysical land classification methodology, relate the biophysical portion of the work to other aspects of the overall Park's inventory program, and provide a documentary reference of project development.

Figure A1 provides an overview of the position of the inventory team within the organizational framework of the entire resource inventory currently in progress in the mountain Parks.

Figure A2 (Holland *et al.* 1975) provides a step-wise view of the inventory procedure.

1. Logistics

The survey requirement is for all of Banff and Jasper, 17518 km² (6764 mi²) at a scale of 1:50,000. The time frame is five years. Logistic problems occur because of:

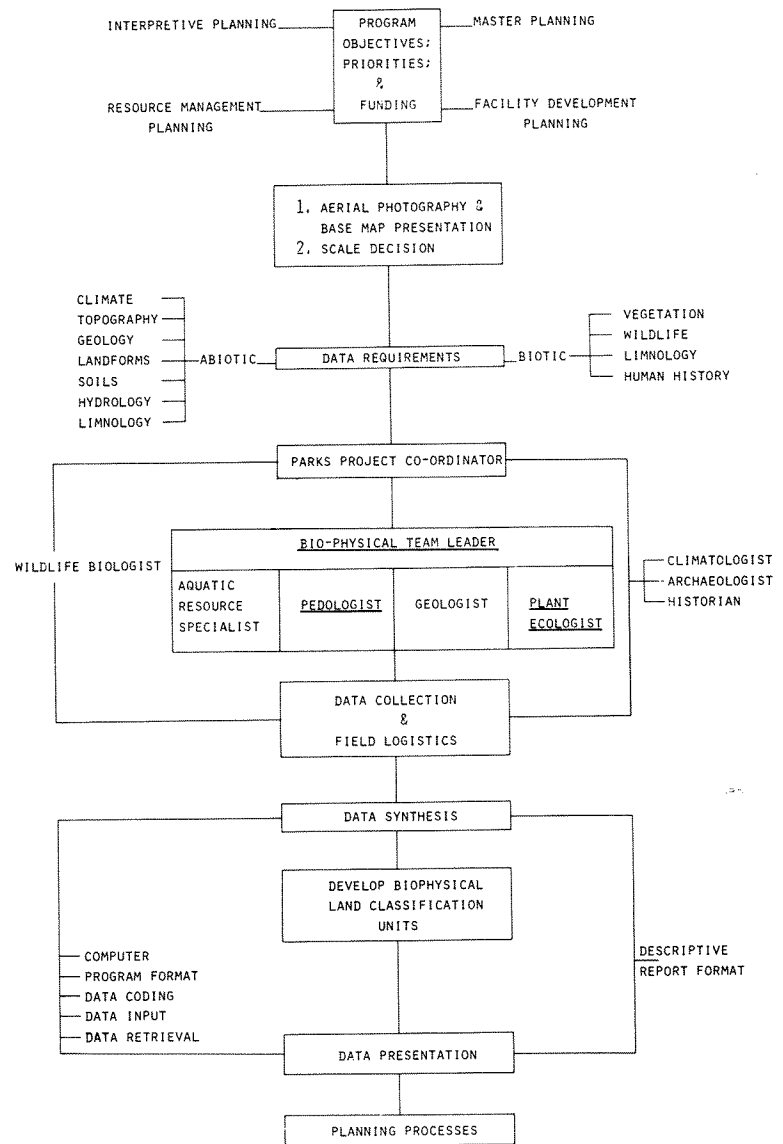
- high relief and terrain variability
- budgetary and Park restraints on use of helicopters
- slowness of ground access by foot and shortness of survey season
- limitations in available photography
- the amount of site-specific work that is requested.

Some of the above restraints have no solutions; however, a serious attempt was made to obtain assistance via new photography.

2. Air Photos

The bulk of the air photography is 1972 black and white panchromatic at 1:66,000 and 1:70,000. A number of different flight lines, some of which cross one another, and four different scales (1:15,840; 1:21,120; 1:66,000; and 1:70,000) have been used to-date particularly in the Bow Valley corridor and Lake Louise area. Because of the need for vegetation detail, especially in alpine areas, an

Figure A1: Biophysical inventory stages (Day *et al.* 1975)

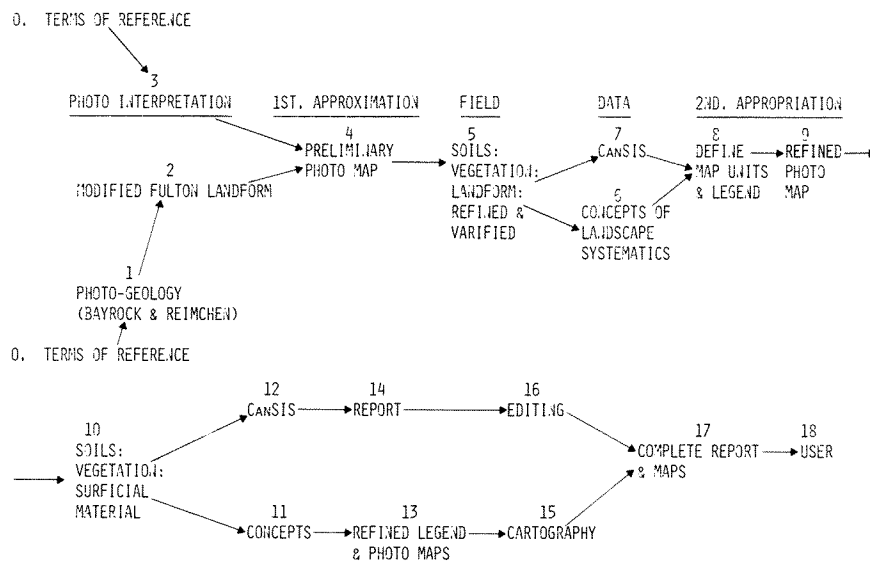


attempt was made in 1974, and again in 1975, to obtain full coverage (at 1:50,000) with infrared Ektachrome (film 2443) and infrared Aero neg. (film 2445).

Results of the color photography were disappointing for two reasons:

- The 1975 flight was flown about July 3, just after a rather vigorous snowstorm, and
- many of the valley bottom areas are under-exposed while the alpine and other high elevation areas are over-exposed. The project might have benefited from a flight using only one film, but with two cameras and two exposures, one for the valley bottoms and another for the alpine and high elevation areas.

Figure A2: Inventory Methodology (Holland et al. 1975)



3. Team Approach

The concepts of a team approach involve an equal and cooperative input from pedologists and vegetation scientists. The team is split between the two Parks, with major input into Banff in the early stages of the inventory and gradual shift of emphasis to Jasper as the project continues. Improvements in the team approach would involve, firstly, a closer and more continuous contact with the geologists, and secondly, the luxury of enough time to become even more involved with site-specific problems and requirements. The site-specific work in which we have been engaged has been one of the better learning and teaching tools encountered to-date.

The advantages of a team approach are gradually becoming more evident. It broadens the work experience and provides interactions that are most useful in development of methodology. Also, the Banff-Jasper team is small enough that field interactions lead to immediate and systematic integration of geology, vegetation, soil, rather than have each discipline go its own way and then attempt integration at the end of the survey. We feel that generalizations made in the field at the time of ground checking are the best way to integrate two or more disciplines.

4. Field and Laboratory Methods

Soil classification and profile descriptions follow the System of soil Classification for Canada (Canada Soil Survey Committee 1970, 1973, 1974). The project is cooperating with, and contributing to CanSIS, the national soil data bank described by Dumanski and Kloosterman (1973). In addition, we are cooperating with CanSIS personnel in developing vegetation data files. CanSIS is assisting the Canadian Wildlife Service in the development of a wildlife data file.

In situ soils data are recorded in the field and quantitative soils analyses are conducted in the soil survey laboratory at the University of Alberta. Methodology is the same as that used in the soil survey of Waterton Lakes National Park (Holland and Coen, in press).

Plant collections are being made by S.Kojima (1975, 1976) and Ian Corns (1976). Nomenclature is based on "Flora of Alberta" (Moss 1959). All specimens are preserved in the Canadian Forestry Service herbarium, Northern Forest Research Centre, Edmonton. Where necessary, specimens will be provided for Parks' herbaria.

APPENDIX B

RESULTS TO-DATE

Area priorities are determined yearly in consultation with Park's personnel. The areas inventories to-date are the more intensive use areas, and include the Bow Valley corridor and Lake Louise area in Banff and in Jasper, the main Athabasca Valley from about Jasper Lake to Sunwapta Falls (See Figures B1 and B2).

Table B1 provides information on data collected to-date.

Table B1: Vegetation and Soil Observations 1975		
	Banff	Jasper
No. of veg. plots	587	103
No. of veg. types	29	53
Vascular plant species	505	400
Vascular plant families	55	48
Vascular plants collected	1000	2000
Bryophytes collected	2000	1500
Soil observation points	558	555
Soil laboratory samples	73	64
<i>In situ</i> soil tests	12	-
Notebook records	65	450
CanSIS soil description sheets:		
Daily forms	475	78
Semi-detailed	1	18
Detailed (sampling sites)	11	9
Area surveyed (mi ²)	600	800
Foot traverse mileage	0	650

The following site-specific work has concerned various members of the biophysical team during

1975:

1. Rehabilitation guidelines for Lakes Edith and Annette area, Jasper (Bull *et al.* 1975).
2. Lake Louise Special Study Area, Banff.
3. Environmental impact study, Mt. Kerkeslin campground, Jasper (Trottier *et al.* 1976).
4. Whistler Mountain rockfall, Jasper.
5. Reclamation planting of old highway between Maligne Canyon and Medicine Lake (about 9 mi), Jasper.
6. Twining of C.P. Railway track in Lake Louise area of Banff National Park.

A separate report and map is being prepared for the Lake Louise area; it is also being used as a pilot test area for CanSIS cartographic file. Interim reports are being prepared for Banff and Jasper, using Itek copies (Alberta Forest Service) of annotated air photos instead of drafted maps.

Some of the results are being utilized almost immediately, or at least within the first year, particularly the site-specific work. Results are also required for the various Planning Units recently established throughout the Parks; eg. the Columbia icefields Planning Unit, the Lake Louise Special Studies Area, etc. To this extent, Parks Planners want our data by September 1 of each year in order that resource analysis and planning functions may be completed by the end of the fiscal year. The complete master planning for the Parks is required at the end of the project.

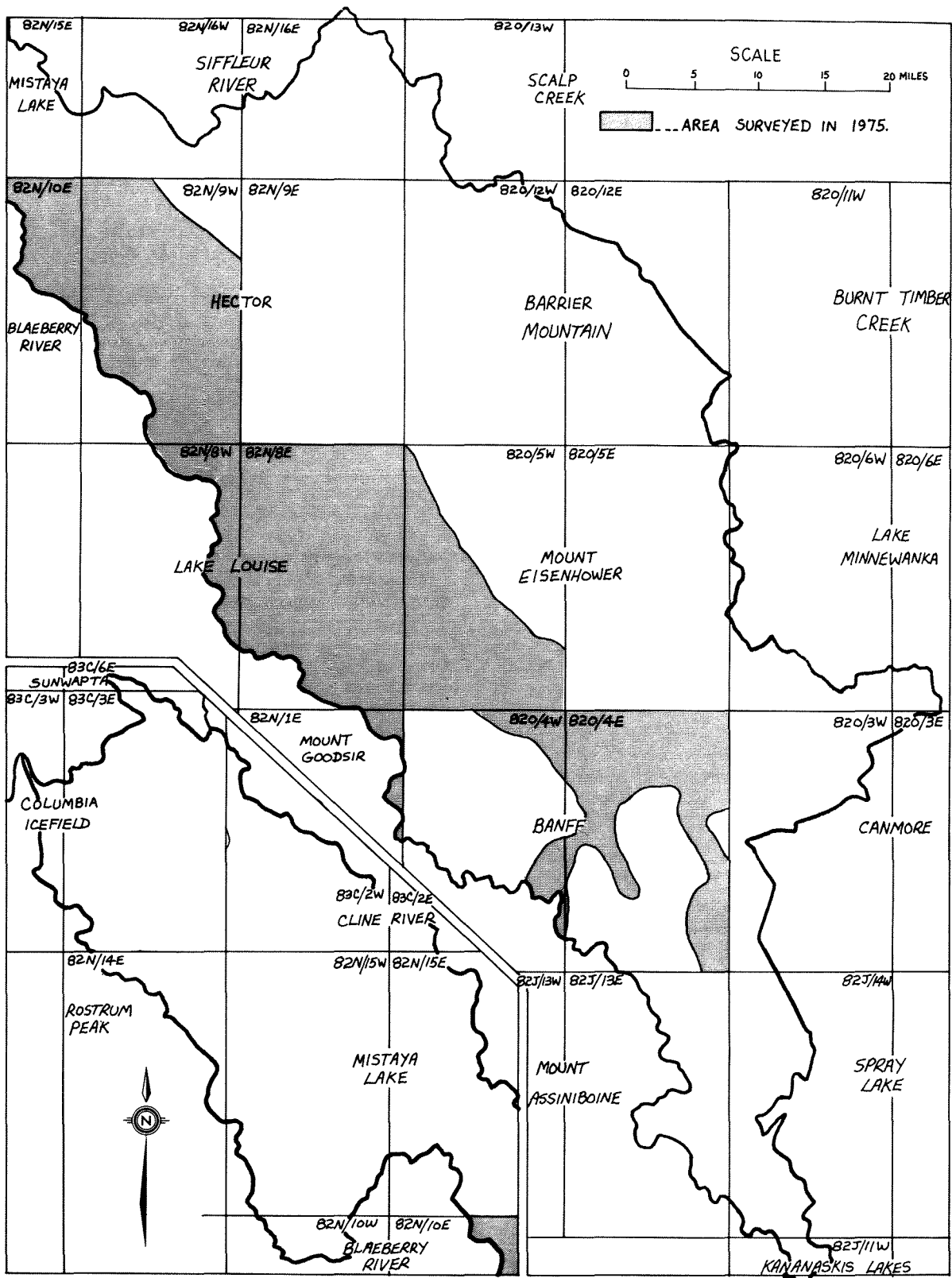


Figure B1: Area surveyed in Banff in 1975

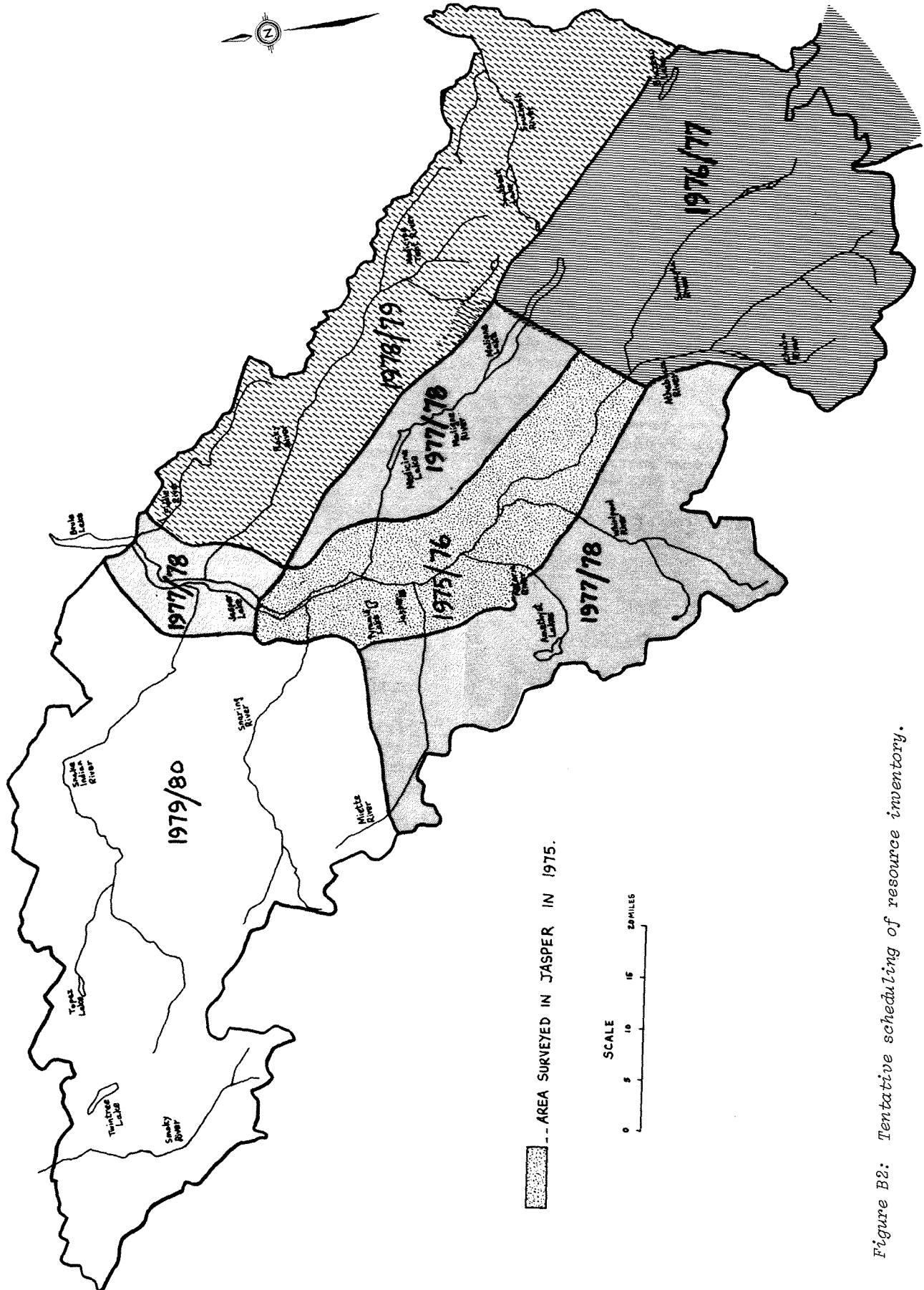


Figure B2: Tentative scheduling of resource inventory.

APPENDIX C

USER CONTACT AND ANTICIPATED APPLICATIONS

USER CONTACT

User contact is excellent; by telephone, personal contact, written reports, seminars, field tours, and workshops. The Park users include various levels of park planners (see top of Fig. A1), park administration, regional administrators, and interpretive personnel. These users are at local and regional Park levels. A number of other users occur within the DOE establishment; eg. fire, regeneration (reclamation and rehabilitation), and Canadian Wildlife Service. Users external to Environment Canada and Parks are consultants, provincial agencies, and various schools. Requests for reports have come from Australia and England. It is interesting to note that the soil map and data used by the master planners during the Public Hearings on Waterton Lakes National Park was displayed before some 45 different agencies in southern Alberta, including Chambers of Commerce, Boards of Trade, University of Lethbridge, etc.

ANTICIPATED APPLICATIONS

The main user, of course, in Parks Canada. Park user requirements are listed in some detail by Day *et al.* (1975). Resource data uses are already being applied; however, a list of uses, including those that are anticipated, may be summarized as follows:

1. Parks want to manage land, or ecological systems; hence the holistic (and integrated) approach to inventory.

2. Master planning of planning units and whole Parks; eg. for conservation zoning, use zoning, potential visitor facility location, resource distribution. In fact, a thorough resource analysis will be required before the master planning can be completed.

3. Resource management and resource operational planning; eg. wildlife management (introduction, protection, reduction censusing), vegetation management (fire protection, regeneration, reclamation and rehabilitation). Resource operational planning becomes very problem-specific, as for example, in grizzly bear management studies.

4. Interpretive themes and coordination, so that people in one Park area receive a unified story during their visit, and so that

an interpretation of a certain landform, kind of vegetation, etc. is similar from place to place. Included are audiovisual presentation, exhibits, nature walks, printed pamphlets, or whatever.

5. Visitor services will be using resource data in order to provide wilderness experience to the public while minimizing impact on resources. Areas with high recreational potential for beaches, trails, swimming, canoeing, etc. must be identified. Meanwhile, areas must be identified for potential conflict between use for recreation and preservation. Identification of resource constraints to use must be identified; eg. poorly drained soils, unstable landforms, fragile vegetation, etc. Use of resource data will permit better back-country management.

6. Site-specific problems and studies; the movement of sand dunes in Jasper, study of caves in Banff, study of intensive use areas such as hot springs, waterfalls, etc., reclamation and rehabilitation of abandoned roads, campsites, gravel pits, conflicts of use between ungulates and humans, etc. Most of the site-specific uses occur in intensive use areas in the main valley corridor and around townsites and service centres.

7. Upgrading of skills of planners, wardens, naturalists, through familiarization with resource data, maps, air photos. The next five to ten years will see a marked upgrading of skills by many of the Park personnel. It is occurring now.

8. A first-time correlation of wildlife, over large areas, with habitats and other specific environmental situations. The effect on the wildlife approach is already exemplified by the work of Oertli and Stelfox (1975), McGillis *et al.* (1976), and Karasiuk (personal communication).

9. Resource data are expected to be used at public hearings, and by Park administrators, as evidence for decisions on land use assignments or changes, rules etc.

10. Engineering services are also expected to use the resource data.

Other uses, presently occurring and anticipated include:

1. Demonstration of methodology; the Multiple Land Use Section and other sections of the Alberta Forest Service; Alberta Environment, and some people in the Alberta Oil Sands, Environmental Research Program (AOSERP).

2. A teaching tool; seminars to students in forestry and at agricultural schools,

inclusion in course work at Hinton Forest Technology school.

3. Reference material; requests by schools, various libraries, and individuals.

Certainly the main uses of demonstrated methodology, interpretative uses, and provision of resource data for planning purposes, could be further developed with more time for external contact.

APPENDIX D

PROBLEM AREAS

A broad range of problems exists with varying degrees of intensity of problem. The following is not necessarily in any particular order of priority, nor does it suggest solutions.

1) Acceptance of biophysical terminology:

This, or perhaps the lack of acceptance of terminology by many professionals, including pedologists, causes difficulties in communications. Objections include such items as the use of geographical names for map units. The implication is a weakness in biophysical terminology and definitions, an innate stubbornness in professionals, or a lack of communication between various workers, or a mixture of all three.

2) Differing philosophical approach: There are differences in approach between various professional groups, in particular between the pedologists and vegetation scientists. The pedologist recognizes the mapping problems quite early, develops concepts of modal mapping units, the range and limits of such units, and proceeds with mapping. The vegetation scientist, on the other hand, attempts to sample the entire population before committing any kind of decision. Both approaches have merit, but it does present difficulties with developing and maintaining an integrated biophysical approach.

3) Transfer of knowledge to users: The user audience is extremely variable in its interests and level of training. Thus, we feel strongly about how data are presented; for example, we prefer the use of simple map symbols and an extended legend. However helpful the above techniques may be, they do not solve all of the transfer-of-knowledge problem. We know that the presentation of methodology and resource data must be augmented by interpretative information. Some users possess highly skilled training and require no further assistance with using the inventory data, but others will require very fundamental training before they will be able to use the information. Who is going to provide the necessary training, when, and how?

4) Cartographic problems: Mountainous areas like Banff and Jasper always present problems due to relief and variability of terrain; for example, how does one indicate very small areas of crucial winter range for Rocky Mountain Sheep, when such areas are below the minimum size for symboling, and which virtually disappear when transferred to a planetable map?

Also, correction for photographic distortion is still a problem in transfer of data to maps.

The production of generic interpretative maps by CanSIS has not yet become a reality.

One limitation of the present approach of the biophysical land classification is that the prime objective, which is "to differentiate and classify ecologically significant segments of the land surface" (Lacate 1969), cannot always be met. The biophysical approach emphasizes landform base, which enables the rapid delineation of land units. However, landforms may be rather heterogeneous in terms of vegetation, and conversely, one vegetation type may cover several landforms. Thus, segmentation of the land surface on landform alone is undesirable. Mappable (scale dependent), ecologically distinct (as reflected by vegetation) units upon one landform must be separated. We must recognize the difficulty in mapping apparently homogeneous vegetation units which cross landform boundaries. The recognition and mapping of these instances will be dependent upon the mapper's field experience in the area concerned. Where the mapper is not well-familiarized with the vegetation or in areas which have a lower intensity of 'ground truth' information, mapping units will have a stronger landform base - perhaps an unavoidable situation. A problem thus lies in the recognition and mapping of vegetationally uniform, ecologically significant segments of the land surface where landform boundaries are crossed. To partially alleviate this problem, level 3 of the Banff-Jasper Bio-physical Land Classification System (Table 1) will provide improved continuity of vegetation, at a somewhat generalized level, across landform boundaries.

5) Research requirements: The Banff-Jasper project is an operational one, and as such does not have the time or funding for some of the background research that now appears to be desirable. We know, for example, that organic matter content of Park soils varies from virtually zero to highly organic, but we do not know what level of organic matter content is optimal for best results for trail location, campsites, or any area receiving intensive human use. We know that alpine soils are different from subalpine soils, but the extent and significance of such differences are not fully known. Some Park land uses, such as large campgrounds (800 - 1000 acres), can be subjected to rotations (an old agricultural custom), but unique areas such as hot springs,

waterfalls, etc., cannot be rotated in a management system, yet must be maintained in an aesthetic state for public consumption. Such unique areas require very site-specific research with regard to rehabilitation and/or maintenance of a favourable environment.

Requirements for rehabilitation of sites have every variation imaginable. Much of the vegetative material, rootstocks, and/or seeds, is not available in sufficient quantities for rehabilitation; for example, few vegetative materials are available for rehabilitation of 40-60 acres of bulldozed ski-runs in a Vegetation Type 8 - alpine larch forest in the Upper Subalpine unit. We know much about horticultural stock and our main forest trees, but lack information on many kinds of plants useful to the mountain Parks.

One of the user requirements, mentioned earlier, was for the identification of resource constraints to Park development. Some, such as slope, or impeded soil drainage, are not too difficult to measure, but others are very difficult. For example, the word 'fragility' is frequently used to refer to sites or vegetation types that are sensitive to disturbance. Firstly, it appears as though an overall 'Environmental fragility index' should be developed along the lines of the following formula:

$$\begin{array}{lcl} \text{Environmental} & & \text{time} \\ \text{fragility} & = & f(\text{soil} + \text{vegetation} + \text{of} + \\ \text{index} & & \text{use} \\ & & \\ & \text{intensity} & \\ & \text{of} & + \text{wildlife)} \\ & \text{use} & \text{use} \end{array}$$

However, such a 'fragility' index cannot be thoroughly developed until we find out what vegetation parameters need to be measured and how.

Measurement of land response to management is another area of concern.

This paper is not a review of research requirements; however, we do know that there is a need for research.

6) Generalization of map units into a hierarchical classification: How is this best accomplished?

7) Logistic problems: These were discussed earlier under "Operational Methodology", Appendix A. The majority of the easily accessible land in the main corridor is surveyed, so the teams are moving into the backcountry areas but have limited helicopter support. There does not appear to be a fully satisfactory solution to the logistics problem.

8) Determination of user needs: The user requirements are gradually becoming known to the biophysical team; production of resource data and interpretation, plus continued user contact will solve these needs as they occur. No doubt some new requirements will appear before the project is completed.

9) Publications: Reports emanating from the project are in limited quantity, usually four or five copies, except for the Lake Louise Study Area (300 maps printed). This problem will be a difficult one to solve unless budgetary constraints are eased.

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