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An Information System for Rural Land-Use Planning

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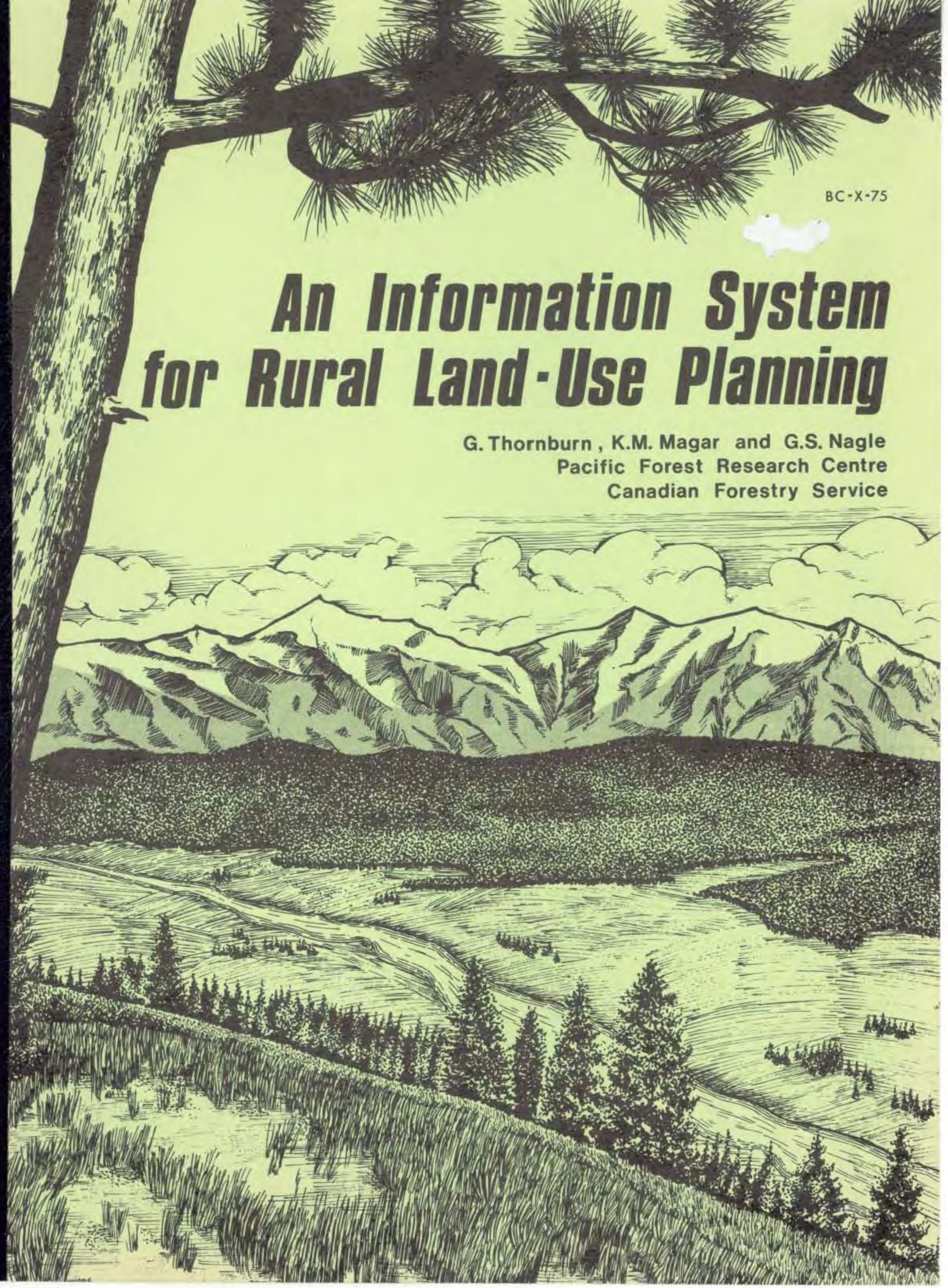

AN INFORMATION SYSTEM FOR RURAL LAND-USE PLANNING

by

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CANADIAN FORESTRY SERVICE

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ABSTRACT

This report describes a method of calculating and displaying economic consequences of land-use proposals for rural (crown owned) lands. A computerized system for storing, integrating and using physical and economic data, based on Canada Land Inventory map data for most resource sectors, has been developed to a stage that is operational, although further refinements are required for practical use.

For specified areas and land use (single or multiple) the system accumulates physical capability data which is translated into production capability based on data concerning product mix and industry structure. The estimated physical product is, in turn, processed through economic subroutines to generate economic effects.

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PREFACE

The computerized land-use information system described in this report has been developed by the Economics and Biometrics sections of the Pacific Forest Research Centre. This work has been carried out under Canadian Forestry Service Study No. PC 075. The system was developed on a Univac 1108 computer in Calgary, accessed by dataphone from a rented terminal at the Pacific Forest Research Centre. By June, 1972, the program had been converted to the Research Centre's new Digital Equipment Corporation PDP 11/20 computer.

To develop the system in a meaningful way, a case study area was selected, in consultation with provincial authorities and Canada Land Inventory personnel, in the East Kootenay district in south-eastern British Columbia. This report presents only methodology, without direct reference to the case study, due to the confidentiality of much of the data.

Although responsibility for the conduct of the study, and for opinions expressed in this report, is that of the authors, this work could not have been accomplished without the encouragement and cooperation of the British Columbia Environment and Land-Use Technical Committee, in particular the Technical Sub-Committee, and the agencies represented thereon. The assistance of many individuals in provincial and federal government agencies, industry and other organizations is gratefully acknowledged. The collaboration and advice of A.H. Vyse, also an economist at the Pacific Forest Research Centre, as well as his assistance in preparing the manuscript for publication, is further acknowledged. Programming in the conversion process has been the responsibility of J.D. Rudd, who

also prepared the sectoral flowcharts in Appendix A.

The study has reached a point at which the system is operational, although further work can be done on extensions and modifications. This report is descriptive rather than technical in nature. Comments concerning technical details, desirable changes or extensions of the system are invited. Address correspondence to the Director, Pacific Forest Research Centre, 506 West Burnside Road, Victoria, B. C.

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THE NEED FOR AN INFORMATION SYSTEM

> "The image of the frontier is probably one of the oldest images of mankind, and it is not surprising that we find it hard to get rid of."
>
> \- Kenneth Boulding[1]

Only recently have many Canadians come to realize that land and its natural resources are, or soon will be, in short supply even in the vast relatively isolated parts of the country. The main forces contributing to this realization include the rapid rate of expansion in industrial activity, tremendous strides in resource production and transportation technology, and the recent increase in concern for environmental quality and the protection of our natural heritage. The fact that all land is not equally suited to all uses intensifies the problem in specific areas.

With this realization comes the need for a mechanism of land allocation. In theory, when land becomes a scarce commodity, it should be optimally allocated by the market system - its best use would be determined by the user most willing to pay for it, based on relative economic returns from alternate uses. Society has not allowed, and should not allow, economic returns alone to govern land use. The reasons evolve from the fact that the effect of many private economic decisions may not result in

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[1] K.E. Boulding, "The Economics of the Coming Spaceship Earth," by H. Jarrett, ed., Environmental Quality in a Growing Economy. (Washington, D.C.: Resources for the Future., 1966.), p. 3.

a socially desirable land-use allocation, because those private decisions are not independent of, and often adversely affect, other members of society, and because the interests of the latter are not effectively represented in the "market".* We have, therefore, an institutional arrangement - vesture of land ownership in the Crown - to ensure that land allocations are made not only on economic grounds but also on the basis of social, environmental and other considerations reflected by the political process.

As the governments remain accountable for their actions, land-use decisions must be rational and in the long-term interests of society. Further, because the allocation of land to a certain use often restricts or prevents other uses for long periods of time, the land "budget" must be balanced not only for the present but also for many future years. Thus, land use must be allocated on the basis of careful planning, and justified on economic and/or other (such as environmental) grounds. Such planning and justification must be based on information. Many years of observation and research, facilitated by modern data storage techniques, have resulted in a very large and continually growing volume of data on which to base decisions. This alone is of little use, however, as such data must be organized in a manner that separates the relevant from the superfluous and

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* For economists, at least three issues are involved - (a) the role of externalities resulting from the effects of one user on other members of society, (b) the "public goods" issue whereby the market system does not reflect values generated by some land uses because they cannot be distributed in discreet units on the basis of marginal cost of an individual's consumption of the good produced, (c) the problem of "equity" whereby all members of society do not have equal market power.

presented in a form that is understandable to and usable by the decision-maker. For a particular decision, data requirements must be identified and the necessary data gathered from often diffuse sources. Modern land-use planning, with all its complexities furthered by a vast unconsolidated data base, requires some system which can assemble, analyse and interpret data in a manner relevant to the user of the system.

DEVELOPMENT OF A COMPUTERIZED LAND-USE INFORMATION SYSTEM ("CLUIS")

To investigate techniques for providing economic input to the land-use decision making process, a study was undertaken to develop a computerized system for storing and integrating physical and economic data, using Canada Land Inventory map data where possible.*

The goals of the study were to (1) identify the types of information, that can be used to improve the decision-making processes for allocating rural public lands to alternate uses; (2) investigate and test the usefulness of Canada Land Inventory map data in their present form, as the physical land capability input for such an information system, and (3) identify areas of serious information deficiency.

Several basic precepts and assumptions are inherent in the approach taken in developing the system:

- A regional case study is essential to real progress toward a

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* A brief description of the Canada Land Inventory, with further references, is provided in Appendix C, along with a discussion of previously developed attempts to use CLI map data for land-use planning in British Columbia and their short comings. Appendix C also discusses the Canadian Geographic Information System developed by CLI and why it was not used in the development of this project.

relevant system. The area chosen was the East Kootenay region in South East British Columbia because (i) all CLI maps had been completed for the area, (ii) the region has a relatively simple economic structure, and (iii) significant land-use conflicts exist in the region which require resolution in the near future.

- Much useful information exists in reports or unpublished (and often unwritten) sources. Although much of this information must be improved for accurate analysis, land-use decisions must be made in the meantime. Hence development of the system was not made dependent on the provision of accurate data, although efforts were made to acquire the best data available.
- Canada Land Inventory map information is essentially sound and sufficiently accurate over large areas to provide an estimate of physical land capability. The data should thus be scrutinized only in terms of its ability to provide information of the form and type required by the system.
- The system must be flexible in its ability to accept changes in data, particularly production and economic, because of the weakness of much of the current data and the rate of technological changes in resource sectors. This would allow the use of new or alternate data for different resource management techniques.
- Social accounting systems must take the environmental as well as economic effects of production into account. The difficulties of quantifying these effects in their physical, let alone social, dimensions are well known, but should not prevent the system from

taking account of these effects in broad terms.

- The set of public and private land-use objectives, physical and economic constraints and external influences acting on regional land-use decisions are too complex, and available data too weak, for mathematical optimization at this stage. Thus, the system is not designed to generate optimal or "best" land-use configurations, but to display a simple but useful set of effects for alternate land-use proposals. By weighing these effects according to the relative social values of the criteria they represent, a ranking of alternate proposals could be calculated. As experience and information grow, the simulation of effects can become more complex and closer to the real life situations.

Selection of Economic Criteria

A large number of planning criteria, both economic and non-economic, are relevant and necessary for land-use decision-makers. Several basic economic parameters were selected because they appeared to represent the fundamental economic goals of regional land-use development. Non-economic criteria are presumed, at this stage, to be taken into account by the decision-makers as they consider the econimic information provided by the information system. Further criteria can be added as the goals of land-use policy become more clearly defined and as data and methodology become available.

The specific parameters selected on this basis are the amount of value added, net regional income and direct employment generated by a particular land-use decision, and the stability and annual rate of growth (on a historical basis) of value added, the latter being regarded as a substitute for stability and growth of the other parameters as well.

Value added can be defined as gross sales value of production, less the cost of materials and supplies (including fuel and electricity) purchased or, alternately, as the net contribution to net provincial product.

Net regional income is defined as gross sales value, less income leakages (such as purchases and returns to capital from outside the region), times an income multiplier reflecting further rounds of expenditure stemming directly from the original income-generating activity. It represents the total amount of economic activity generated within the region by the land-use decision.

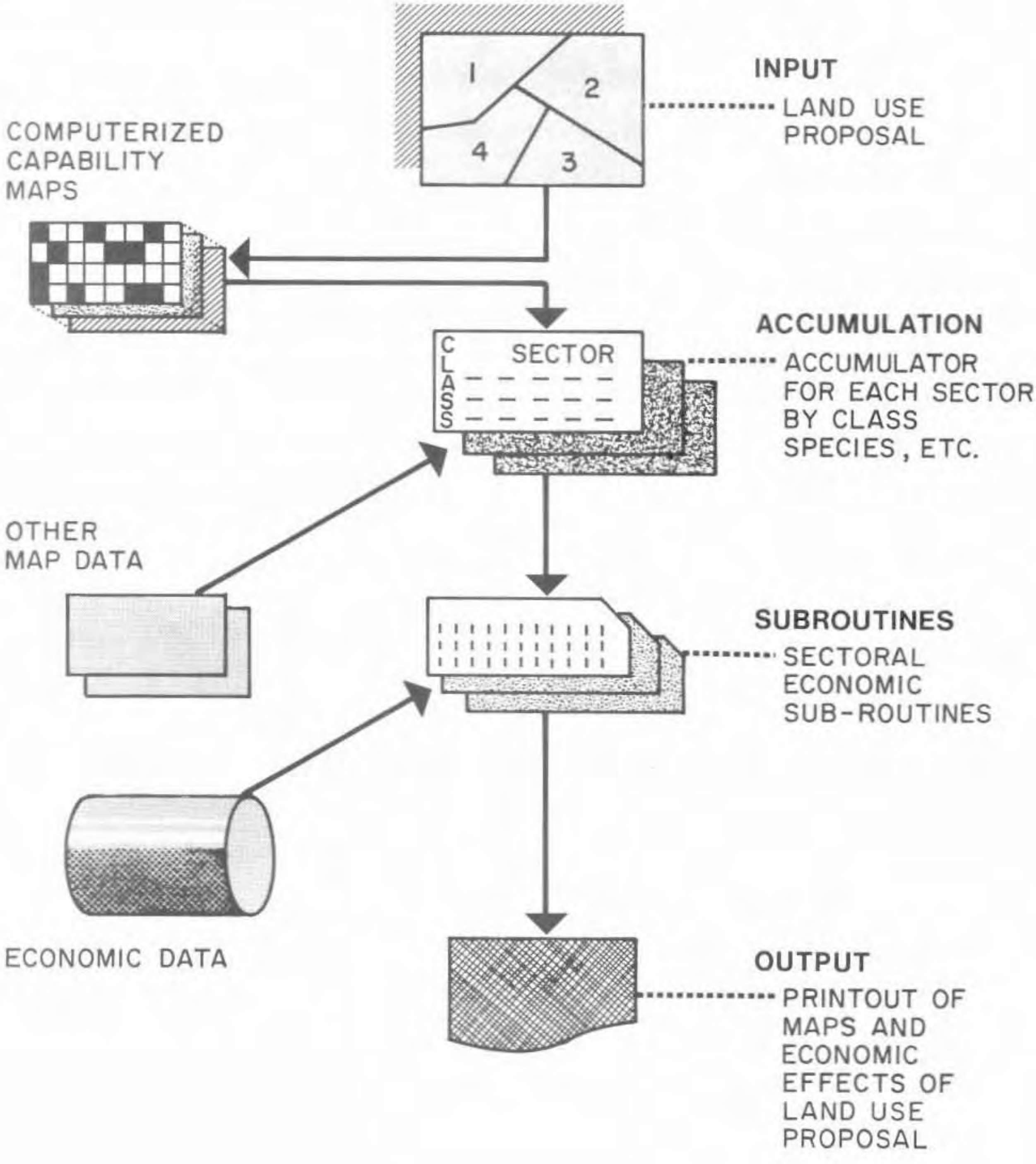
Summary Description

An outline of the basic system is shown in Figure 1. CLI and other maps are stored on a computer file with each point identified by coordinates on a square grid. The other maps include those of mineral locations, lakes, streams and roads, drainage patterns, fisheries capability, forest cover, accessibility, present use and various administrative boundaries.

For specified areas and land uses (single or multiple) the system accumulates physical capability data, which is translated into production capability based on data concerning product mix and industry structure. The estimated physical product is, in turn, processed through economic subroutines to generate economic effects. At present, final output includes

FIGURE I

COMPUTERIZED LAND USE INFORMATION SYSTEM



the following economic measures: sales value (or total expenditure), value added, distribution, of value added between factors of production expected growth rates and stability of value added, net regional income and direct employment.

One of the original concepts of system design was also to provide estimates of the environmental effects of land-use proposals. Due to lack of data and methods for analyzing environmental effects, however, this aspect of CLUIS has not been developed, except for a procedure for "flagging" potentially "dangerous" situations.

The remainder of this report describes the system in detail, in the following order: Data Base, Instructions to the System, Accumulation of Physical Data, Economic Subroutines, Output, Future Options, Use of the System.

Appendix A provides summarized flow charts for each sector, and Appendix B consists of a sample computer run for a small area.

DATA BASE

The main data file consists of series of digitized maps, 24 at present, covering the entire study area. The maps were hand-coded on a square grid, key-punched and stored on magnetic tape. Automatic digitizers are available for this work. Map data, including change of grid size, can be readily updated by re-coding, and new maps can be added, if necessary.

The grid system is based on (x,y) coordinates with the origin at a point from which the axes would embrace all parts of the irregular shaped area. A square grid was used to keep the size of grid unit constant over the 10,000 square mile study area. The resulting grid was transferred onto all maps so that the information for a particular geographic point contained on each map was matched to a unique x and y coordinate. A vertical base line (longitudinal only at the centre of the area) was established on each map sheet to facilitate extension of the grid from one map sheet to another. This was necessary because map sheets are not perfectly rectangular so that grid units overlap from one map sheet to the next. Hence, the grid system must be tilted slightly to maintain a rectangular coordinate system over the whole area.

Although the system is independent of grid size, a one-square-mile grid unit was selected to minimize the time and cost of manual coding, minimize editing and processing computer time for the large area, and to have the facility to hold as large a portion of that area as possible within the computer at one time. On the other hand, the grid unit had to be meaningful for planning purposes, subject to the degree of accuracy of the data.

There are three basic types of maps included in the data base — CLI, other capability maps, and maps depicting information other than land capability.

CLI Capability Maps

CLI maps provide the basic land capability data for most resource sectors. A list of the sectors involved and the information coded from each map is provided in Table 1. Not all information on the maps was coded. Symbols ("sub-classes") indicating physiographic constraints on land capability (e.g. adverse climate, topography, soil deficiencies, etc.) were

Table 1: Canada Land Inventory Map

Information Used in CLUIS

Sector	Definition of Class	Subclass	Number of subclasses
Agriculture	Limitations on diversity of crops due mainly to soil characteristics.	Irrigation status	2
Forestry	Capability to grow commercial timber when stocked with optimal number and species of trees.	Species	10[2]
Recreation	Quantity of recreational use that land unit can attract and sustain without undue deterioration of resource base.	Activity or landform feature	25
Ungulates	Capability to sustain ungulate wildlife populations at various intensities.[3]	Species Range type	6 2
Wetland Wildlife	Capability for the support or production of waterfowl, determined by the degree of limitation affecting the quality and/or quantity of suitable habitat.	—	—

[1] Irrigation, as well as other improvement practices, is assumed where considered "feasible", both technically and economically and not requiring a major reclamation project. This breakdown (irrigable/non-irrigable) is not actually identified by a subclass on the maps but as a double rating for those lands that are irrigable.

[2] The data record identifies the 9 species common to the area, lumping all other minor species in an "other" category.

[3] One additional "super" class was created to delineate several extremely productive areas, on advice of Fish and Wildlife personnel. There are normally seven capability classes, but in wildlife, eight are used.

omitted for this study.

The use of a relatively large grid unit required some rules concerning assignment of a capability class to that grid unit. As a general rule, the classification of the area which covered the major portion of the unit was accepted for the grid unit as a whole, with one major exception noted below. This approach led to some degree of bias in that small areas, such as along small streams and bluffs, were often omitted. Such areas may be a class higher or lower than the surrounding area. It was decided, however, that the advantages of the large grid and consistency were more important than identifying the relatively unimportant (in terms of relative area and economic significance) narrow strips of area at this stage of development. The one major exception was the specific inclusion in the coding of high quality recreation areas around lakes and along streams. In this case, these high quality areas, though small in case area, are, in fact, dominant over the immediately adjacent terrain including the lake or stream, and are of considerable economic significance. The expansion of area assigned to high class recreation (by assigning the whole grid unit to it) is not a serious problem as such uses are usually linear rather than areal in concept (beach, boat launching), site specific (waterfalls, historic sites) or require "buffer" zones around the actual area used (camping, viewing). Thus it was decided to classify the whole grid unit as high quality recreation if at least one quarter of the grid unit was so identified on the map.

Other Capability Maps

Land capability for two important resource sectors, fisheries and minerals, are not provided by the Canada Land Inventory. To provide at least a framework for considering these resource activities, a fisheries map, developed by the B.C. Fish and Wildlife Branch, and a historically-based minerals map, developed in co-operation with the Mineralogical Branch, B. C. Department of Mines and Petroleum Resources, have been used.

Fisheries Map. Developed by regional fisheries officers, the fisheries map is based on local knowledge rather than scientific survey, and represents estimates of sport fishing capability based on actual use (largely related to angler success) and the streams' physical characteristics. It identifies streams and lakes believed to have present fishery capability, potential, marginal and no capability (the latter due to small size, steep grade, periodicity, etc.) as well as probable spawning areas and artificially stocked lakes.

Stream fishery capability within a grid unit is identified on a code of 1 to 7. A zero code means that there is no stream within the grid unit. Fishing capability is also stored in the stream file, discussed below. If more than one capability code occurs within a grid unit, the one covering the largest area or length of stream prevails.

Lake fishing capability is identified on a 1 to 4 scale which, again, also identifies unclassified lakes within the grid unit.

Table 2: Fishing Capability Codes for Lakes and Streams

Lake Capability	Code	Stream Capability
Artificially stocked	1	Spawning area
Natural fishery	2	Good fishing and spawning area
Potential fishery	3	Good fishing
Unclassified	4	Potential fishery
—	5	Marginal fishery
—	6	No fishery possible
—	7	Unclassified

Both stream and lake fishing capability codes merely indicate whether a capability exists within the grid unit. Unlike the CLI maps, there are areas with no capability rating if neither a stream nor a lake is present. The area involved (or length of stream) is stored in separate stream or lake files.

Mineral Capability Map. A true capability map, in terms of the physical land capability for various quantities and types of mineral, is not available, although one is in the early stages of development by the Provincial and Federal mines agencies. In the short term, therefore, a map has been prepared showing the locations of known mineral deposits, past and presently producing mines and proposed mines, by type of mineral. In addition, the broad areas judged to have high, medium and low probabilities of finding commercial mineral formations are outlined on the map. No information regarding potential quantities or ore densities is, however, included. The following information is coded for each grid unit, if relevant:

(a) type of mineral or mineral combination

(b) status of area, i.e. mineral bearing area, or tested locality, past producing mine, presently producing mine, etc., within the grid unit.

Maps Other than Capability Maps

At present, several maps are used within the system which do not provide land capability information as such. They identify physical, economic or administrative characteristics which may act as incentives or constraints to a particular use, link geographic locations to relevant economic data on file, or are used in some other way within the system. The most important of these maps are described below.

Present Use Map: Included in the Canada Land Inventory series, this map indicates the predominant present use of lands, within broad categories. Present use of lands is an important economic and sociological consideration in land-use planning, and the map could form a basis for estimating the costs of changing existing land-use patterns.

Stream and Drainage Map: A stream and drainage network has been developed in which each stream, uniquely identified by an eight-digit code, is coded by each grid square through which it passes (i.e. mile by mile) from its headwaters to the point at which it enters another stream or leaves the study area. Each point (grid unit through which it passes) is also identified with its fishing capability, approximate lineal length within the grid square and stream flow. The latter, at the present time, is generated by the computer from historical flow records (Canada Water Survey) at various points on the stream network and from the drainage map. The drainage map consists of a drainage code for each grid unit which records the point where run-off from that grid unit enters the stream network. The number of grid units draining to a given flow record point, downstream from any higher flow record point, is calculated and an average (per grid unit) net flow is established. Then flow is assigned for each point on the stream on the basis of average (per grid unit) net flow and number of grid units drained at that point.

Lake Map: To identify significant lakes located in the study region (lakes greater than 120 acres or groups of small lakes) for the recreation and fishing sectors, all such lakes have been coded, together with their fishing code, area and perimeter within the relevant grid square.

Accessibility Map: A network map has also been derived to take account of road access parameters. It consists of three parts:

(a) Road network: sections of major highways are identified by number and coded by each grid square through which it passes, west to east or south to north. Secondary (usually gravel) roads are identified by a number and the points at which they enter highway segments.

(b) Viewability Index: each grid square is identified as being; viewable within one half mile or three miles of a highway; viewable within one half mile or three miles of a secondary raod; or outside those areas.

(c) Accessibility Index: each grid square is coded as to its distance from a secondary road and distance on that road from a specified highway segment.

Administrative maps include identification for each grid unit of the following administrative information: Public Sustained Yield Unit (or Tree Farm License) in which it is located, forest inventory map number, grazing permit assigned to the unit, land status (whether it is alienated land, or under Forest Service or Lands Service jurisdiction) and designated use under the Regional Plan. Any number of such data can be included, depending on the requirements of the user of the system.

Economic Data

Economic data have been taken or derived from many sources, supplemented by two field trips into the case study area to obtain knowledge on a first hand basis. Most of the regional data were obtained from the files and publications of federal and provincial government agencies and industry in the region or at Victoria and Vancouver. In many instances, such data were not derived analytically but on the basis of experience and observation. In addition, much data have been taken from published reports on research in other areas, particularly the United States. Although they may not directly concern the case study area, these data provide realistic estimates of values for the economic parameters concerned. Where no data were available, feasible values were assigned on the basis of expert advice or values in other related sectors. The rationale of this approach to data use stems from the following presumptions:

(a) the primary goal of the project is to develop an operational system rather than provide an accurate assessment for the case study area; hence the lack of specific data was not allowed to prevent development of the system;

(b) given the inaccuracies of inter-class boundaries and coding in grid units, the returns from providing extremely accurate economic data (often requiring extensive research and field work) are likely to be low, particularly in relation to other research priorities;

(c) improvement of data can occur subsequently on an incremental basis, once data requirements and shortcomings are clearly identified. It should also be the responsibility of the agency operating the system, rather than a research establishment, to refine data.

The types of economic data required vary between sectors but usually concern one of several basic operational steps:

Product mix - data concerning industry structure and marketing patterns (e.g. saw log/ peeler/ pulp wood breakdown, foreign / resident hunter proportions, cow/ calf herd composition, etc.).

Physical Conversion ratios - data providing linkages between the resource and its product, and between various forms of the resource or product (e.g. board feet of lumber per unit of wood, recreation space standards, hunter success ratios, animal unit months per mile of range and animal weights).

Revenue data - (e.g. beef prices, expenditures per angler day, etc.)

Economic conversion factors - which allow conversion of the basic economic measure, sales value or regional expenditures into criteria such as value added, net regional income and employment. These include the proportions of revenue expended on materials and supplies, income leakage factors and multipliers, and employment/production or employment/revenue ratios.

Other economic data include historical and projected growth trends, income distribution patterns and measures of economic stability.

With respect to revenue data, the values used are statistically derived for a point in time or are expected averages over time. Thus the interactions of supply and demand within the region are not taken into account. A demand is assumed to be present for the quantity of resource or activity supplied by the land-use allocation, and that the addition to supply will not affect market prices. The validity of such an assumption holds only when the additional supply is a small proportion of the total market and hence the producer is a "price-taker". This is clearly the case with the agricultural (beef cattle) and forestry sectors of the case-study area, which have national and international markets, respectively. It is also the case with individual recreationist-hunter-fisherman expenditures, except for the portion spent on camping, other accommodation and other site-specific fees, which have a restricted spatial market. Total expenditures may be constrained, however, due to a lack of demand for recreation facilities, and thus where over-capacity results. Obviously, these instances would artificially inflate the value of such activities and severely bias the inter-sectoral comparison of alternate land uses. This could also be the case with other products having restricted spatial markets, such as perishable agricultural products and pulp chips, and with specialty products for which there is only a small market.

Ideally, a market simulation model should be included to take account of supply-demand interactions. In the meantime, however, the system relies on the decision-maker to avoid creating drastic over-supply situations, or to change the revenue data as necessary. The former is the more likely alternative and could be exercised by restricting the amount of land allocated to any one use at the instructional phase of operating the system.

INSTRUCTIONS TO THE SYSTEM*

The purpose of the instructional stage of the system is to define for the computer the geographical area of interest for which information is required, and assign or give rules by which to assign a land-use pattern for the area. The basic philosophy in this approach is to provide as much flexibility as possible and to allow the user to play a decision-making role within the system. Thus great importance is placed on the user describing one or more feasible land-use patterns, based on his (their) knowledge of the area, experience, and social, political or other constraints.

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* For examples pertaining to this and following sections, see Appendix B.

Alternate proposals (in subsequent computer "runs") can be compared and proposals adjusted as necessary by the assimilation of "feedback". Internal optimization by the computer, could only be achieved at this point by adding a subroutine by which the computer would run all possible combinations of uses and, for each grid unit, assign the "best" use on the basis of some criterion such as maximum net regional income. Such a process would be cumbersome and costly.

Instructions involve two basic steps, as noted above: definition of boundaries and use assignment.

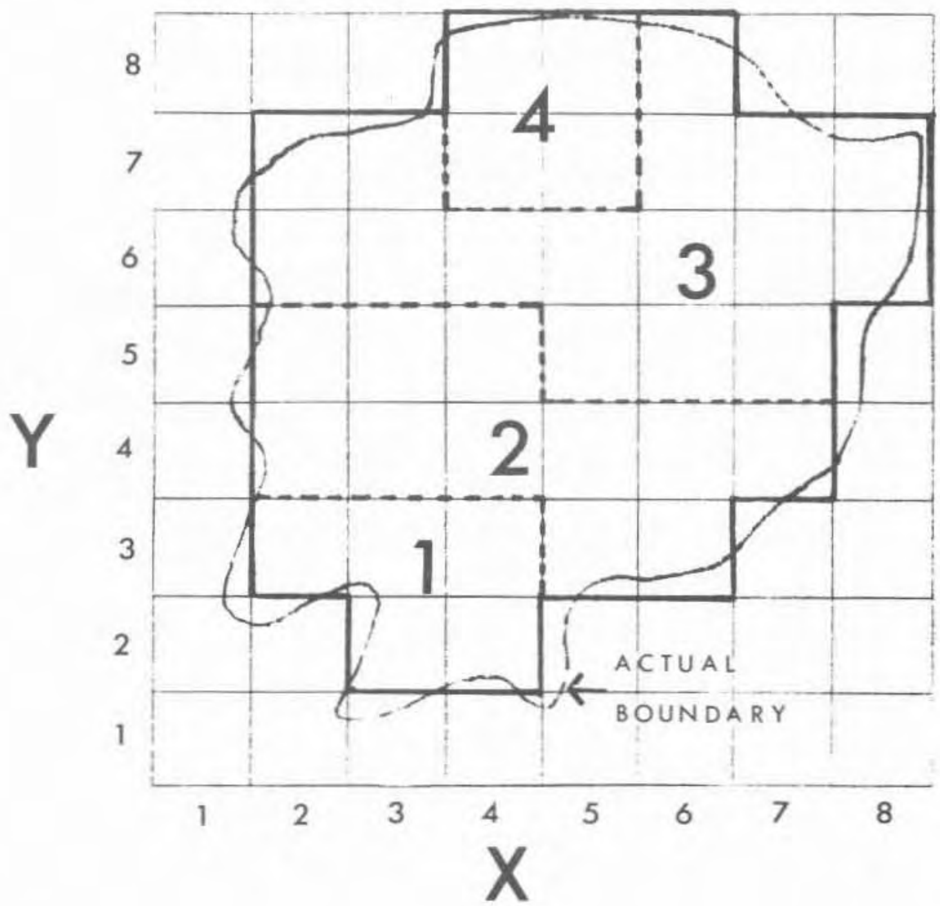
Definition of Boundaries

The first step is to define the "major" area for which information is required. It must, of course, lie within the area for which map data is stored. The boundary is defined by giving a minimum and maximum "x" (abscissa) value for each "y" (ordinate) value through which the boundary passes on the grid system. In other words, for each grid unit on the vertical axis containing part of the boundary, there are two corresponding grid units on the horizontal axis, on the western and eastern boundary, to be defined. Figure 2 gives an example.

The major area can be divided into as many as 20 sub-areas, each of which is defined in the manner described above. The restriction on number is set arbitrarily at any point in time, to allocate computer core space. When defining an area with two or more sub-areas, it is only necessary to define all of the sub-areas, not the major area. In fact, a boundary instruction for an undivided major area is treated in the same manner as an instruction for a single sub-area.

With the boundaries specified, the system will scan only the

FIGURE 2 BOUNDARY SPECIFICATION



Boundary for:	Y	X Min	X Max
Sub-area 1	2	3	4
	3	2	4
Sub-area 2	3	5	6
	4	2	7
	5	2	4
Sub-area 3	5	5	7
	6	2	8
	7	2	3
		6	8
	8	6	6
Sub-area 4	7	4	5
	8	4	5

section of the file containing grid units within and including the co-ordinate boundaries for data relevant to the specified land use.

Use Assignment

The reason for defining sub-areas is to make assignments of different uses to different parts of the area. There are two basic methods for making assignments, direct assignment and logical assignment. In each case, the assignment can be for single or multiple use.

Direct Assignment - Single Use. This is the simplest method, in which a particular use is assigned to each of the sub-areas. For example, sub-area 1 might be assigned to forestry*, sub-area 2 to agriculture*, etc. Thus the program assumes that the sub-area will be managed for that particular use alone and will produce 100 percent of the land capability (CLI or adjusted) for that use.

Direct Assignment - Multiple Use. More than one use can be assigned to a sub-area as multiple use combinations of up to three. In general, multiple use means that the full land capability for any of the single uses involved will not be attained. With the addition of a second use to a land area, the productive capability for the first one will usually diminish. The relationship between the rates at which the capability for one use diminishes as the other use increases is termed the "trade-off" curve.

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* Forestry, in the context of this report as in CLI, refers to the growing and harvesting of timber only. Other forest values are accounted for in other sectors.

Agriculture, as used for examples in this report, refers to domestic cattle ranching and related activities.

Ideally, trade-offs between the various land uses should be determined within the information system. By integrating trade-off simulation models into the system, the optimal proportion of each resource's capability that could be developed on an area would be generated from data concerning the physiographic characteristics of the land and the particular resource characteristics, including economic values. Such models are not available at this time, although one is being developed at the Pacific Forest Research Centre to establish trade-off functions between trees, grasses and shrubs.

In the meantime, the system calls for direct input from the decision-maker and resource manager. They must inform the computer what proportion of capacity can be realized for each use in a multiple assignment, on the basis of experience and knowledge of the resources and land area involved. As the trade-off is normally a continuous function rather than a point, this input requires some assumptions concerning management practices and a value judgement as to which use should be dominant. For example, one might propose that in a certain sub-area, 80 percent of the forestry capability and 30 percent of the recreation capacity could be realized, or vice versa. In defining the trade-off point, the sum of percentages of capability need not be 100 percent. Some use combinations are complementary in that an increase in one use of the land does not result in a proportional reduction in the other use, while other combinations are competitive in that an increase in a particular use results in a greater than proportional decrease in a concurrent use. Thus the percentages may sum to more or less than 100. If there is no obvious optimal trade-off point, alternate percentage combinations can be assessed by running of preliminary computations for the sub-area, and the most desirable trade-off point (in terms of percentages of capability) could then be selected.

One further technicality should be noted. The program assumes that the concurrent uses are fully integrated over the entire sub-area. The capability of each grid unit and of each sub-class is reduced by the relevant proportion over the entire sub-area. The alternative to this approach is to define several small sub-areas with different multiple use proportions.

Logic Assignment - Single and Multiple Use. Logic assignment is one of the most powerful and useful features of the system. Instead of making direct land-use assignments, program instructions can be used to select one of a number of proposed uses for each grid unit on the basis of the individual grid unit's characteristics as identified by its data record. Thus the program can be instructed to assign one use if the grid unit has a certain data characteristic, but a different use if it does not.

Several conditional statements can be employed for a sub-area, but one must ensure that the most restrictive statement is read first and that the group of statements are logically complete so that each grid unit will be assigned a use under one of the statements. The program reads the first statement and if the grid unit meets the condition, it assigns the specified use and proceeds to the next grid unit; if not, it reads the next statement, and so on, until it reaches the last statement, which must be an all-inclusive statement to assign a use to all grid units not otherwise assigned. The following example shows a set of logic statements, using verbal terminology:

For each grid unit in the sub-area:

> If it contains a lake of less than $1\frac{1}{2}$ square miles in area and has good fishing or stocked capability, assign to fishing use;
>
> If it contains a lake equal to or greater than $1\frac{1}{2}$ square miles and has a recreation rating higher than Class 4, assign to recreation use;
>
> If neither condition holds, assign to forestry use.

Similarly, any other parameter contained in the data base can be employed as a constraint on the use assignment. As all data in the computer are numeric, such instructions must be translated into computer language, identifying the constraint as an integer falling within the allowable range for the particular data field, and using one of the following "operators": greater than, less than, equal to, greater than or equal to. As many as 100 logic statements are permitted at this stage for the whole of the area under consideration.

Optional Instructions

In addition to the instructions required to operate the system, a number of optional instructions are available which result in additional information print-out. At present, four such options are available, although others can be added at will. The options now in use are a listing of use assignments and boundaries for each sub-area, a map of the area and assigned uses resulting from the instructions, and a listing of present use by assigned use combination, and can each be requested by specifying "yes" or "no" at the beginning of the run.

If required, a listing that "flags" grid units, for which the land-use assignment results in a situation potentially harmful to the environment, can also be requested. At present there are 20 such situations that can be flagged. At the beginning of a run a check for any or all of these situations can be specified. For example, the decision-maker may wish to be informed if a mining operation would occur on a stream with spawning potential immediately downstream, or if certain types of recreation are proposed on a high quality ungulate winter range area.

ACCUMULATION OF PHYSICAL DATA

Once area boundaries and uses have been determined, the program proceeds to the data accumulation stage. This process calculates the major area's capability for producing resource commodities, in terms of area, resulting from the land-use proposal. This information is summarized in a series of matrix tables called accumulators.

The accumulation procedure operates on each grid unit in the data base, one at a time. If the data record indicates that the unit is within the major area, the program determines the sub-area and use, calculates the proportion of capability that can be realized, and stores the result in the appropriate accumulator. Subsequent grid units are examined in the same manner and the results added to the previously accumulated capability for the relevant accumulator.

There is at least one accumulator, usually by CLI class and species or sub-class, for each resource sector or land-use. At present, there is one accumulator each for forestry, agriculture, recreation, waterfowl and mining, two accumulators for present use (assigned use x present use status, and forest types x administrative unit), and two accumulators for fishing (stream, lake). Wild ungulates has three accumulators - CLI Class x species, for (1) total theoretical capability, (2) winter range adjusted by range condition, and (3) winter range adjusted by range condition and the proportion that can be removed by hunting (see Appendix A3). Such multiple accumulators are required if sub-sets as well as the total of capability data are required either for print-out or for the economic subroutines, or if transformations of the data are dependent on other characteristics of the grid unit (such as range condition contained in the data file.)

Two current limitations of the program should be considered at this point. For the sake of efficiency, system design is such that once the data concerning a grid unit reaches the relevant accumulator, the unique identity of that grid unit, including the sub-area to which it belongs, is lost. Hence, any manipulation of that data or process of identification which is based on the unit's characteristics or geographical position must be accomplished before this point. Secondly, because one grid unit at a time is passed through this process, it is not possible for the system itself to take account of contiguous grid units in order to set minimum or maximum constraints on the size of area in a given use. The onus of setting constraints must fall to the user of the system during the process of establishing a land-use proposal. These constraints would ensure that a sub-area would be technically and economically viable, while not so large as to drastically alter market conditions for the product. However it is unlikely that within the area of any particular land-use planning exercise the total production would be anything more than a small proportion of the total supply (except for certain types of recreation.)

At the accumulator stage, capability is still in units of area but this does not mean that the summation of these capability figures is equal to the actual area. This apparent anomaly results from: (i) adjustments to capability which occur prior to accumulation because they depend on the data record of the individual grid unit (such as adjusting downward for poor range condition); (ii) removal of part of the area from the accumulated area (subtracting area of lake surfaces from land-based sector accumulators), and (iii) proportional reduction of capability for a given use due to multiple-use configurations. In addition the summed entries do not remain in whole units, for the above reasons and also because CLI ratings may be complex (e.g. 80% class 2, 20% class 3). Table 3 represents a typical accumulator matrix at the end of the process.

Table 3: Hypothetical Accumulator Matrix

Agriculture	Irrigable	Unirrigable	Total
	(square miles)		
CLI Class 1	.0	.0	.0
2	.5	.0	.5
3	12.2	0.8	13.0
4	16.2	10.5	26.7
5	2.9	18.2	21.1
6	0.9	8.5	9.4
7	.0	1.6	1.6

In this example, there is the equivalent of 12.2 square miles of Class 3 irrigable agriculture capability resulting from the land-use assignment.

ECONOMIC SUBROUTINES

When the accumulation of total equivalent areas for each sector is completed, the program directs each accumulator's total to the economic subroutine for the relevant resource sector. Each subroutine is unique, but all have the purpose of converting area into physical production which, in turn, is converted into economic parameters. Sectoral flow charts are presented in Appendix A, and only a summary for each sector is given in the text, below. Each sector is described from the beginning of the accumulation stage to indicate the type and origin of data entering the subroutine.

Forestry Sector

Forestry capability data are accumulated directly from the CLI Forestry maps, resulting in area equivalents by class and species. It can also be broken down by administrative unit. The forestry sector is the most straight forward for converting areas to physical product because the CLI classes are based on ranges of mean annual increment of wood volume. Under sustained yield forest management of second growth areas, the volume increment approximates allowable cut and hence the volume of wood harvested.* This volume is adjusted downward to reflect transitional unstocked areas, cull and waste in harvesting, etc. It could also be adjusted for changes in management practices to techniques other than those assumed by CLI. Introduction of a forest fertilization program, for example, could result in an increase in yield by some average factor.

Timber volume is broken down into log grade and type (pulp logs, sawlogs, peelers and miscellaneous), depending on industry structure in

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* CLUIS does not take account of old-growth timber which also affects the quantity of timber harvested. In the case study area there was very little mature timber and volume increment in second growth stands does approximate allowable cut. For other areas an allowable cut subroutine will have to be developed.

the region, end-use policy and log grade data. This allows conversion into various products using known conversion factors, resulting in volumes of lumber (dimension and boards), plywood, pulp (from bolts, if relevant, and chips) and miscellaneous products, including shakes and poles, depending on species.

Estimated production is multiplied by current (or expected average) market price for each product to obtain sales revenues. Using average or mill-specific ratios, these are translated into value added and employment, each of which is totalled over all products. Sales revenue less estimated transfer of funds from the region, times an income multiplier provides net regional income.

Agriculture Sector

The subroutine for the agricultural sector is based on beef cattle ranching, the only significant agricultural production possibility in the case study area. Thus the major agricultural use of land is for cattle grazing. Two ancillary products are included, fodder production and Christmas trees. With the former, it was assumed that the region would be self sufficient, producing just enough fodder for its winter feed requirements. A level of Christmas tree production which would not reduce total range carrying capacity and which would be primarily aimed at preventing forest succession on rangeland is also assumed.

The physical data base in agriculture is less well defined than in forestry. CLI gives ratings that reflect the degree of limitation to the production of a wide range of crops, rather than a quantitative ranking of productivity. Class 1 has no limitations imposed by soil conditions on the range of crops; Classes 2 and 3 have moderate and moderately severe limitations; Class 5 lands are suitable only for the continuous growth of hay and pasture, and Class 6 lands can be used only for open grazing.

For the principal activity, grazing, an average animal carrying capacity for native range (Classes 5 and 6) was estimated from reports on file with the B.C. Department of Agriculture, and this was used as a basis for ranking those classes as well as extrapolating for Classes 3 and 4. Fodder production was estimated in the same way for Classes 1-3, and for Christmas trees (Classes 3-6), unlike other products, a larger number of such trees were permitted on the lower land class because of much reduced animal carrying capacity.

Potential yield per grid unit in terms of animal-unit-months (A.U.M.)* for summer range, tons of hay and number of Christmas trees is thus accumulated. True utilization, however, requires the areas in fodder and range (which are assumed completely separate) to be calculated on the basis of summer and winter AUM requirements. This, in turn, is based on herd composition (cows/yearlings/calves) in both summer and winter as well as food requirements of each age group. Having calculated the optimal summer/winter AUM ratio, the program assigns agricultural capability, converted into AUM capacity, to fodder production (starting at the highest class) and summer range until all land is assigned in the optimal ratio.

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* An animal-unit-month is the food required to sustain one mature animal for one month. In this subroutine, the animal unit is an adult cow. Younger animals require only part of an AUM per month.

With the number of summer AUM defined, herd size can be determined, of which certain proportions of cows, yearlings and calves are sold each year. The number of animals is converted into live weights which, times a market price per hundred weight for each type of animal, results in selling value and the other economic measures based on selling value.

Fodder, because it is used within the region, does not result in direct economic returns, although its value and employment effects are included in beef sales. The economic returns from Christmas trees result from the number of trees cut annually (the proportion cut is the inverse of the number of years in the rotation period) and their market value.

Wild Ungulate Sector

Ungulate maps are used as the physical data for big game hunting activity. This was an important economic sector in the case study area. Hunting and observing of big game is a sub-class of the CLI Recreation maps, but development of hunting within the recreation subroutine would not have been satisfactory.

According to historical data, the level of hunting activity is more a function of number of game animals than size of area, so it is necessary to take account of land productivity for producing game within the region. This is not provided by the recreation maps, but by the ungulate maps. In fact, the size and quality of area available for big game winter range is the constraining factor on game populations and hence hunting activity. One of the major conflicts of land use in the case study area was that between big game, domestic cattle and forest succession on the winter ranges. The actual location of the hunting activity, however, was not considered important as long as it occurred within the region.

The system, at present, allows hunting as the only economic activity stemming from wild ungulates. It is recognized that non-consumptive uses, such as viewing, are important components of the total benefits gained from wildlife management.* Because of the great methodological and practical difficulties involved in measuring such benefits, as well as the need for further theoretical exploration of the subject, no direct account is taken of non-consumptive benefits. However the system does facilitate their consideration in an economic framework. A net opportunity cost of assigning land to ungulate use can be calculated by determining the amount of revenue, net regional income or employment that is foregone by not allocating the land to alternate uses. Thus the subjective value of non-consumptive benefits can be placed in economic perspective. If the economic impact of hunting is in itself greater than that of alternate uses, the opportunity cost is negative, and non-consumptive uses can be ignored for purposes of land allocation.

The accumulated winter range area, adjusted by range condition and the proportion of each species that can be hunted, is the data that enters the subroutine stage. The adjustment for huntable proportions is based on the average proportion of each species that can be harvested in any given year. This is dependent on herd population dynamics, game

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* Remarks in this and the following paragraph apply equally to other sectors, described below, involving non-consumptive uses - wetland wildlife, certain types of recreation and fishing.

management objectives and range condition. If required, the system can also calculate the amount of summer range available to ensure a balance between summer and winter range. This is not usually a problem, however, as summer range is at high altitudes and generally outside of land-use conflict areas.

One additional capability class was created for ungulates. Because Fish and Wildlife Branch records indicated that there were a few small but extremely productive winter range locations in the study area, a "super" class was created with over double the normal Class 1 carrying capacity.

Area equivalents are converted into the number of animals, by species, that can actually be produced and hunted. The number of AUMs that the land is capable of producing within each CLI class is known. Such data are expressed in white tail deer units (in the study area). Hence, where other species are identified, these units must be converted into those of other animals, e.g. one mule deer AUM is the equivalent of 1.2 white tail units*, one mountain sheep unit the equivalent of one white tail unit, etc. Where multi-species classes were indicated, a proportional breakdown of the grid unit into the different species columns in the accumulators is necessary, the actual proportion depending on number of species indicated and position in the species code.

The number of animals that can be removed from the population of each species is multiplied by the inverse of the expected hunter success

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* CLI maps do not differentiate white tail and mule deer. For purposes of food requirements only, it was assumed that the populations were even in numbers and each deer requires an average of 1.1 AUM.

ratio (number of hunters per animal of each species killed) and broken down into foreign, including Canadians from other provinces, local and other British Columbia hunters. Such conversions are based on historical data for the study area. This results in the annual number of hunters by origin. The daily expenditure and length of stay in the region are known, and allow calculation of total expenditures (the equivalent of sales revenue) and the other economic measures as in the other sectors.*

Wetland Wildlife (Waterfowl) Sector

CLI classes for waterfowl were grouped, on the basis of class definitions, into good, fair and poor marshes for the conversion of area directly into potential hunting capability. Space standards developed by the Ontario Department of Lands and Forests, in terms of hunters per acre of good, fair and poor marsh, were used. The number of hunter-days per day is multiplied by the effective number of days in the open season for migratory birds (based on four full days per week) to determine the total number of hunter days, by hunter origin. This number is adjusted by a factor (as was the wild ungulate sector) to take into account the number of days spent in the area without actually hunting by foreign, local and other B.C. hunters. Daily expenditure by hunter origin times the total number of hunter days provides total expenditures and the relevant conversion factors applied to derive value added, net regional income and employment.

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* Value added in the wild ungulate, waterfowl, recreation and fishing sectors is defined as being the same proportion of expenditures as it is of retail sales, including accommodation services, as such expenditures are primarily income to the retail sectors.

Recreation Sector

By far the most complicated subroutine, the recreation sector, is based on space utilization standards and data (or assumptions) concerning the amount of each type of recreation used concurrently by various types of user.

The CLI maps identify 25 different sub-classes or types of recreation. The main difficulty with the CLI data is that it is a largely subjective ranking of recreation capability, reflecting the "quantity" of recreational use that a land unit can attract and sustain without undue deterioration of the resource base. There are usually three types of recreation included in each classification, any one of which, or some combination of them, determines the actual CLI class.

Such a classification system presents problems for a generalized method of determining economic effects of using the recreational capability. CLUIS requires an estimate of capacity for each type of recreation for various land units, and actual utilization in terms of visitor days within a complex recreational activity structure.

To simplify the accumulation process, the 25 sub-classes or types of recreation are consolidated into eight "groups" - (1) beach activities, (2) canoeing, (3) factors yielding quality extensive recreation, (4) specific site capabilities of recreational interest (5) camping, (6) cottaging, (7) boating activities, and (8) skiing. CLI sub-classes for angling, upland wildlife and wetland wildlife were ignored in this subroutine as they have their own subroutines.

Table 4: Derivation of Recreational Groups

Group Definition	CLI Sub-classes included in group
1. Beach activities	B. Beach D. Deep inshore water
2. Canoeing (river) Canoeing (lake)	C. Canoeing -
3. Factors yielding quality extensive recreation	E. Recreationally significant vegetation M. Small surface waters P. Cultural landscape patterns Q. Variety in topography or land and water permitting a variety of activities R. Rock formations V. Viewing
4. Specific site capabilities of recreational interest	F. Waterfalls or rapids G. Glacier viewing or experience H. Historical or archaeological interest J. Gathering and collecting L. Landforms T. Thermal springs X. Other features Z. Man made structures
5. Camping	K. Organized camping
6. Cottaging	N. Lodging (cottaging)
7. Boating activities	U. Deep water boating Y. Family boating
8. Skiing	S. Skiing

Recreational capability is accumulated from the CLI recreation map in conjunction with the lake map. The unit of measurement is not always area in terms of grid units, but varies with the nature of the recreational activity. For those activities which are land area based, capability is accumulated for the proportion of the grid unit remaining after the area of lake surface in that grid unit is subtracted. These activities are camping, skiing, extensive and site specific groups. Other land based activities are lineal in concept because they are related to lake frontage. In these cases, beach activities and cottaging, the unit of measurement is that of lake perimeter within the grid unit, in quarter miles (lineal).

Water based activities include boating and canoeing. The accumulation of boating capability, in terms of lake area, is complicated by the fact that CLI classifies only the land bordering water bodies. Hence CLI's sub-class "U" is defined as "shoreland fronting water suitable for yachts and other large craft...." Access must be available to the water. Some grid units bordering the water body may not be classified as boating capability if there are three more important sub-classes to be displayed in the code or, more importantly, because the particular grid units do not allow access to the water. Also, grid units in the middle of large water bodies may have no classification, yet these sections of water can absorb recreational capacity that can be attributed to the recreation land use as long as sufficient access is available somewhere on the water body.

To surmount this problem, boating capability is determined from the lake maps. If the CLI data indicate a boating sub-class, the area of lake within the grid unit is automatically accumulated. If not, but the lake file indicates part of a lake that is in total size larger than a specified minimum (currently 1.5 grid units or approximately 1000 acres), the area of the lake within the grid square is also accumulated.

An identical process is followed for lake canoeing, which is not specifically identified within CLI. The only difference is that a maximum size is set, usually the same size as the minimum for boating. Thus all lakes between 160 acres (minimum size for identification for a single lake or group of small lakes) and 1000 acres are at present assigned to canoeing. In addition, river canoeing, identified by CLI, is accumulated in terms of miles of river.

One further step is required before accumulation takes place. When more than one recreational activity occurs within the same grid unit, the total capability for each activity cannot be realized in many cases. There is a trade-off between activities within the recreation sector. Capability data for multi-activity sectors are passed through a trade-off matrix to reduce individual activity capabilities as necessary.

The accumulated area capability entering the economic subroutine is transformed into potential capacity, using space standards such as number of campsites per acre. The theoretical and practical problems of defining optimal capacity for a specified level or "quality" of recreational experience, a function of the degree of crowding, were ignored in favor of adopting space standards recommended by the U.S. Bureau of Outdoor Recreation and similar agencies. The daily capacity is multiplied by an estimated season length for each activity to determine total annual capacity, which is summed over CLI classes.

The difficult part of the program is to convert capacity into projected economic values, which are a function of visitor origin. Five types of recreationist are recognized: cottagers, campers or origin within the region (local campers), campers from outside the region (visitor campers), local recreationists who do not camp (local day-users), and those from outside the region who do not camp (visitor day-users). It is assumed that the latter type stay in motels or hotels within the region one night for every day of recreation capacity utilized. In addition, campers are subdivided into those who use only camping facilities and those who engage in other recreational activities in the area. All of these ratios have been assumed for current purposes.

To specify what proportion of capacity for the various recreational activities are used by the different types of recreationist, a use-priority structure was assumed. The program assumes that cottagers, the number of whom is determined by cottaging capacity, have first call on other activity capability, the mix and amount of which is also assumed. The program must check, of course, that the amount of capacity of any given activity utilized does not exceed that available. If it does not, the amount of each activity used by cottagers is stored; if it does, the maximum capacity figure is stored.

This process is repeated for campers, who are assumed to have second priority, and the remaining capacity, if any, is assigned to day-users. The proportions of visitors vs. locals for campers and day-users are constant for all activities. The result is a matrix of capability in terms of man-days for all activities and each type of recreationist. An example of such a matrix is given in Table 5. These values are multiplied by those in a similar matrix with estimated expenditures per man-day, the result of which, when summed, is total annual expenditure by local and visitor recreationists. This is converted into value added, etc., in the same way as for the wildlife sectors.

Table 5: Hypothetical Annual Recreation Capability-Matrix

Type of recreationist	1	21	22	3	40	41	5	6	7	8
	Activity Group* — recreation man-days									
Local camping	2095	467	821	2670	10,500	1050	0	0	2308	752
Local day-user	4787	2505	1455	8180	0	0	0	19,861	1215	6509
Visitor camping	6150	252	704	4788	21,540	2100	0	0	3042	2497
Visitor day-user	2429	402	507	3965	0	0	0	24,105	240	315
Cottaging	650	104	312	844	0	0	3120	0	312	210

* Key to activity groups

1. Beach activities
21. River canoeing
22. Lake canoeing
3. Boating activities
40. Camping and using other capability
41. Camping only
5. Cottaging
6. Skiing
7. Extensive group
8. Site specific group

Fishing Sector

Fishing capability is calculated for four distinct fisheries - summer and winter stream fisheries, and summer and winter lake fisheries.

Stream capability is accumulated by capability and stream flow categories. For a grid unit containing a stream with present or potential fishing or spawning capability, the length of stream within the grid unit is added to the appropriate position in the accumulator. Total capability (miles of stream) is translated into summer and winter capacity by using space standards for each season (summer/winter) and flow category. Stream flow is required because larger streams have greater capacity per mile than smaller streams. Annual capacity, in fisherman-days, is obtained by multiplying summer and winter daily capacity by the respective season lengths. Lake capability is calculated in the same manner except flow is not a factor.

The total number of fisherman-days for each of the four fisheries are divided into those of foreign, local and other British Columbia origin, each of which has a different daily expenditure pattern. The annual expenditures for each fishery are added, and the other economic measures calculated in the usual manner.

Mining Sector

The mining sector of the system goes only as far as the accumulator stage. There is no economic subroutine at this time because it was not possible to convert the limited data available into estimates of potential ore production. The data merely indicates the locations of mining claims which have been tested for mineral capability, the actual minerals found on the claim, presently producing mines, and abandoned mines. In addition, the minerals map shows broad areas of land that are probably of high, medium and low potential. There is no indication of the location of potential developments or of the quality and quantity of ore that could be produced.

As a result, CLUIS can provide only an assessment of "mineral status" for each grid unit in the terms described above. This is not without value, however, as the possibility of future mining activity must be considered in land-use planning, particularly where sub-surface rights are independent of land ownership and such rights can take precedence over surface rights.

OUTPUT

Computer printout can be obtained at virtually any stage of computation. Also, a large number of economic criteria can be calculated and displayed. This section, however, describes only the output that the system is currently programmed to provide. This includes what might be described as "automatic" printout as well as "optional" printout, the latter being provided at the request of the user of the system as described on pages 24 and 25 of this report.

Automatic printout

At the end of each computation, the accumulated capability and economic implications (sales revenue or recreational expenditures, net regional income, employment, etc.) for each sector, as well as area-totals of these effects, are printed out. The various sectors also have several items of interim printout concerning the physical capability and details concerning individual products. Table 6 specifies the printout automatically produced for the seven sectors.

In relation to printout, a point discussed earlier in the report must be reiterated. At accumulation, the identity of the individual grid unit and hence the identity of sub-areas disappears. Thus it is not possible to print out information for separate sub-areas. If this is required, separate runs must be made of each sub-area unless there is only one use per sub-area and that use does not occur in more than one sub-area. Computations beyond the accumulation stage and subsequent printout are of total sectoral capability wherever it occurs in the major area.

TABLE 6: AUTOMATIC SECTORAL PRINTOUT FROM CLUIS

	FORESTRY	AGRICULTURE	UNGULATES	WATERFOWL	RECREATION	FISHING	MINING
ACCUMULATOR TOTALS USED IN SUBROUTINES (BY CLI CLASS AND SPECIES OR SUBCLASS	X	X	X	X	X	X	X
OTHER ACCUMULATOR TOTALS FOR ADJUSTED OR UNADJUSTED CAPABILITY	X		X				
MULTI-PRODUCT OPTIMIZATION DETAILS	X	X					
PHYSICAL OUTPUT OF SECTOR OR DAILY CAPACITY	X	X	X	X	X	X	
QUANTITIES OF FINAL PRODUCTS OR ANNUAL USER CAPACITY	X	X	X	X	X	X	
SALES VALUE OF PRODUCTS BY TYPE	X	X	n.a.	n.a.	n.a.	n.a.	
TOTAL SALES VALUE	X	X	n.a.	n.a.	n.a.	n.a.	
TOTAL EXPENDITURES BY USERS	n.a.	n.a.	X	X	X	X	
TOTAL VALUE ADDED (AMOUNT, STABILITY, EXPECTED GROWTH RATE)	X	X	X	X	X	X	
NET REGIONAL INCOME	X	X	X	X	X	X	
DIRECT EMPLOYMENT	X	X	X	X	X	X	

Aside from information for each resource sector, the program provides a total or weighted average for each economic criterion for the entire area. This results from adding the economic effects of each sector or, in cases of distribution, growth, and stability of value added, taking an average weighted by the amount of value added for each sector.

An accessibility table is also printed out automatically. Based on the accessibility map, it portrays the number of grid units, by use assignment, that are in the following accessibility categories:

- less that or equal to one mile from a main (paved) road,
- less than or equal to one mile from a secondary (gravel) road,
- less than or equal to three miles (but greater than one mile) from any road,
- less than or equal to ten miles (but greater than three miles) from any road,
- greater than ten miles from any road.

Optional Printout

As mentioned in the section on Instructions to the System, there are several options for additional printout. These are merely listed below with comments as to their format. Specific examples are contained in Appendix B.

Use Assignment and Boundaries - A listing in computer terminology of the use assignment statements and the co-ordinates of the boundaries of each sub-area, resulting from the instructions to the program. This is used for checking purposes.

Use Assignment Map - A computer map is printed, identifying each grid unit in the test area with its sub-area number and assigned use.

Present-use inventory - A table can be printed which shows, for each use combination assigned by the program, the number of grid units within each of the present land-use categories provided by the CLI present use maps. This allows the comparison of proposed land use status for the area with present use.

Environmental quality status - A listing can be requested to provide "warning" statements if the assigned land use for a grid unit could have a detrimental effect on the "environment" or other land uses. There are 20 different conditions that can be specified by the user. The user can specify which of these 20 conditions he wishes the system to examine. For any particular grid unit up to 5 conditions can be listed.

The format of the printout is a double table. The first part lists the "warning" statements and, for each, the grid units to which each is applicable. The second part of the table specifies, for each grid unit, the uses which evoked a statement and, in each case, the code numbers of the messages applicable to that grid unit.

FUTURE OPTIONS

The number of possible improvements and extensions to the information system, as it has been described in this report, is virtually limitless. A basic framework has been provided into which more sophisticated methods of reading and analyzing data, additional data and subroutines, and further steps in manipulating the data can be integrated. The nature of such modifications, however, is more dependent on the exact requirements of the user of such a system than was the conceptualization and basic development stages which have been completed to date. The other requirement for pursuing development is a conscious and planned program of data collection. The present system has established a data base which identifies data requirements, provides a basis for collecting more accurate data where necessary, and can easily be modified for changes to the system.

Despite the above comments, there are some extensions to the present system which the authors wish to recommend. These concern research tasks that, it is believed, are necessary to provide a more complete system for planning purposes, but have not been provided to date.

1. Time phasing. At present, economic values are provided only on an annual basis. It is, however, desirable to consider such values over a short-term planning horizon, such as ten years. This would involve projection of economic effects for the period, allowing for adjustments, taking into account changes in growth and stability factors over time. Care would also have to be taken in adjusting economic data, due to changes in market values and technology, over time. The benefit stream would include, in many cases, a phasing-in of production capability over several years where the assigned land use is not that presently occurring on an area. For example, assignment of a presently forested area to wild ungulate production may result in a period of several years before winter range is established and game populations are at the appropriate level.

   Printout for the revised measures of economic impact would probably include annual values for certain years during the period, e.g. the first and last years and the year in which full capability is attained, as well as an average annual rate of growth and the net present value of measures such as value added and net regional income over the period.

2. Change-over Cost. As described in this report, the system generates information on economic benefits, but does not take into account the direct costs incurred to achieve those benefits. Such costs would include those of management and capital input, notwithstanding any costs of changing the land from one use to another. This may have a significant impact on the decision. Although one use may have higher benefits than the other, the costs of providing those benefits may be so high as to put the proposed use at a net disadvantage, particularly when the net present worth approach is taken. Again, a simple example can clarify the issue.[1/]

1/ Envision an area of land that could be used for Forestry, Ungulate or Recreation with net present values of the net regional income measure being $16 million, $20 million and $25 million, respectively. Assuming that net regional income is the only decision variable, the Recreation option would be chosen. If the net present value of change-over and management costs were $4 million, $6 million and $15 million, respectively, presumably the Ungulate option would dominate, as the regional present net worths would appear to be $12 million, $14 million and $10 million, respectively. On the other hand, by taking into account the net regional income effect of those costs, as well as the basic income generation, with regional multipliers of 2.5, 1.0 and 0.7, it might be shown that the true net worth is more like $22 million, $20 million and $20.5 million, respectively. Note that these new regional income calculations would not include actual operating costs, as these are already taken into account in the original income multiplier.

The addition of costs to the system would involve a subroutine which would compare projected and present land use (using the present use maps) and determine an average change-over cost per unit of area, year by year, over the planning horizon period. Such costs would be either calculated or available in a data matrix.

In certain instances immediate benefits from change-overs in land use may offset costs. The most obvious example is the presence of timber which has to be removed for conversion to grazing or recreation land, and may result, if merchantable, in a net return, either in direct log sales or income and employment benefits.

In addition to these particular extensions, there are a number of significant modifications that could be implemented as techniques and data become available. These include integration within the system of an environmental quality model, more sophisticated techniques of economic analysis and the use of simulation models to generate physical trade-off functions and market variables. In addition the system could be applied to other geographical areas, the grid size could be changed and the use of sophisticated digitation and display equipment could be investigated.

CONCLUSIONS

As implied by the title of this report, CLUIS was designed as a framework to provide information for rural land-use decision making. As such, its development has been based on the economic structure of a specific and predominantly rural region of British Columbia. It is believed, however, that this information system, and in particular its basic components, could be applicable to the needs of planners in other areas.

The value of the system lies not only in providing information concerning the economic and ultimately environmental implications of broad scale rural land-use decisions. More importantly, the system provides a relatively low cost method of storing, retrieving and manipulating map information of any kind, as long as it can be expressed on a grid basis; and it provides a method of accumulating map data within defined boundaries, either on direct instructions or on the basis of any characteristic or series of characteristics defined within the data base.

Several conclusions can be drawn from the study concerning land-use planning data. Canada Land Inventory information is, in general, capable of providing a usable and consistent physical data base for estimating the economic potential of lands, within the sectors for which coverage is available. The major problem with using CLI for this system is the recreation mapping. Recreation covers a great many activities, each with its own requirements from the land base. By grouping up to three diverse activities within any given classification, the classification system not only obscures the actual land capability for each of those activities, but is forced to be somewhat subjective in its ranking.

The recreation classification would be more useful to the information system if it were broken into several sub-sectors, presenting independent classification and maps for different types of activity such as camping, boating, extensive recreation activities, wildlife viewing/hunting, etc. The maps could then provide an assessment of land capability to attract and sustain individual activities, with classes representing potential utilization levels. This would also permit the use of sub-classes that are more specific and that reflect qualitative aspects of the site.

There is one further major shortcoming of CLI coverage. It does not provide comparable data for fisheries (at least, in British Columbia) and mineral capability. These sectors are important to British Columbia and, in some ways, are the most sensitive resource sectors for land-use planners at the present time.

One of the major implications of the system is the need for up-to-date regional data. Much information exists in files, desk drawers and miscellaneous publications that is useful to land-use planning. Often, however, such information is not readily available in the desired form, or its existence is not known. Equally important, a great deal of information is lacking, particularly with-respect to actual (as opposed to CLI theoretical) land capability and economic data on a regional basis. In addition the mining, fishing, wildlife and recreation sectors have received little attention at all levels of statistical information. For the efficient operation of land-use planning, a concerted and continuing effort will have to be made to establish an accurate and consistent data base and efficient methods of storing and retrieving such data.

Finally, it is useful to reiterate what CLUIS does not do. It does not provide a tool for resource management on specific sites, nor does it provide the definitive answer or elixir for land-use planning decision makers. It does not optimize land use on an area, nor suggest the easy solution to difficult problems. It does not make the decision-makers task any easier but, by providing a system to facilitate the use and analysis of a large quantity of factual information, the output of which is only as accurate as the data provided to the system, it allows them to consider the implications of their decisions and, hopefully, make more informed and better decisions.

APPENDIX A

This Appendix provides summarized flow charts for each sector, showing how map data are accumulated and the resulting total processed through the economic subroutines. They are presented in the following order:

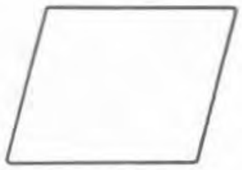
A1 Forestry
A2 Agriculture
A3 Wild Ungulate
A4 Wetland Wildlife (Waterfowl)
A5 Recreation
A6 Fishing
A7 Mining

EXPLANATION OF CHARTING

SYMBOLS

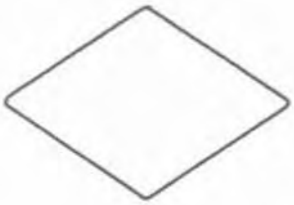
Processing Symbol

An operation performed on the input data
eg. subtraction, division



General Input Output Symbol

Input or output data
Input or output operation

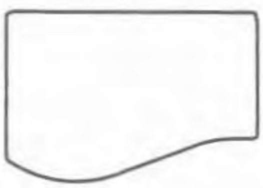


Decision Symbol

Indicates a comparison to decide and select among alternate sequences or operations

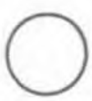
Magnetic Tape Symbol

Indicates data is stored in a file on tape--
M. D. refers to Main Data File which contains all map data on a grid unit basis



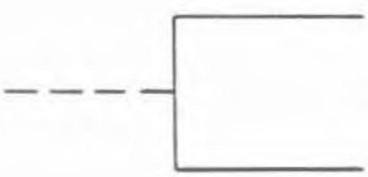
Document Symbol

Indicates hard copy output



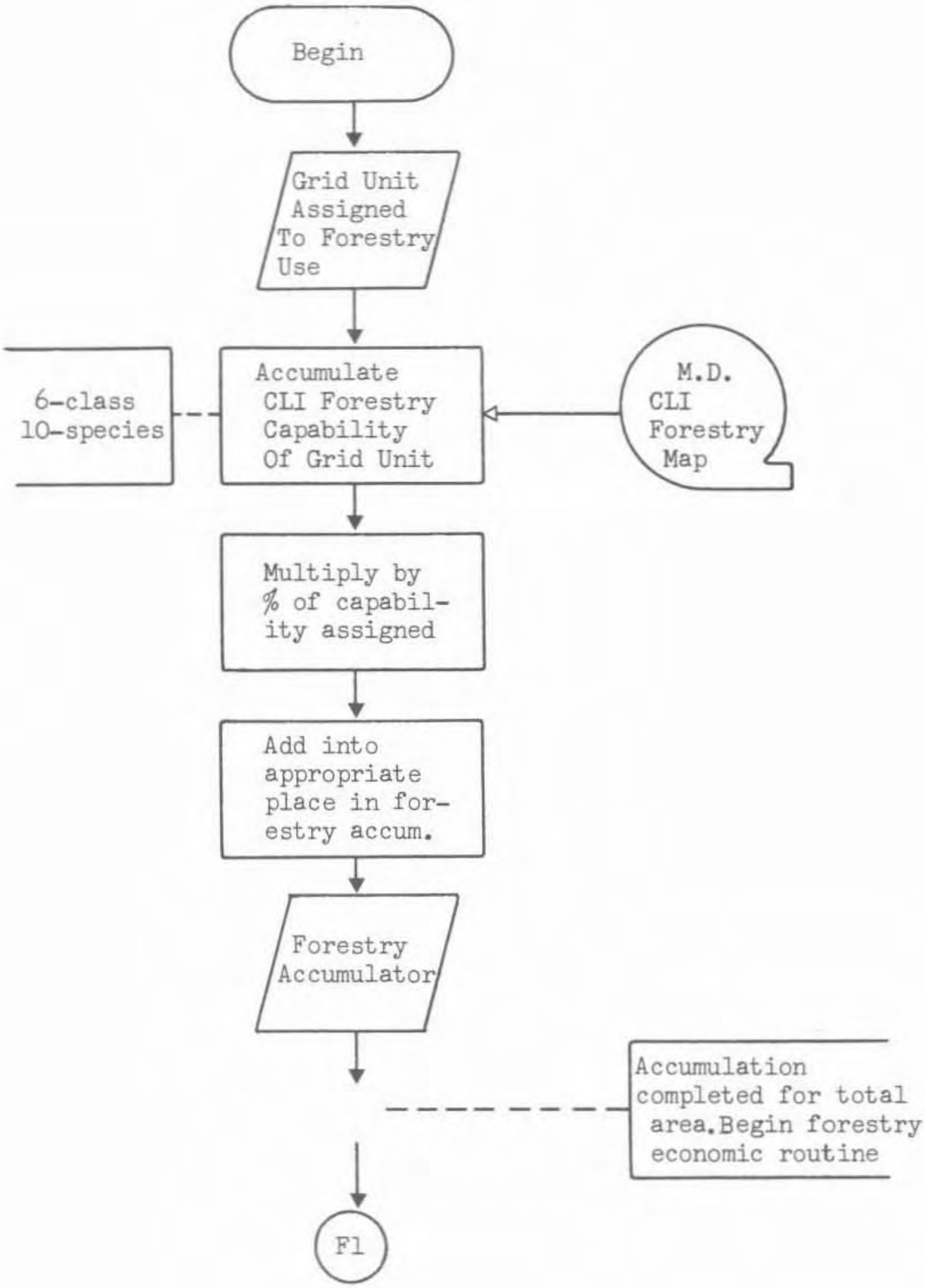
Connector Symbol

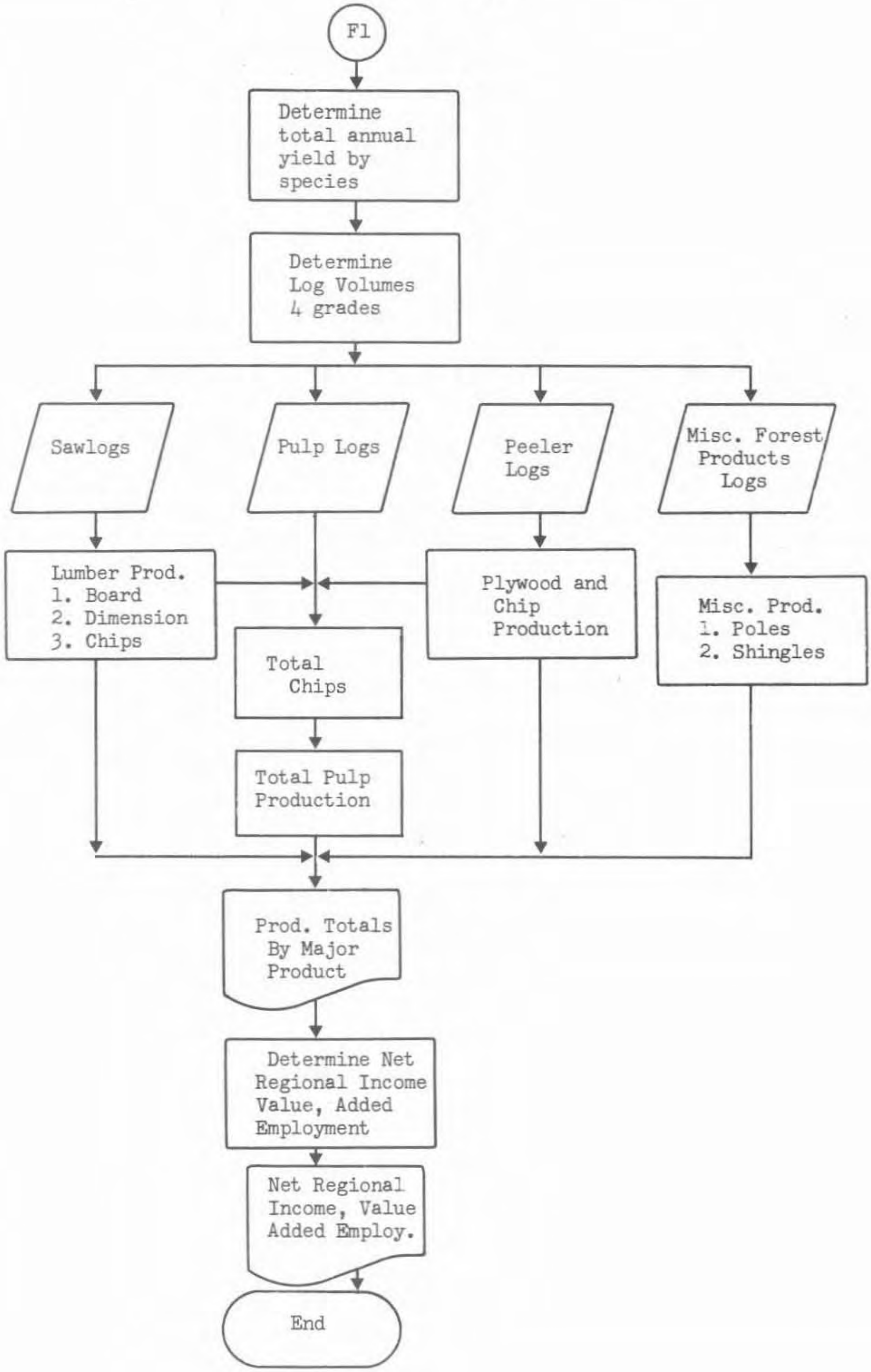
Contains a number--Look for the same number to pick up the flow



Comments Symbol

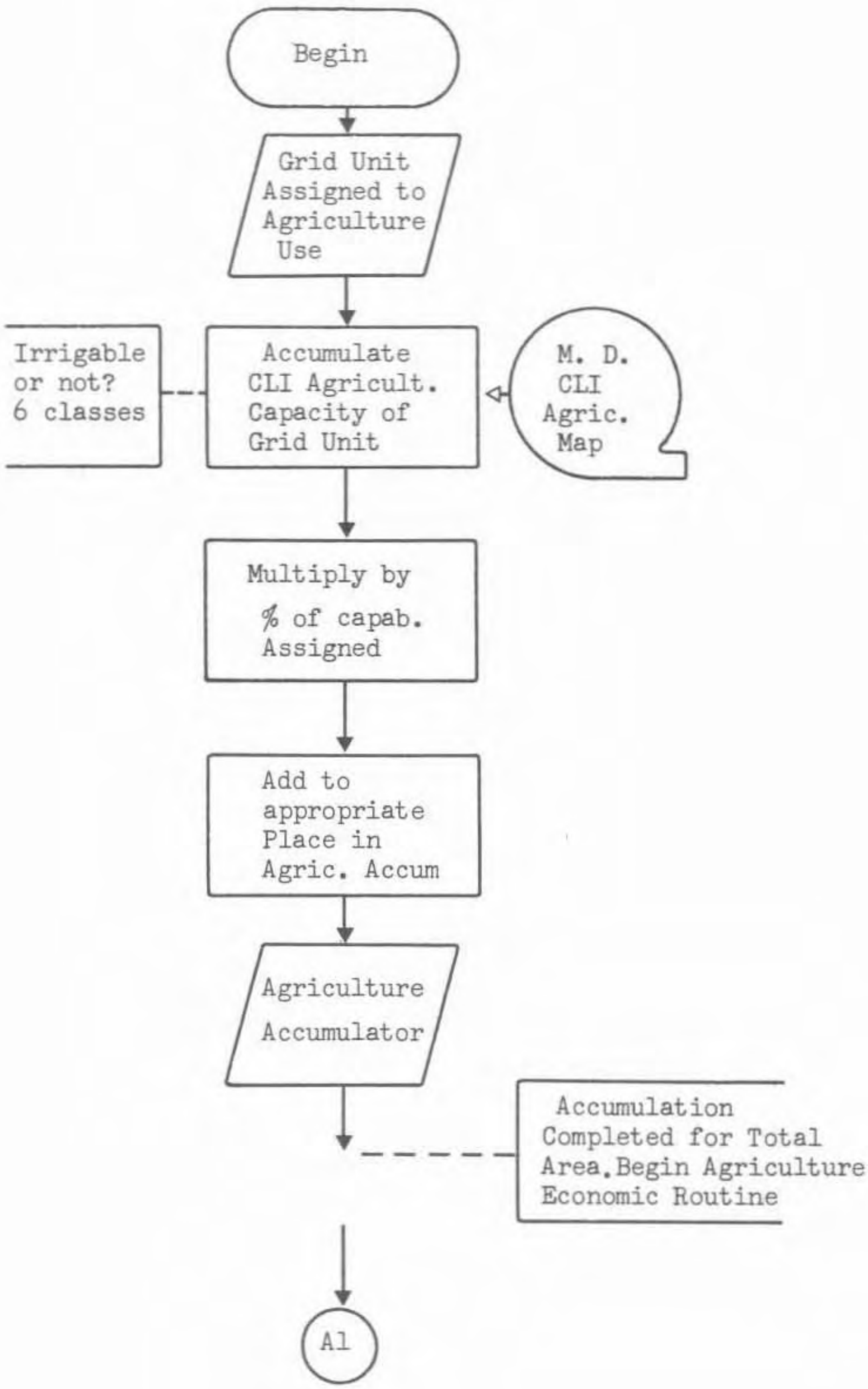
Forestry Sector
Flowcharts

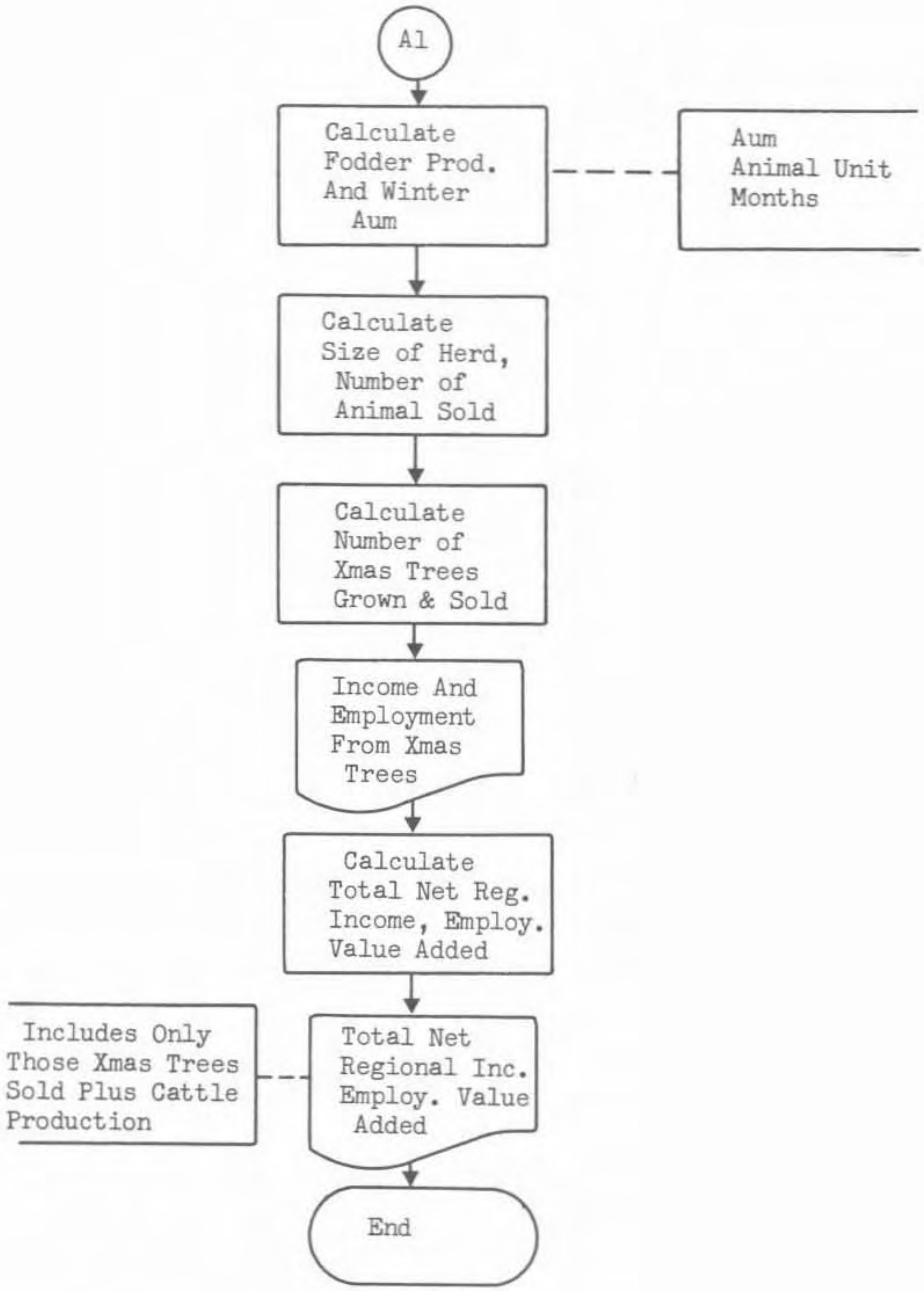



F1
Determine total annual yield by species
Determine Log Volumes 4 grades
Sawlogs
Pulp Logs
Peeler Logs
Misc. Forest Products Logs
Lumber Prod.
1. Board
2. Dimension
3. Chips
Plywood and Chip Production
Misc. Prod.
1. Poles
2. Shingles
Total Chips
Total Pulp Production
Prod. Totals By Major Product
Determine Net Regional Income Value, Added Employment
Net Regional Income, Value Added Employ.
End

Appendix A2

Agriculture
Sector
Flowchart

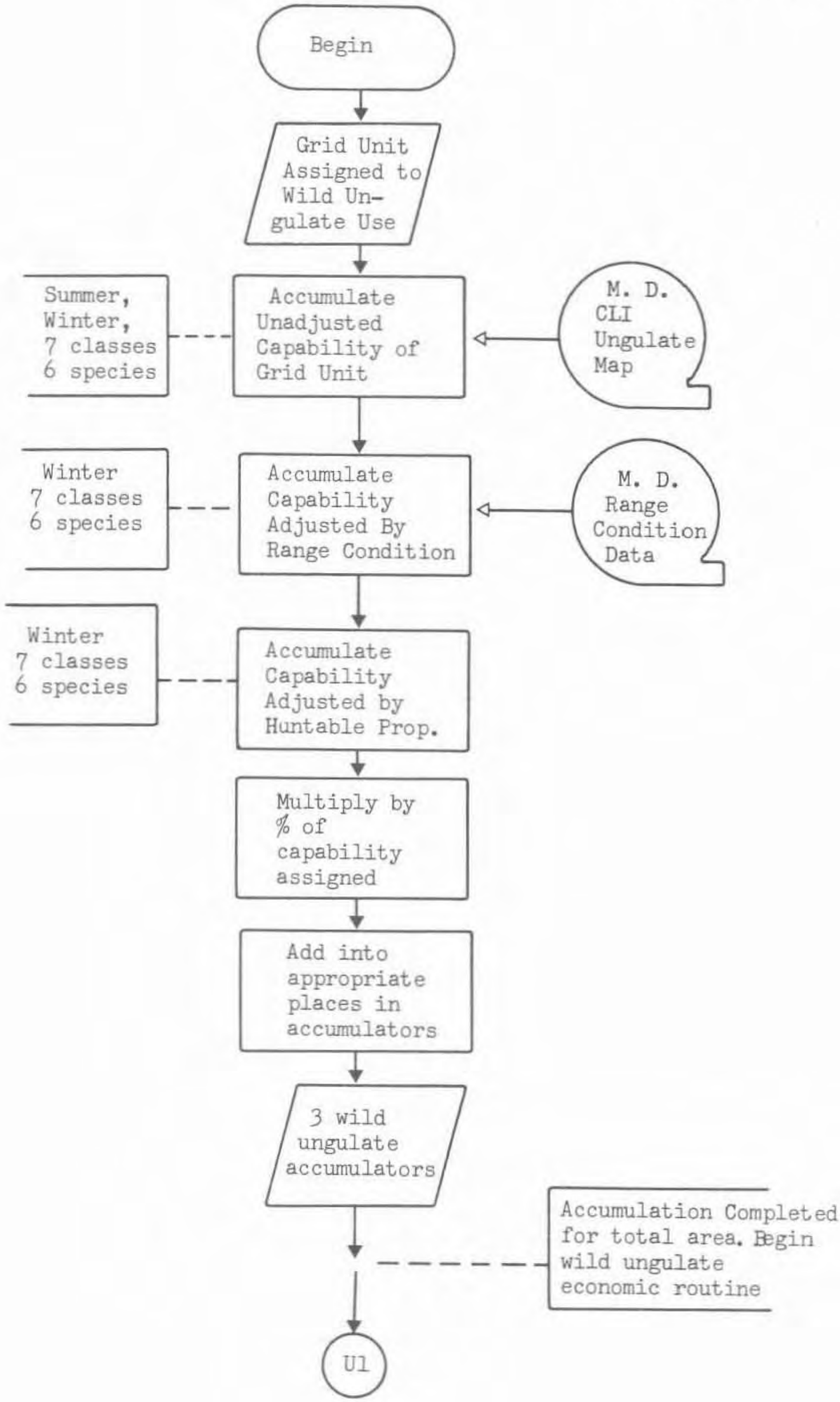


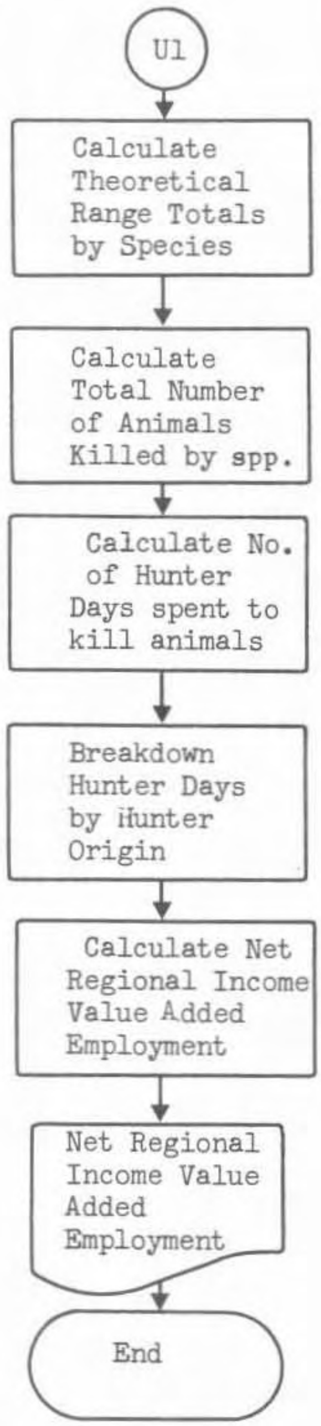

A1
Calculate Fodder Prod. And Winter Aum
Aum Animal Unit Months
Calculate Size of Herd, Number of Animal Sold
Calculate Number of Xmas Trees Grown & Sold
Income And Employment From Xmas Trees
Calculate Total Net Reg. Income, Employ. Value Added
Includes Only Those Xmas Trees Sold Plus Cattle Production
Total Net Regional Inc. Employ. Value Added
End

Appendix A 3

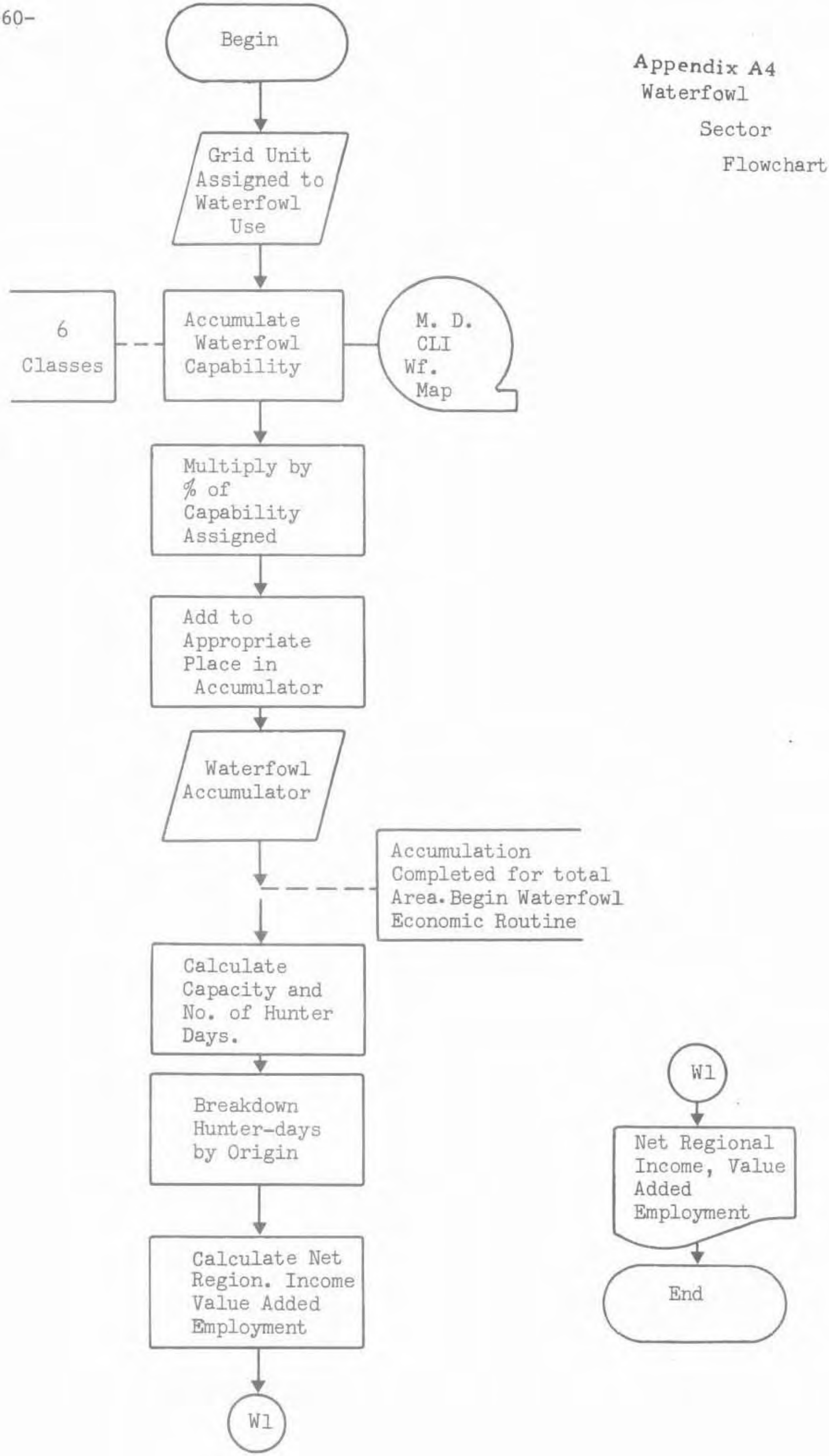
Wild Ungulates

Sector Flowchart




U1
Calculate Theoretical Range Totals by Species
Calculate Total Number of Animals Killed by spp.
Calculate No. of Hunter Days spent to kill animals
Breakdown Hunter Days by Hunter Origin
Calculate Net Regional Income Value Added Employment
Net Regional Income Value Added Employment
End

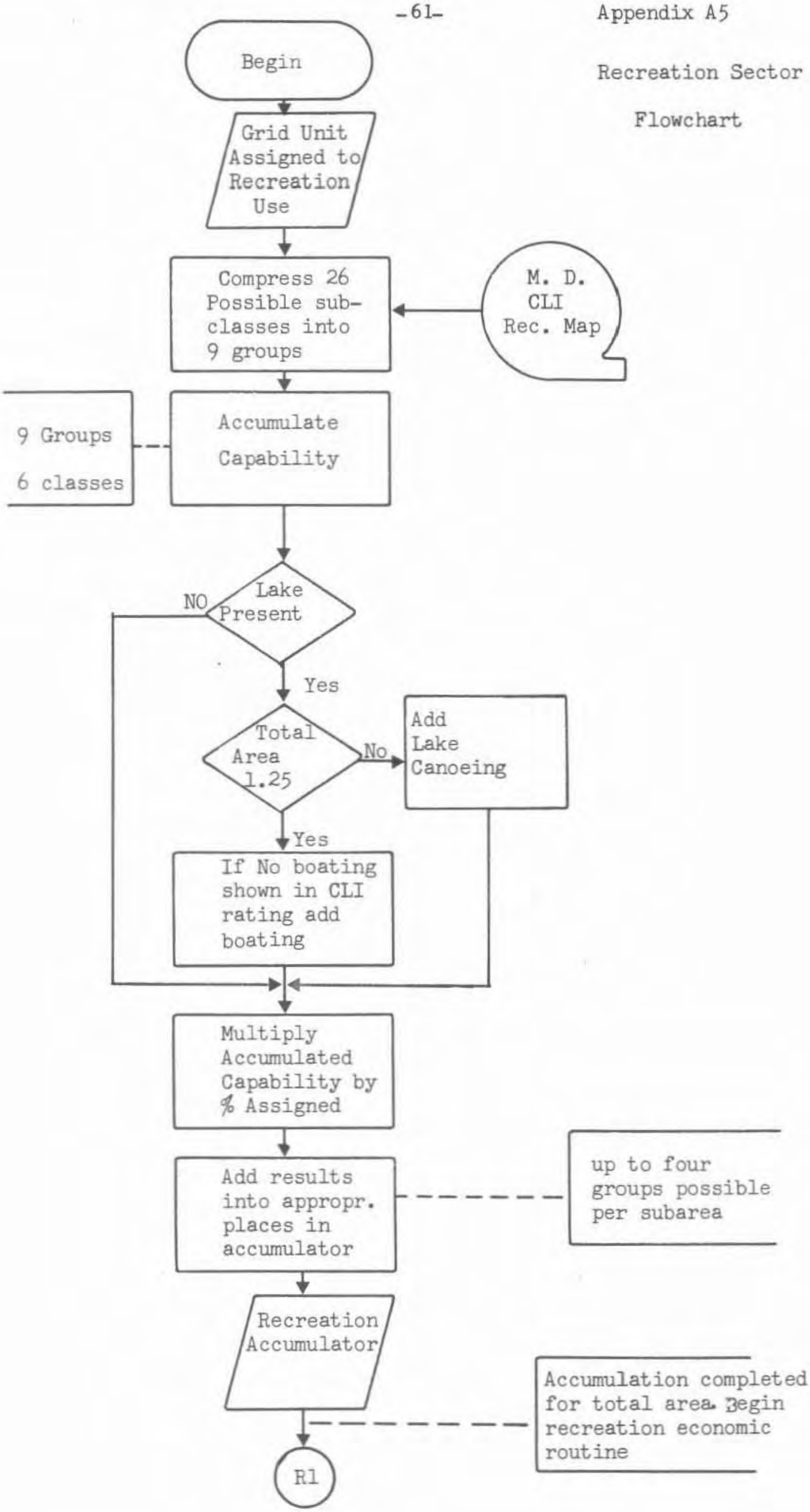
Appendix A4 Waterfowl Sector Flowchart

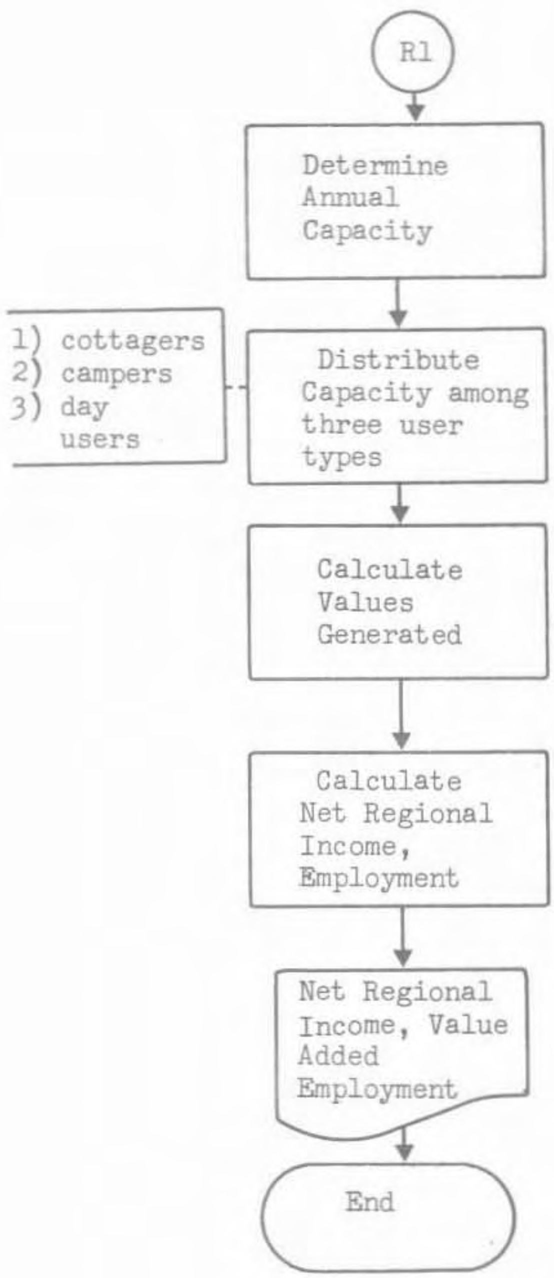


Appendix A5

Recreation Sector

Flowchart

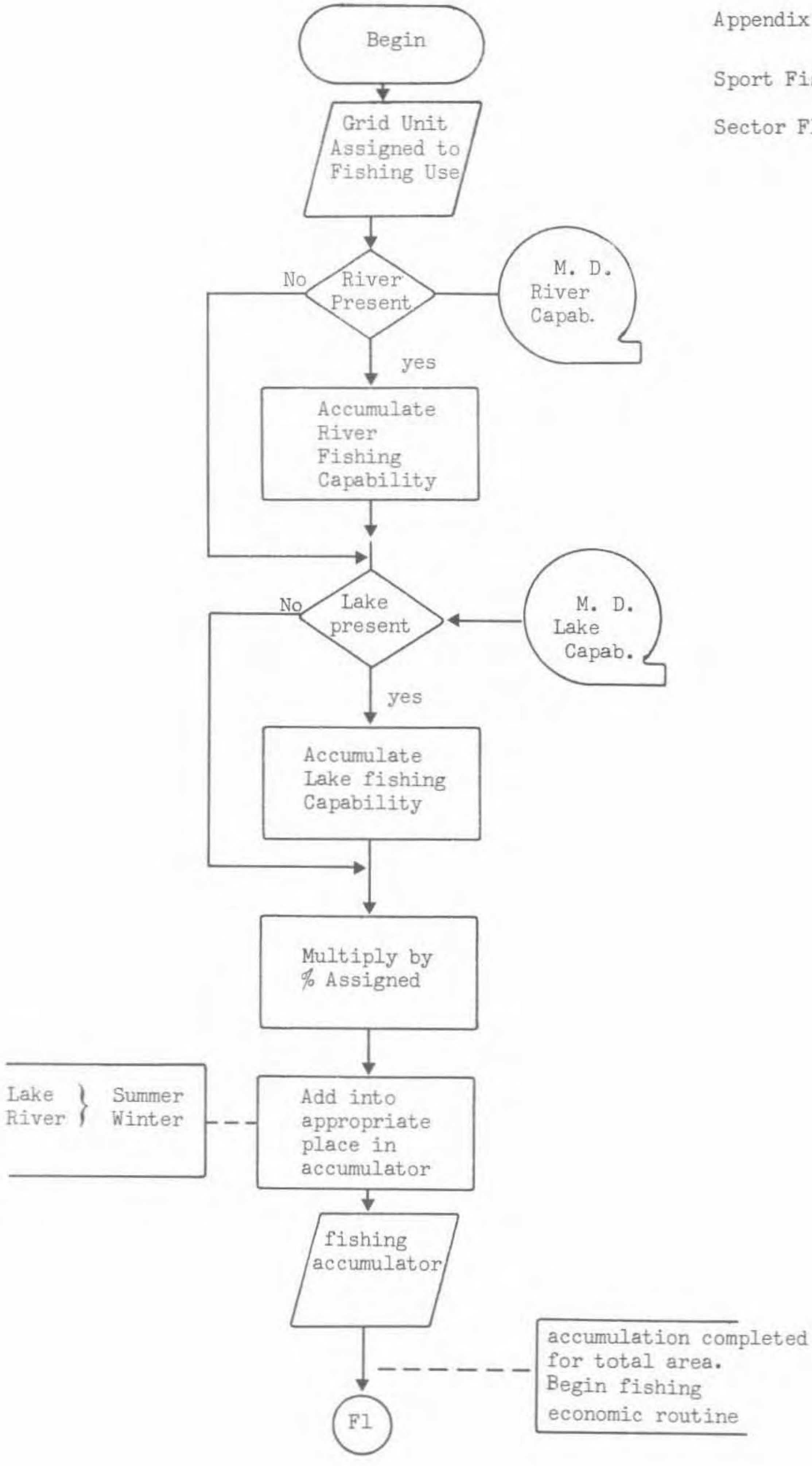


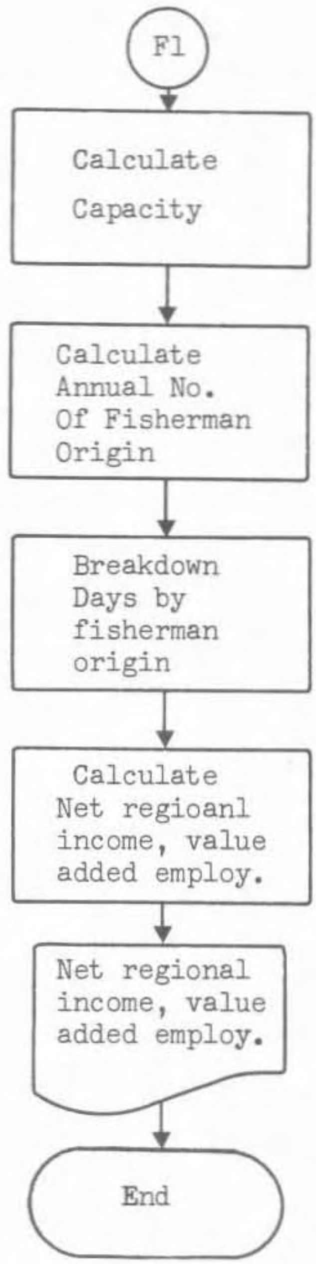

R1
Determine Annual Capacity
1) cottagers
2) campers
3) day users
Distribute Capacity among three user types
Calculate Values Generated
Calculate Net Regional Income, Employment
Net Regional Income, Value Added Employment
End

Appendix A6

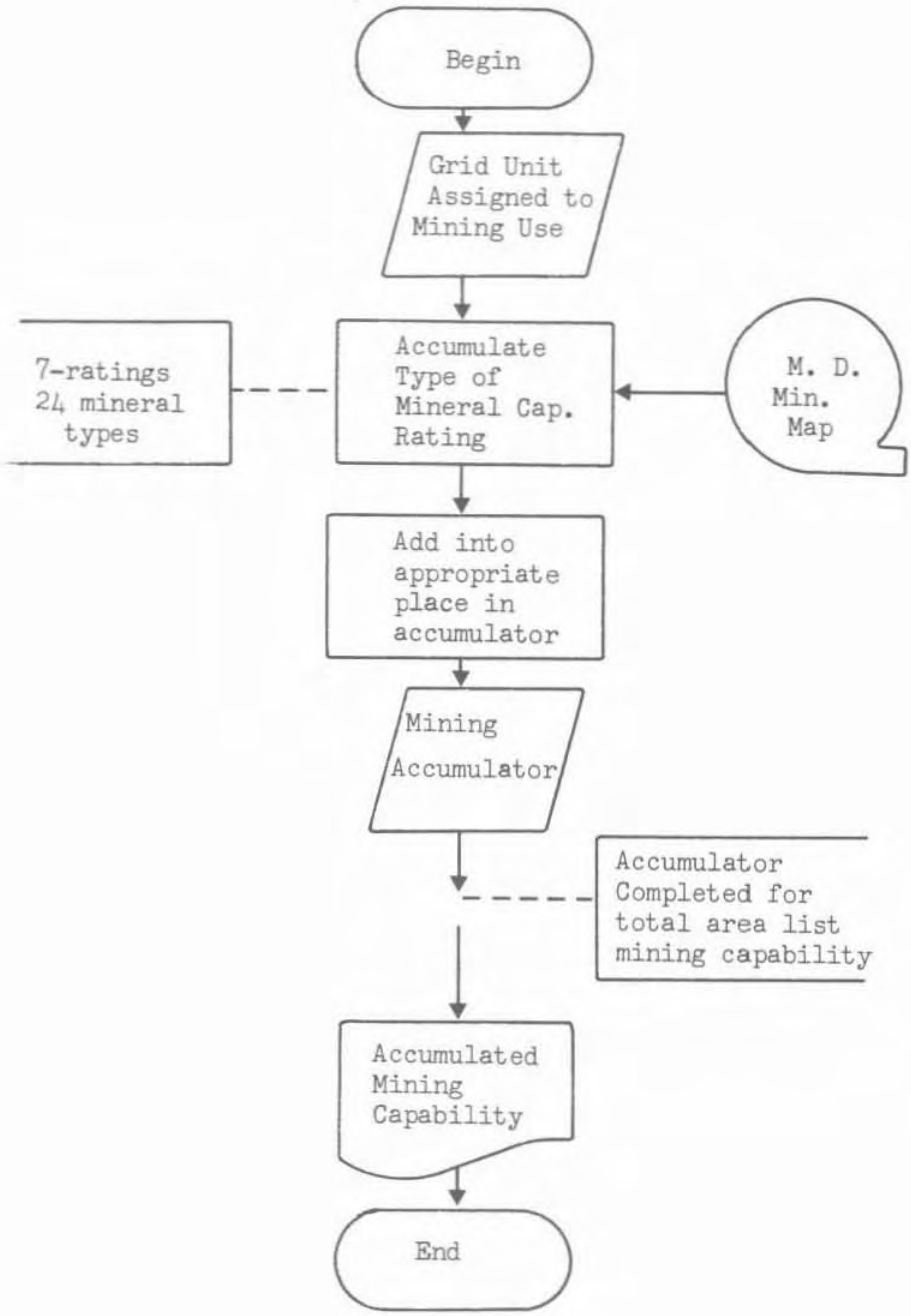
Sport Fishing

Sector Flowchart




F1
Calculate
Capacity
Calculate
Annual No.
Of Fisherman
Origin
Breakdown
Days by
fisherman
origin
Calculate
Net regioanl
income, value
added employ.
Net regional
income, value
added employ.
End

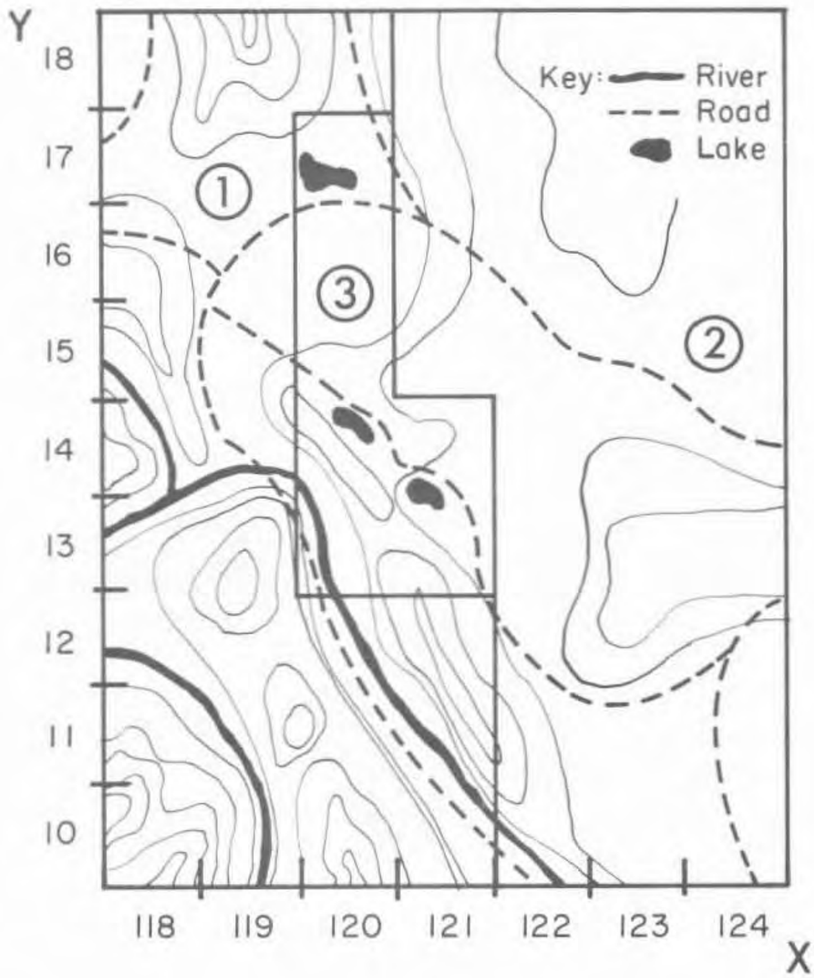
Mining Sector
Flowchart



APPENDIX B

A sample computer run, compiled for this report, is contained in Appendix B. All optional printout was requested, including a listing of the instructions to the program. The following page depicts a stylized map of the actual area processed, and a specification of the assignment instructions as they might be provided by the user of the system.

Map of sample area, showing grid units and assigned boundaries:



Appendix B

Assignment Instructions:

For each grid unit in

Sub-area 1 If there is a good fishing stream, assign 60% fishery capability: and
If Recreation class is greater than 4, assign 100% Recreation capability, or,
If Recreation class is less than or equal to 4, assign 90% Forestry capability and 20% Recreation capability:

Sub-area 2 If there is a good fishing stream, assign 80% fishing capability; and
Assign 50% Agriculture capability and 70% Ungulate capability

Sub-area 3 If there is a good fishing stream, assign 80% fishing capability; and
If there is a stocked lake, assign 80% of lake Fishing capability and 60% Recreation capability or,
If there is not a stocked lake, assign 100% Recreation capability.

CLUIS

ENVIRONMENT CANADA

FORESTRY SERVICE

PACIFIC FOREST RESEARCH CENTRE

COMPUTERIZED LAND USE INFORMATION SYSTEM

APPENDIX B SAMPLE RUN -- JULY, 1972

```
*******************************************************************************************************************
                                   OPTIONAL LISTING OF INPUT REQUESTED
*******************************************************************************************************************

                BOUNDARIES OF SUBAREA  1

                Y   XMIN   XMAX

                10   118   121
                11   118   121
                12   118   121
                13   118   119
                14   118   119
                15   118   119
                16   118   119
                17   118   119
                18   118   120


                  LOGIC STATEMENTS

         ASSIGN USE =PRF = IF FIELD :  79 GT   1 :  79 LT   4 :

         ASSIGN USE =R   = IF FIELD :  43 LT   4 :

         REMAINDER ASSIGNED   20% R,  90% F,


                BOUNDARIES OF SUBAREA  2

                Y   XMIN   XMAX

                10   122   124
                11   122   124
                12   122   124
                13   122   124
                14   122   124
                15   121   124
                16   121   124
                17   121   124
                18   121   124


                  LOGIC STATEMENTS

         ASSIGN USE =PAU = IF FIELD :  79 GT   1 :  79 LT   4 :

         REMAINDER ASSIGNED   50% A,  70% U,
```

BOUNDARIES OF SUBAREA 3

Y	XMIN	XMAX
13	120	121
14	120	121
15	120	120
16	120	120
17	120	120

LOGIC STATEMENTS

```
  ASSIGN USE =RP  = IF FIELD :  74 EQ   1 :

  ASSIGN USE =RP  = IF FIELD :  79 GT   1 :  79 LT   4 :

  REMAINDER ASSIGNED  100% R,
PART  1 COMPLETED
PART  2 COMPLETED
PART  3 COMPLETED
```

*** ROAD ACCESSABILITY TABLE ***

PROPOSED USE	MILES FROM ROAD-- TYPE OF ROAD---	< ONE MAIN	< ONE SECONDARY	< THREE ANY	< TEN ANY	> TEN ANY
AU		0	16	12	0	0
PAU		0	1	0	0	0
PRF		0	3	4	4	0
R		0	1	1	1	0
RF		0	2	3	9	0
RP		0	4	0	0	0

*** PROPOSED VS PRESENT LAND USE -- OPTIONAL OUTPUT ***

PROPOSED USE	A	B	E	G	H	K	L	M	O	P	S	T1	T2	U1	U2	X	SS
AU	0	0	0	0	0	2	0	0	0	0	0	2	18	8	0	0	0
PAU	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
PRF	0	0	0	0	0	0	0	0	0	0	0	6	5	0	0	0	0
R	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0
RF	0	0	0	0	0	0	0	0	0	0	0	5	9	0	0	0	0
RP	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	1	0
TOTALS	0	0	0	0	0	2	0	0	0	0	0	16	36	8	0	1	0

A -- CROPLAND
B -- BUILT-UP AREAS
E -- MINES, QUARRIES AND GRAVEL PITS
G -- ORCHARDS AND VINEYARDS
H -- HORTICULTURE
K -- OPEN GRASSLAND
L -- ROCK OR UNVEGETATED SURFACE
M -- SWAMP, MARSH OR BOG

O -- OUTDOOR RECREATION
P -- IMPROVED PASTURE OR FORAGE CROP
S -- SANDFLATS, DUNES OR BEACHES
T1 -- MATUREPRODUCTIVE WOODLAND
T2 -- IMMATURE PRODUCTIVE WOODLAND
U1 -- NON PRODUCTIVE WOODLAND ON A PRODUCTIVE SITE
U2 -- NON PRODUCTIVE WOODLAND ON A NON PRODUCTIVE SITE
X -- WATER SURFACE

```
     .
 18  . 1R 1R 1R 2A 2A 2A 2A
     . F  F  F  U  U  U  U
     .
 17  . 1R 1R 3R 2A 2A 2A 2A
     . F  F     U  U  U  U
     .
 16  . 1P 1R 3R 2A 2A 2A 2A
     . RF F  P  U  U  U  U
     .
 15  . 1P 1P 3R 2A 2A 2A 2A
     . RF RF    U  U  U  U
     .
 14  . 1P 1P 3R 3R 2A 2A 2A
     . RF RF P  P  U  U  U
     .
 13  . 1P 1P 3R 3R 2A 2A 2A
     . RF RF    P  U  U  U
     .
 12  . 1R 1R 1P 1R 2A 2A 2A
     . F  F  RF F  U  U  U
     .
 11  . 1R 1R 1P 1P 2A 2A 2A
     . F  F  RF RF U  U  U
     .
 10  . 1R 1R 1R 1P 2P 2A 2A
     . F  F  F  RF AU U  U
     .
     .........................................................................................................
      118    120    122    124
```

*** ENVIRONMENTAL QUALITY WARNINGS RESULTING FROM ASSIGNED USES ***

RUN TITLE-- APPENDIX B SAMPLE RUN -- JULY,1972

---------- TABLE ONE ----------

MESSAGE # 3 < .5 MILE FROM MAJOR GRAVEL ROAD

Y =	X =	USE	Y =	X =	USE	Y =	X =	USE	Y =	X =	USE	Y =	X =	USE
11	121	F	12	121	F	15	118	F	15	119	F	16	118	F
16	119	F	17	118	F									

MESSAGE # 4 < 3 MILES FROM AND WITHIN VIEW OF A MAINSTREAM GRAVEL ROAD

Y =	X =	USE	Y =	X =	USE	Y =	X =	USE	Y =	X =	USE	Y =	X =	USE
10	120	F	10	121	F	11	120	F	12	119	F	12	120	F
13	118	F	13	119	F	14	118	F	14	119	F	17	119	F
18	118	F	18	119	F	18	120	F						

MESSAGE # 5 < 1 MILE FROM STREAM WITH GOOD FISHING OR SPAWNING AT ENTRY

Y =	X =	USE	Y =	X =	USE	Y =	X =	USE	Y =	X =	USE	Y =	X =	USE
10	121	F	11	120	F	11	121	F	12	120	F	13	118	F
13	119	F	14	118	F	14	119	F	15	118	F	15	119	F
16	118	F												

MESSAGE # 6 < 3 MILE FROM STREAM WITH GOOD FISHING OR SPAWNING AT ENTRY

Y =	X =	USE	Y =	X =	USE	Y =	X =	USE	Y =	X =	USE	Y =	X =	USE
10	118	F	10	119	F	10	120	F	11	118	F	11	119	F
12	118	F	12	119	F	12	121	F	16	119	F	17	118	F
17	119	F	18	118	F	18	119	F	18	120	F			

MESSAGE #19 MINING CAPABILITY CLASS 1,2 OR 3 WITHIN LOCATION COORDINATES

Y =	X =	USE	Y =	X =	USE	Y =	X =	USE	Y =	X =	USE	Y =	X =	USE
14	118	P	14	118	R	14	118	F	14	119	P	14	119	R
14	119	F												

MESSAGE #20 CLASS 1, 2 OR 3 WINTER RANGE WITHIN LOCATION COORDINATES

Y =	X =	USE	Y =	X =	USE	Y =	X =	USE	Y =	X =	USE	Y =	X =	USE
14	118	P	14	118	R	14	118	F	14	119	P	14	119	R
14	119	F												

```
---------------------------------------------------------- TABLE TWO ----------------------------------------------------------

Y = X =  USES IN CONFLICT                                          Y = X =  USES IN CONFLICT
 10 118   F    6                                                   10 119   F    6
 10 120   F    4  6                                                10 121   F    4  5
 11 118   F    6                                                   11 119   F    6
 11 120   F    4  5                                                11 121   F    3  5
 12 118   F    6                                                   12 119   F    4  6
 12 120   F    4  5                                                12 121   F    3  6
 13 118   F    4  5                                                13 119   F    4  5
 14 118   P   19 20       R  19 20        F   4  5 19 20           14 119   P   19 20       R  19 20        F   4  5 19 20
 15 118   F    3  5                                                15 119   F    3  5
 16 118   F    3  5                                                16 119   F    3  6
 17 118   F    3  6                                                17 119   F    4  6
 18 118   F    4  6                                                18 119   F    4  6
 18 120   F    4  6
        PART  4 COMPLETED
```

*** AGRICULTURE USE TYPE 1 ***   APPENDIX B   SAMPLE RUN -- JULY,1972

ACCUMULATED SQUARE MILES

TREATMENT

CLASS	UNIRR.	IRRIG.	TOTAL
1	0.0	0.0	0.0
2	0.0	0.0	0.0
3	0.0	0.5	0.5
4	0.0	2.0	2.0
5	0.4	5.6	6.0
6	1.6	5.4	7.0
7	0.0	0.0	0.0

THEORETICAL RATIO OF SUMMER AUM / WINTER AUM = 1.039

OPTIMIZATION DETAILS

CLASS	MILES	SUMMER	WINTER(AUM)
1	0.0	225.0	6400.0
2	0.0	200.0	5200.0
3	0.5	175.0	3800.0
4	2.0	150.0	2400.0
5	6.0	125.0	0.0
6	7.0	75.0	0.0

OPTIMUM SUMMER AUM = 1589.53

NUMBER ANIMALS IN HERD = 179.61

CLASS	SQ. MI. IN RANGE
1	0.00
2	0.00
3	0.05
4	2.00
5	6.05
6	7.00

*** ANIMALS ***

	COWS	YEARLINGS	CALVES	TOTAL
NO. SOLD	29.	41.	81.	151.
VALUE	6538.	10522.	13021.	30080.

*** XMAS TREES ***

SALES VALUE = 1572.02

EMPLOYMENT (MAN YRS.) = 0.89

****

*** TOTAL AGRICULTURE ***

VALUE ADDED = 18163.08

EMPLOYMENT (MAN YEARS.) = 3.69

REGIONAL INCOME = 55817.68

STABILITY OF V.A. = 15.70

GROWTH OF V.A. = 3.02

****

ACCUMULATED UNADJUSTED WINTER RANGE PRODUCTION

CLASS	DEER	ELK	GOAT	MOOSE	SHEEP	CARIBOU
1	0.0	0.0	0.0	0.0	0.0	0.0
2	4.5	6.8	0.0	0.0	0.0	0.0
3	0.1	0.2	0.0	0.3	0.0	0.0
4	0.2	0.3	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0
SUPER	0.0	0.0	0.0	0.0	0.0	0.0

ACCUMULATED UNADJUSTED SUMMER RANGE PRODUCTION

CLASS	DEER	ELK	GOAT	MOOSE	SHEEP	CARIBOU
1	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0
3	7.8	0.0	0.0	0.0	0.0	0.0
4	1.5	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0
SUPER	0.0	0.0	0.0	0.0	0.0	0.0

WINTER RANGE PRODUCTION ADJUSTED BY RANGE CONDITION

CLASS	DEER	ELK	GOAT	MOOSE	SHEEP	CARIBOU
1	0.0	0.0	0.0	0.0	0.0	0.0
2	1.0	1.6	0.0	0.0	0.0	0.0
3	0.0	0.1	0.0	0.1	0.0	0.0
4	0.0	0.1	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0
SUPER	0.0	0.0	0.0	0.0	0.0	0.0

WINTER RANGE PRODUCTION ADJUSTED BY HUNTABLE PROPORTION

CLASS	DEER	ELK	GOAT	MOOSE	SHEEP	CARIBOU
1	0.0	0.0	0.0	0.0	0.0	0.0
2	0.2	0.3	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0
SUPER	0.0	0.0	0.0	0.0	0.0	0.0

SPECIES TOTALS

	DEER	ELK	GOAT	MOOSE	SHEEP	CARIB.
THEOR. RANGE TOTAL	503.	281.	0.	25.	0.	0.
ADJUSTED RANGE TOTAL	116.	65.	0.	8.	0.	0.
ADJUSTED HUNT. TOTAL	27.	11.	0.	1.	0.	0.

TOTAL DAYS HUNTING

	DEER	ELK	GOAT	MOOSE	SHEEP	CARIB.	TOTAL
FOREIGN	8.	110.	0.	47.	0.	0.	165.
LOCAL	1993.	2383.	0.	433.	0.	0.	4809.
OTHER B.C.	416.	581.	0.	60.	0.	0.	1057.

****

*** TOTALS FOR RUN ***

VALUE ADDED ($) 59555.45

REGIONAL INCOME ($) ... 119411.17

EMPLOYMENT (MAN YRS) .. 7.07

STABILITY OF VA. (%) ... 17.40

GROWTH OF VA. (%) 1.50

****

ACCUMULATED SQUARE MILES

SPECIES

CLASS	WS	ES	LP	PP	WP	ALF	D	WL	WH	OTHER	TOT
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	1.
4	0.	0.	6.	0.	0.	0.	1.	0.	0.	0.	7.
5	0.	0.	3.	0.	0.	0.	8.	1.	0.	0.	12.
6	0.	0.	0.	0.	0.	0.	2.	0.	0.	0.	2.

CLI - TOTAL ANNUAL YIELD (CCF)

SPECIES

CLASS	WS	ES	LP	PP	WP	ALF	D	WL	WH	OTHER	TOT
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	92.	276.	0.	0.	0.	0.	0.	0.	0.	369.
4	0.	0.	2419.	0.	0.	0.	276.	0.	0.	0.	2696.
5	0.	0.	714.	0.	0.	0.	2120.	184.	0.	0.	3018.
6	0.	0.	0.	0.	0.	0.	242.	0.	0.	0.	242.
TOT.	0.	92.	3410.	0.	0.	0.	2638.	184.	0.	0.	6324.

TOTAL ADJUSTED ANNUAL YIELD (CCF)

SPECIES

CLASS	WS	ES	LP	PP	WP	ALF	D	WL	WH	OTHER	TOT
TOT.	0.	58.	2187.	0.	0.	0.	1717.	120.	0.	0.	4081.

TOTAL VOLUME BY LOG GRADE (CCF)

SPECIES

CLASS	WS	ES	LP	PP	WP	ALF	D	WL	WH	OTHER	TOT
PULP	0.	3.	656.	0.	0.	0.	86.	6.	0.	0.	751.
PEELER	0.	9.	0.	0.	0.	0.	429.	18.	0.	0.	456.
SAWLOG	0.	46.	1421.	0.	0.	0.	1288.	96.	0.	0.	2851.
MISC.	0.	0.	109.	0.	0.	0.	0.	0.	0.	0.	109.

LUMBER PRODUCTION
SPECIES

CLASS	WS	ES	LP	PP	WP	ALF	D	WL	WH	OTHER	TOT
TYPE 1	0.	19.	782.	0.	0.	0.	837.	62.	0.	0.	1700.
TYPE 2	0.	12.	0.	0.	0.	0.	0.	0.	0.	0.	12.
CHIPS	0.	14.	583.	0.	0.	0.	399.	30.	0.	0.	1026.

MISCELLANEOUS PRICES: 15.00 0.85

MISCELLANEOUS F.P. PRODUCTION
SPECIES

CLASS	WS	ES	LP	PP	WP	ALF	D	WL	WH	OTHER	TOT
TYPE 1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TYPE 2	0.	0.	5467.	0.	0.	0.	0.	0.	0.	0.	5467.

*** TOTAL PRODUCTION BY MAJOR PRODUCTS ***

PULP PRODUCTION (TONS)	969.
PLYWOOD PRODUCTION (MFT2)	798.
SAWLOG LUMBER PROD. (MBM)	1711.
MISC. F.P. TYPE 1 (SQS)	0.
TOTAL VOLUME (CCF)	4167.
TOTAL CHIP PRODUCTION (BDU)	1938.
MISC. F.P. TYPE 2 (LINFT)	5467.

****

*** TOTALS FOR RUN ***

VALUE ADDED PULP	35455.
VALUE ADDED PLYWOOD PROD.	32088.
VALUE ADDED LUMBER + CHIPS	53807.
VALUE ADDED MISC. F.P.	1952.
VALUE ADDED LOGS	77802.
********** TOTAL VALUE ADDED	201104.
********** REGIONAL INCOME	904967.
********** TOTAL MAN YRS. EMP	17.01

********** STABILITY V.A.

PULP	25.5%
LUMBER	30.2%
PLYWOOD	20.0%

********** GROWTH V.A.

PULP	15.0%
LUMBER	11.5%
PLYWOOD	11.0%

****

KEY TO RECREATION GROUPS

GROUP	CLI RECREATION SUBCLASS
1	BEACH,SWIMMING
2(1)	CANOEING (LAKES)
2(2)	CANOEING (RIVERS)
3	VEGETATION,SMALL SURFACE WATERS,TOPOGRAPHIC PATTERNS,ROCK FORMATIONS,VIEWING
4	WATERFALLS AND RAPIDS,GLACIERS,HISTORIC SITE, GATHERING AND COLLECTING LANDFORMS,THERMAL SPRINGS,MISC.,MANMADE FEATURES
5	CAMPING
6	COTTAGING
7	BOATING
8	SKIING

*** ACCUMULATED CAPACITY ***

GROUP / CLI CLASS	1	2(1)	2(2)	3	4	5	6	7	8
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.18	0.00	1.36	0.00	1.14	0.00	0.00	0.00
5	0.00	0.30	0.00	2.75	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	4.80	0.00	0.00	0.00	0.00	0.00

*** TOTAL DAILY CAPACITY ***

GROUP / CLI CLASS	1	2(1)	2(2)	3	4	5	6	7	8
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	1.080	0.000	13.600	0.000	218.880	0.000	0.000	0.000
5	0.000	1.200	0.000	27.500	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	48.000	0.000	0.000	0.000	0.000	0.000

*** TOTAL ANNUAL CAPACITY ***

GROUP	1	2(1)	2(2)	3	4	5	6	7	8
CLI CLASS									
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	162.00	0.00	2856.00	0.00	32832.00	0.00	0.00	0.00
5	0.00	180.00	0.00	5775.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	10080.00	0.00	0.00	0.00	0.00	0.00
TOTALS:	0.0	342.0	0.0	18711.0	0.0	32832.0	0.0	0.0	0.0

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*** TOTALS FOR AREA ***

TOTAL VALUE ADDED:	310918.56
NET REGIONAL INCOME:	746204.56
GROWTH VALUE ADDED:	0.10%
STABILITY VALUE ADDED:	0.10%
EMPLOYMENT (MAN YEARS):	51.89

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*** SPORT FISHING USE ***            APPENDIX B    SAMPLE RUN -- JULY,1972

                                  STREAMS          LAKES

          DAILY SUMMER CAPACITY      7.29          16.00      FISHERMEN PER DAY
          DAILY WINTER CAPACITY      0.00           6.40      FISHERMEN PER DAY

          TOTAL SUMMER CAPACITY    874.80        1920.00      FISHERMAN DAYS
          TOTAL WINTER CAPACITY      0.00         384.00      FISHERMAN DAYS
          TOTAL YEARLY CAPACITY    874.80        2304.00      FISHERMAN DAYS

                    NET REGIONAL INCOME ($) .......  28642.51

                    EMPLOYMENT (MAN YEARS) ........      1.60

                    VALUE ADDED ($) ...............  23038.54

                      V.A. WAGES + SALARIES ($)....  18430.83

                      V.A. GOV. REVENUE ($) .......    691.16

                      V.A. PROFITS ($) ............   3916.55

                      STABILITY OF VALUE ADDED (%)     17.40

                      GROWTH OF VALUE ADDED (%) ...     4.00
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          TOTALS FOR RUN NAMED ---          APPENDIX B    SAMPLE RUN -- JULY,1972
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                                        REGIONAL INCOME ($) ...   1855843.

                                        VALUE ADDED ($) .......    612779.

                                        EMPLOYMENT (MAN YRS) ..      81.26

                                        AVERAGE GROWTH RATE (%)       4.22


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APPENDIX C

CANADA LAND INVENTORY AND ITS CURRENT APPLICATIONS IN BRITISH COLUMBIA

The Canada Land Inventory Program

The Canada Land Inventory (CLI)* is a comprehensive survey of physical land capability and present land use, designed primarily for land-use planning rather than land management purposes. Undertaken as a joint federal-provincial program in 1963, CLI has established a common base for land capability data description, and is continuing to provide maps of land capability for five resource sectors: agriculture, forestry, recreation, wild ungulates and wetland wildlife. A map of present land use, in terms of cover type, is also provided. Bounded areas on the maps, of which there is one for each sector, represent homogeneous units based on physical characteristics relevant to the particular sector and identified by a capability code. This code gives the CLI capability class (a 1 to 7 ranking of land capability for the particular use), sub-class (identifying either significant limitations or type of use) and species where relevant. Published maps are on a 1:126,840 scale.

Intersectoral Comparison of Maps - Manual Techniques

CLI has been extended to inter-map comparison by two means in

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* Detailed descriptions of the CLI system and techniques are available in various CLI publications, and are summarized in:

Department of Regional Expansion, The Canada Land Inventory: Objectives, Scope and Organization. CLI Report No. 1. Ottawa: Queen's Printer. 1970. Catalogue No. RE63-1/1970.

__________, A Guide for Resource Planning. Ottawa: Queen's Printer, 1970. Catalogue No. RE63-7/1970.

British Columbia. Both of these techniques have stemmed from a desire to use CLI data to provide information for land-use planning and have been developed by the provincial ARDA staff.

The first method, called inter-sector analysis, involves preparing a composite map, based on grouping sectoral CLI ratings into high, moderate, extensive and special categories, on which uses are assigned to that sector displaying the highest capability category for an area. Where an area has more than one sector of prime or moderate capability, allocation is made by a committee of resource managers on the basis of the overall pattern of use - size of area, uses in contiguous areas, and the likelihood of dominance by one use (only primary uses are indicated). The inter-sector map is of limited use for planning, however, due to the type of information it presents and, more importantly, does not present.

The CLI classification is, in most cases, a ranking of relative physical capability for the production of a particular resource. The forestry and wild ungulate classes are cardinal, i.e. they represent definable levels of physical capacity. Other sectors receive only an ordinal ranking and, in the case of recreation, a subjective ordinal ranking. In either case, however, the inter-sector analysis, in comparing all sectors, takes into account only the ordinal qualities of the ranking. Yet such a ranking provides only the capability of stating that one location is better forestry or recreation land than another. The classes for agriculture can not be compared for example, with the same or different classes for forestry or other resource sector classes. Equally tenuous is a comparison between the grouped classifications. Hence there is no basis for stating, as does the inter-sector analysis, that Class 2 agriculture is a superior use to

Class 3 forestry, or that Class 3 forestry, agriculture or recreation (high capability group) is a preferred use to u.c. class 3 wildlife (moderate capability group). The allocation to a primary use or special category further complicates the issue and could lead to inconsistencies.

The second application of CLI map data is the "resource atlas" for a region. This consists of a series of transparencies, each printed with the generalized CLI capability map for one sector or other types of map information, overlaid to provide a combined image. Areas of potential conflict, as well as areas of high single resource capability, thus become visible. The resource atlas is useful in focusing the attention of land-use decision makers on specific locations and potential uses, but does not aid in the solution. Further research can be directed, however, to such areas in order to make a calculated decision.

The Canadian Geographic Information System

The need for automated data management and analysis has resulted in the development of many computerized geographical information. A comprehensive review of several important systems is available in the proceedings of the Second Symposium on Geographical Information Systems, held under the auspices of UNESCO and the International Geographical Union in 1972.*

The system most relevant to this report is the Canadian Geographic Information System (CGIS) which was established to make use of large-scale computers in order to reduce, tabulate, manipulate and analyse the vast

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* Tomlinson, R.F., ed. Geographical Data Handling. UNESCO/IGU Symposium on Geographical Information Systems. Washington: Dept. of Commerce, U.S. Geological Survey, 1972.

quantities of data provided by the Canada Land Inventory. Some stages of the sophisticated system are operational now and the final phase of development has been reached. The system will accept maps (at scales of 1:25,000, 1:50,000 and 1:126,840) containing areas represented by closed boundaries. The maps are automatically scanned, reduced and stored, along with descriptive data. The retrieval subsystem was designed to allow analysis of the data and the production of reports and tabulation. The subsystem is dynamic in nature and will allow a processing system to be built from the various components as required. The scope of the system is outlined in publications available from the Lands Directorate, Department of the Environment.*

Consideration was given to basing the rural land-use information system described in this report on CGIS. At the time the project was initiated (April, 1970), however, there were major technical problems with CGIS. Also, processing of map data is costly and requires a large computer (IBM 360/50). For these reasons, and because most of the systems analysis and programming (related to stream and accessibility networks, economic subroutines and non-CLI data files) remained to be done, it was decided to develop a separate system which could be run on a smaller computer and which would be more flexible in design.

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* Tomlinson, R.F. An Introduction to the Geo-Information System of the Canada Land Inventory, Ottawa: Department of Forestry and Rural Development, 1967.

Department of the Environment, Lands Directorate. Geo-Information System, Ottawa, 1972.