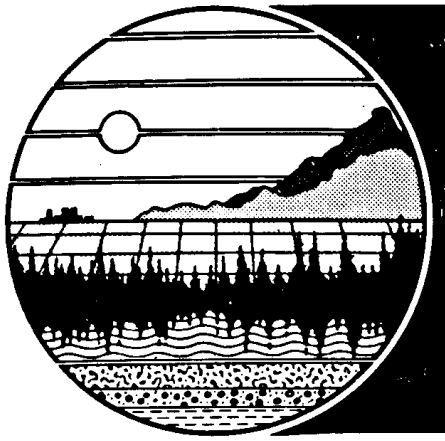

LANDS DIRECTORATE

DIRECTION GÉNÉRALE DES TERRES

FEASIBILITY OF CONSTRUCTING A MULTISECTOR LAND EVALUATION SYSTEM : THE NEW BRUNSWICK PILOT STUDY

WORKING PAPER No. 42

Environment Canada
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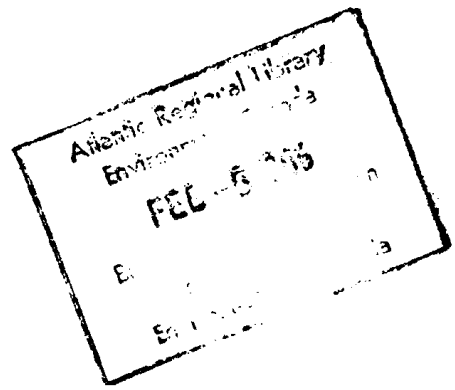
Canada

FEASIBILITY OF CONSTRUCTING A MULTISECTOR LAND EVALUATION SYSTEM: THE NEW BRUNSWICK PILOT STUDY

Barry Smit and Michael Brklacich



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PREFACE

The Canadian land resource is the common base for production for renewable resource sectors as well as the place where Canadians must work, live and recreate. They must draw upon this resource for their minerals and energy and the land resource base provides the habitat for Canada's wildlife. But traditionally, each sector does its own planning for its own aims and objectives. Too seldom is the land resource base given the consideration it requires as both an opportunity and a constraint to resource development. But to adequately understand the opportunities and constraints of the resource base we must have the capability to understand the productivity potential of each discreet part of that base and to understand the trade-offs which must be made when one sector is developed at the expense of another.

In order to develop and test means of building resource base constraints into the planning process, the Lands Directorate of Environment Canada commissioned the Land Evaluation Group at Guelph University to develop and test a pilot application of a land evaluation methodology they had developed in Ontario applicable primarily to trade-offs within the agricultural sector. New Brunswick was chosen as the test site for this model because of the high priority given by that province to both its agriculture and forestry development, and because the province presented a study area large enough to be a true test of the model's flexibilities yet small enough to permit practical pilot study within a one-year period. In the New Brunswick test case, both agriculture and forestry were considered together and the modelling process was developed to accommodate the types of problems associated with longer-term growth, with siting problems relative to major mill facilities, and with the type of tenure divisions which are both opportunities and constraints for forest and agriculture management in New Brunswick.

The Lands Directorate publishes this document as a Working Paper in the interest of furthering knowledge about the methods of evaluating the land resource base of Canada relative to investment and development decisions. Through a thorough knowledge of the land resource base it is intended that better decisions with respect to the long-term sustainability of the land resource base and its optimal use in renewable resource production can be made.

ACKNOWLEDGEMENTS

This project has been funded by the Lands Directorate, Environment Canada. The authors gratefully acknowledge the contributions of:

- Dr. E. Manning and Ms. N. Lavigne of the Lands Directorate,
- representatives from New Brunswick Departments of Natural Resources, Agricultural and Rural Development, and Environment,
- representatives from Agriculture Canada, and
- members of the Land Evaluation Group at the University of Guelph.

EXECUTIVE SUMMARY

I Project Overview

The purpose of this project is to assess the feasibility of developing a multisector land evaluation system which, if implemented, could assess constraints and opportunities for production in both the agricultural and forestry sectors.

Multisector resource assessment has application in decision making at the federal and provincial levels, and thus, this project is intended to provide guidelines for the development of multisector land evaluation systems at both levels. The strategy adopted to prepare these guidelines was to conduct a pilot study for the province of New Brunswick. New Brunswick was selected for the pilot for the following reasons:

1. Forestry and agriculture are currently the two most important sectors in the New Brunswick economy.
2. Many of the long-term development strategies for New Brunswick hinge upon further development of the forestry and agricultural sectors.
3. The relationship between the forestry and agri-food sectors is sufficiently complex that if it is feasible to construct a multisector land evaluation system for New Brunswick it should be feasible to do so elsewhere.
4. Scientists and government representatives in New Brunswick were eager to co-operate on a feasibility study.

Each stage involved collaboration with scientists from Lands Directorate (Ottawa), Environment Canada; from the New Brunswick Departments of Natural Resources, Agricultural and Rural Development, and Environment; and Agriculture Canada (Fredericton).

II Recommendations for the Development of a Multisector Land Evaluation System in New Brunswick

1. It is apparent that economic development in New Brunswick will continue to rely heavily on the forestry and agri-food sectors. A fully operational multisector land evaluation system for New Brunswick would assist resource and policy analysts by providing assessments of the concurrent opportunities for forestry and agricultural production, and of the extent to which changes in the biophysical and socio-economic conditions would affect production prospects. Thus, it is recommended that a multisector land evaluation system for New Brunswick be constructed.

2. The structure proposed in this report (Section 4) for a multisector land evaluation system for New Brunswick has been shown to be practicable and has been endorsed by representatives from provincial Departments of Natural Resources, and Agricultural and Rural Development. Therefore, it is recommended that a multisector land evaluation system be developed around this framework.

3. Decisions affecting the long-term use of New Brunswick's land resources are being made in the absence of an analytical system that can measure the aggregated impact of several independent courses of action. It is recommended that the construction of a multisector land evaluation system for New Brunswick commence as soon as possible.

4. Many of the existing data sources are not consistent with the proposed structure for a New Brunswick multisector land evaluation system. Nevertheless, a first approximation of the data base could be compiled either by modifying the available data or by supplementing these with data from independent sources. Therefore it is recommended that a prototype multisector land evaluation system be constructed. This would permit an assessment of some of the issues at the earliest possible date, and facilitate construction of the system. The forestry component of the prototype could employ the data base and analytical procedures implemented by the New Brunswick Department of Natural Resources. The agricultural component would utilize reported data on land use and crop yields, and where necessary these data would be supplemented by expert opinion.

5. Implementation of all facets of the proposed structure for a multisector land evaluation system for New Brunswick and its efficient application should be guided by an interdisciplinary team of scientists. Without such a co-ordinating unit it is extremely unlikely that the necessary data would be generated or compiled in an appropriate form, and it is even more unlikely that the pertinent tools for data management and multisector analysis would be constructed. The expertise is available, but for constructing and implementing a multisector land evaluation system, this expertise needs to be co-ordinated. It is recommended that this team be established as soon as possible and include scientists with expertise in the following areas: co-ordination of interdisciplinary projects, land resource science, crop productivity modelling, forest productivity modelling, commodity demand forecasting, policy formulation, and systems design and programming.

III Implications for Land Evaluation Systems at the National Level

1. Preliminary evidence indicates that resource analysts at the federal level must resolve issues relating to the concurrent opportunities for production in two or more sectors. The decision-making process would be enhanced by systematic procedures for resource assessment which could be applied nationally to issues relating to a) production prospects in the agricultural and forestry sectors and b) the extent to which developments in one sector would impinge upon opportunities in the other.

2. The University of Guelph's Land Evaluation Group, Environment Canada and Agriculture Canada have developed considerable expertise in the area of applied land evaluation research. A co-operative program involving these groups would be a cost-effective approach to co-ordinate the development, construction and application of a nation-wide multisector land evaluation system.

3. The initial step in establishing a nation-wide multisector land evaluation system should be an assessment of its potential applications. This has been conducted elsewhere for the agricultural component. It needs to be extended to forestry and other sectors, and to consider the extent to which sectors interact.

4. The Land Evaluation Group and Agriculture Canada are presently designing and constructing the agricultural component of a Canadian Land Evaluation System. A feasibility assessment of the prospects for developing a nation-wide multisector land evaluation system is required however to ensure that this system is sufficiently flexible that it could readily incorporate a forestry component.

TABLE OF CONTENTS

LIST OF FIGURES

1 INTRODUCTION

1.1 Background

The development of effective policies for land resource use depends to a large extent upon evaluations of the biophysical characteristics of the land base relative to socio-economic conditions pertaining to its use. Biophysical characteristics that are often considered in evaluations include the availability and quality of land resources, the suitability and productivity of different types of land for selected uses, the vulnerability of lands to degradation processes, the constraints imposed by the land base, and the extent to which constraints can be ameliorated. From the socio-economic perspective, evaluations must recognize the long-term needs for the production of a wide array of commodities, the socio-economic conditions under which these commodities can and cannot be produced, and national and regional goals for development.

Any policy-oriented assessment of resource-use options requires the synthesis of vast amounts of diverse types of information. This process has been hampered by inconsistencies in the required data bases and by inadequate procedures for integrating information on biophysical characteristics with socio-economic conditions. Recently, however some practical methods have been developed for compiling and integrating the required data, thereby extending the applicability of land-related information in the policy arena.

These methods have been applied in Ontario by the University of Guelph's Land Evaluation Group (LEG) in collaboration with scientists from Agriculture Canada, Environment Canada, and the Ontario Ministry of Agriculture and Food. This land evaluation system for Ontario (LEM 2) comprises a comprehensive data base and associated analytical procedures designed to assess opportunities for land use and production given specified physical and socio-economic conditions. This system has been employed by federal and provincial agencies in the formulation of agri-food policies for Ontario.

Many of the land-related issues that decision-makers must resolve are concerned with the concurrent opportunities for production in two or more sectors. The LEM 2 system however has been designed primarily to assess prospects for food production. In its application to a wide range of issues, other activities such as forestry, recreation and housing have been addressed indirectly. While it should be feasible to incorporate other sectors within this analytical framework and to develop operating systems in other jurisdictions and at other geographic scales, these extensions have not been investigated thoroughly. Some preliminary research indicates that it will be feasible to construct a national system which would assess production prospects from an agricultural perspective. Clearly, there is still a need to develop techniques which can gauge the concurrent opportunities for production in multiple sectors.

1.2 Purpose and Overview of the Project

The purpose of this project is to assess the feasibility of developing a multisector land evaluation system (MLES) which, if implemented, could assess constraints and opportunities for production in both the agricultural and forestry sectors.

Multisector resource assessment has application in decision making at the federal and provincial levels, and thus, this project is intended to provide guidelines for the development of MLES's at both levels. The strategy adopted to prepare these guidelines was to conduct a pilot study for the province of New Brunswick. New Brunswick was selected for the pilot for the following reasons:

1. Forestry and agriculture are currently the two most important sectors in the New Brunswick economy.
2. Many of the long-term development strategies for New Brunswick hinge upon further development of the forestry and agricultural sectors.
3. The relationship between the forestry and agri-food sectors is sufficiently complex that if it is feasible to construct a MLES for New Brunswick it should be feasible to do so elsewhere.
4. Scientists and government representatives in New Brunswick were eager to co-operate on a feasibility study.

The feasibility study for New Brunswick is divided into six stages:

1. Issue identification.
2. Development of an analytical framework.
3. Identification of data requirements.
4. Assessment of suitability of available data.
5. Recommendations for construction of a system for New Brunswick.
6. Pilot assessment (data permitting).

Each stage involved collaboration with scientists from Lands Directorate (Ottawa), Environment Canada; from the New Brunswick Departments of Natural Resources, Agricultural and Rural Development, and Environment; and Agriculture Canada (Fredericton).

An initial meeting was held in Fredericton on June 20 and 21, 1984, at which time the issues confronting agriculture and forestry were identified, and the status of land-related information systems were described. Progress reports which outlined the envisaged applications of a MLES for New Brunswick, sketched an analytical framework for multisector resource assessment, and proposed a structure for a MLES for New Brunswick were prepared in July and November 1984, and forwarded to Ottawa and Fredericton. Proposals introduced in the progress reports were endorsed by representatives from New Brunswick during a second meeting in Fredericton on January 21, 1985.

1.3 Organization of the Report

Section 2 outlines the potential applications of a MLES for New Brunswick. Major land-related issues in each of the agricultural and forestry sectors are reviewed, and the relationship between the sectors is examined. The section concludes with an outline of an analytical framework for a MLES for New Brunswick.

Section 3 introduces a general conceptual model for resource assessment and evaluation. It is based upon three distinct approaches to resource assessment, all of which should be part of a multisector land evaluation system. Section 3.1 outlines procedures for examining the resource base and its potential use. Section 3.2 describes a framework for measuring production potential, and Section 3.3 sketches a technique for judging the prospects for attaining specified levels of production. Section 3.4 summarizes the relationships among the three types of resource assessment.

Section 4 proposes a structure for a multisector land evaluation system for New Brunswick. It embraces the three approaches to resource assessment outlined in the previous section, and examines the options for implementing the proposed structure. Its major features are introduced in Section 4.1. Sections 4.2 through 4.4 respectively sketch procedures for addressing issues relating to:

- the resource base and its potential use,
- production potential, and
- prospects for attaining production targets.

The section concludes with an assessment of the feasibility of constructing the proposed structure using available data, and recommendations for the development of a multisector land evaluation system in New Brunswick.

Section 5 explores the opportunities for multisector resource assessment at the national level.

2 POTENTIAL APPLICATIONS OF A MULTISECTOR LAND EVALUATION SYSTEM FOR NEW BRUNSWICK

The improvement and maintenance of New Brunswick's land resources are often included as an integral part of provincial strategies for economic development. Recently completed studies have concluded that the overall productive potential of New Brunswick's land resources for forestry and agricultural commodities is far greater than current levels of production in these sectors. The sound development of this unused potential could strengthen the provincial and regional economies by providing employment opportunities throughout the entire economy. However the degree to which production could be expanded over the long-term, and the extent to which development in one sector would infringe upon opportunities elsewhere remain unclear.

A system for evaluating the extent to which land resources in New Brunswick constrain concurrent opportunities for production in the province's agricultural and forestry sectors would assist resource analysts during the policy formulation process. It would facilitate assessments of the limitations imposed by current and possible changes in biophysical conditions on the productive capacity of the land base. These broadscale assessments would provide a basis for more detailed appraisals of particular resource development options.

The necessary first step in the development of effective procedures for resource assessment is the identification of the major issues confronting decision makers and the information needed to address those issues. For New Brunswick, this involves a review of major land-related concerns in both of the agricultural and forestry sectors, as well as an appraisal of the extent to which these issues are interrelated.

2.1 Agricultural Issues

Within the agricultural sector, the majority of the land-related issues pertain to increasing production levels of feed crops and maintaining production levels for potatoes over the long-term. Specific issues needing investigation include:

1) To what extent would it be physically possible to expand the area of land used for the production of forages and feed grains, and potatoes?

2) Where are these areas relative to current livestock and potato producing areas?

3) What is the productivity of lands that are either currently being used or could be used for the production of livestock feeds or potatoes?

4) Which lands might benefit from improvements such as drainage or subsoiling? What is the extent and location of these lands?

5) To what extent would land improvements increase yields and upgrade crop quality?

6) What is the susceptibility of different types of land to erosion, and in which areas is erosion currently a problem?

7) What effect does erosion have on yields for particular crops?

8) Which land use practices would maintain land quality over the long-term?

9) To what extent do non-land factors such as farm management, tenure and the location of processing plants constrain agricultural production in New Brunswick?

10) What are the prospects for increasing the production of livestock feeds in New Brunswick under present conditions, and to what extent would changes in conditions (e.g. land improvements and better management) expand these opportunities?

11) To what extent could present feed shipments from Central and Western Canada be replaced by feeds produced in New Brunswick?

12) In order to maintain production levels for potatoes, how much land would be required for rotation crops? Could these rotation crops be used to increase livestock feeds?

13) To what extent would soil erosion reduce the production potential for potatoes?

2.2 Forestry Issues

The major land-resource issues confronting the forestry sector relate to the potential shortfall in the supply of softwoods. Specific issues include:

14) How much softwood can New Brunswick's forests produce annually without impairing the productive capacity of the forest over the long-term?

15) What portion of this total supply originates
- from Crown lands?
- from large freehold lands?
- from small freehold parcels?

16) What is the milling capacity of New Brunswick's pulp mills, and other mills requiring softwood? In order to maintain a viable operation, what proportion of the productive capacity of the forest must be used?

17) At the provincial scale, what is the gap between annual supply of softwoods and annual milling capacity?

18) In which regions can periodic shortfalls in supply be expected given current management practices?

19) In which regions would the shortfalls be so serious (i.e. either in total magnitude or in duration) that it would not be economically viable to operate mills?

20) How would alternative management practices such as increases in rates of replanting, better weeding, timely harvesting and more intensive management of small freehold parcels affect the long-term supply of softwoods?

21) Would increases in supply via better management be sufficient to meet the milling demands for softwoods?

22) To what extent might insect infestations, disease and fire reduce the supply of softwoods?

2.3 Agricultural and Forestry Issues

The small freehold lands are the dynamic edge between the agricultural and forestry sectors. Future increases in agricultural production will to a large extent rely upon a more intensive use of existing farms and land clearing. The small privately owned woodlots are regarded as a valuable but presently underutilized forest resource. Issues relating to the concurrent opportunities for increasing production in the agricultural and forestry sectors include:

23) To what extent would an expansion of agricultural land in the small freehold areas impinge upon prospects for forest development? and vice versa?

24) What are the concurrent opportunities for expanding production in each sector?

2.4 Implications for the Analytical Framework

The units of analysis and structure of any resource evaluation system are determined by the intended applications of the system. The issues identified in Sections 2.1 through 2.3 indicate that the units of analysis would need to be structured around the following three dimensions: land uses, biophysical characteristics of the resource base, and infrastructure.

Land Uses:

The following land uses and their associated products would need to be considered explicitly:

forestry: softwoods (for pulp and paper)
hardwoods (for timber)

agriculture: potatoes (for processing, seed, table)
cereal grains (for feed and processing)
hay forage (for feed)
improved pasture (for feed)

Other land uses which currently utilize a small proportion of the province's land resource but are economically important would be exogenous to the MLES.

Biophysical Characteristics:

Climate and land quality are aspects of the biophysical resource base limiting the feasible location and yields for agriculture (crops) and forestry.

Infrastructure:

Tenure and proximity effectively limit either the areas useable by each sector or yields. There is need to delineate crown lands, large freehold lands, and small freehold lands. Proximity to processing plants effectively limits the areas useable for the production of potatoes and of forest products; and livestock production must occur in close proximity to the areas used for forages.

3 CONCEPTUAL MODEL FOR RESOURCE ASSESSMENT AND EVALUATION

It is convenient to classify the issues identified in the previous section according to three broad categories. First, there are those issues relating to the extent and quality of the resource base and its possible uses. Second, some of the issues pertain to possible levels of production that could be expected given a particular pattern of land use and other restrictions on resource use. And third, the remaining issues relate to the prospects for attaining production targets given specified limitations on the availability, quality and potential use of the resource base.

A land evaluation system for agricultural and forestry development in New Brunswick should encompass all the data and resource assessment procedures required to address issues in each of these categories. That is, it should have the capacity:

- to provide access to information on the resource base and its potential use,
- to assess production potential,
- to ascertain the feasibility of attaining production targets.

The general characteristics of these three approaches to resource assessment and the connections amongst them are represented schematically in Figure 1. Each approach has its own requirements for data and is based upon a different set of analytical procedures. These are expanded upon in Sections 3.1 through 3.3.

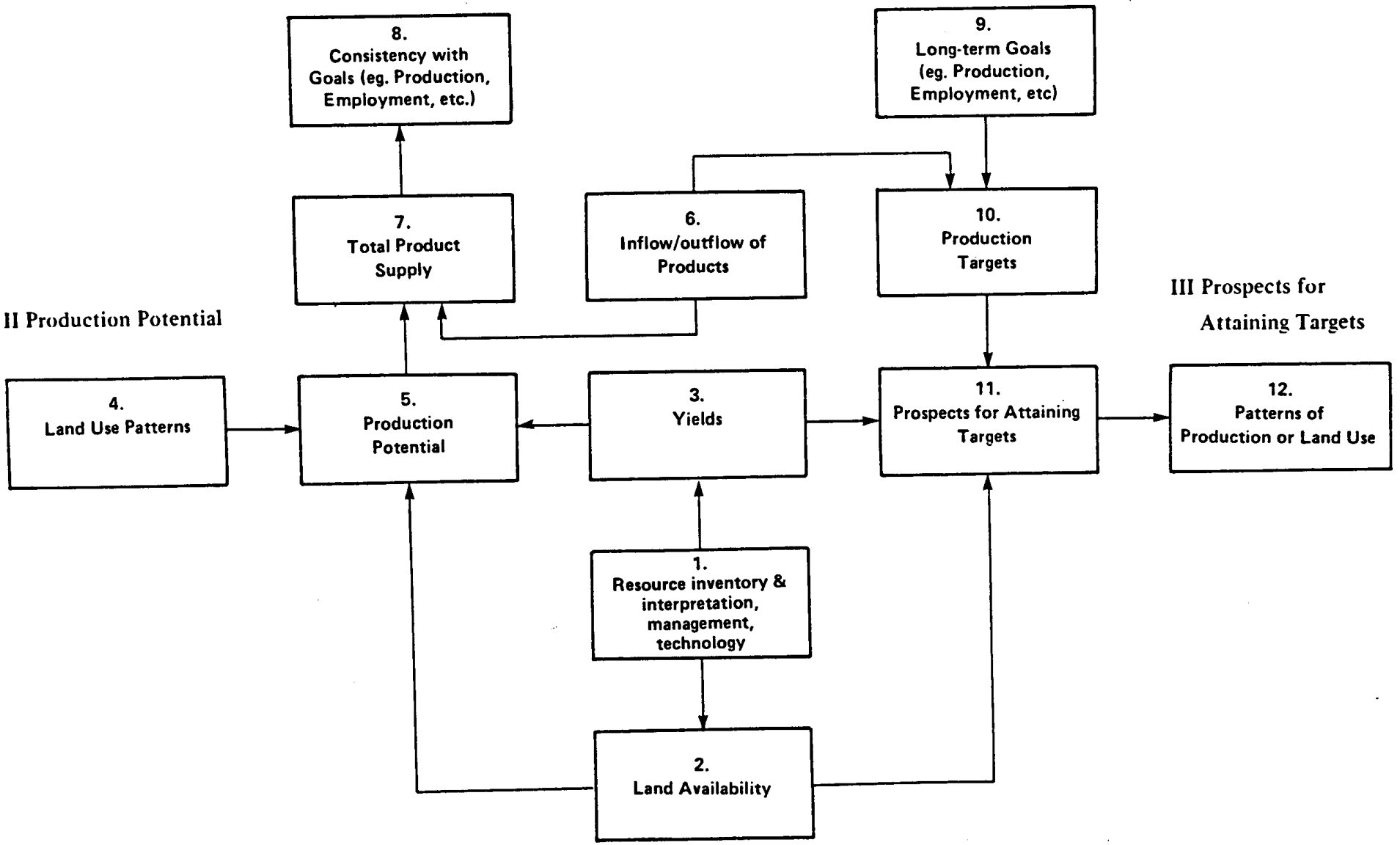
3.1 Information on the Resource Base

This approach to resource assessment is appropriate for addressing issues relating to the area of land available for crop production and forestry, the productivity of these lands for particular crops and tree species, and the extent to which management, technology and other non-land inputs might enhance or restrict land availability and/or quality. It involves collecting, managing and accessing information on resource availability, quality and potential use.

Compilation of this information base usually begins with an inventory and interpretation of land resources that might be used for the production of particular commodities, and assumptions regarding inputs to the production process such as management and technology (Figure 1, Box 1). The major products from this approach are estimates of the availability of different types of land (Box 2), and yield or productivity levels for specified uses on each of the land types (Box 3).

Within the policy formulation process, this approach to resource assessment has been used to provide qualitative assessments of the long-term adequacy of the resource base by evaluating the suitability of different types of land for the production of a wide range of possible uses, and by isolating areas or regions where there is untapped potential for production. The sensitivity of these assessments to changes in conditions such as climate change, degradation, and land improvements can be incorporated into this approach at the inventory stage or through the assumptions relating to production.

FIGURE 1: THREE APPROACHES FOR ASSESSING THE LONG-TERM ADEQUACY OF LAND RESOURCES FOR PRODUCTION



3.2 Production Potential

The "Production Potential" approach is designed to quantify possible levels of production given a predetermined pattern of land use and a set of restrictions on resource use (e.g. availability, quality, etc.). That is, it measures the extent to which these conditions constrain levels of production.

The approach utilizes the major outputs of land availability and yields from the previous approach (Figure 1, Boxes 2 and 3 respectively), and integrates these data with data on patterns of land use (Box 4). The major product is an estimate of the maximum levels of production for specific commodities that could be expected (Box 5) given the stated conditions. It would be possible to extend the analysis to include other factors such as interprovincial commodity movements (Boxes 6 and 7), and eventually infer whether the full set of assumed conditions or scenario is consistent with broader societal goals such as desirable levels of production, employment and so on (Box 8).

Production potential as an approach to resource assessment and a tool for policy formulation has been explored by the Food and Agriculture Organization of the United Nations (FAO). One of the strengths of the approach is that once the required data on land availability, productivity and land use patterns are compiled, it is a relatively straightforward task to implement procedures which would measure production potential. Of course, it would be possible to judge the sensitivity of these estimates of production potential to changes in future conditions by adjusting any of the input parameters.

3.3 Prospects for Attaining Production Targets

The "Prospects for Attaining Production Targets" approach to resource assessment is designed to measure the feasibility of attaining and exceeding predetermined levels for production given restrictions on resource availability and productivity. It is based upon procedures which systematically integrate targets for production with data on biophysical conditions affecting the production of specific commodities.

This approach commences with a clear statement of the long-term goals for production, employment, trade and so on (Figure 1, Boxes 6 and 9), and utilizes this to estimate targets or requirements for the production of specific commodities (Box 10). Then these data are integrated with data on resource availability and productivity (Boxes 2 and 3 respectively), thereby ascertaining the prospects for meeting and exceeding the production targets given the stated supply-side conditions (Box 11). The procedure can also be extended to indicate patterns of production and/or land use which would be conducive to meeting the targeted levels for production (Box 12).

The "Prospects for Attaining Production Targets" approach has been developed by the Land Evaluation Group (LEG). The Ontario Directorate of Agriculture Canada's Regional Development Branch has utilized it in its development of an agri-food strategy for the province (LEG 1984c and 1983). The approach relies heavily upon the availability of specific types of data, and sophisticated data management systems and analytical procedures. Once

implemented, this approach to resource assessment is especially useful for quantifying the feasibility of attaining alternative projections for production given a specified set of supply-side conditions, and for measuring the sensitivity of feasibility assessments to likely changes in one or more supply-side condition.

3.4 Implementing the Conceptual Model

It should be possible to design and implement a land evaluation system which would store and manage the required data, and house the appropriate procedures necessary to implement each approach to resource assessment. Such a system could be constructed in an incremental fashion, adding data and analytical procedures as they become available.

Clearly there is considerable overlap in the information requirements associated with the three approaches to resource assessment. In order to ensure that the information can be used for all three types of assessment there must be a commitment to the development of a highly structured data base, with consistent units of analysis, and an efficient data management system.

4 PROPOSAL FOR A MULTISECTOR LAND EVALUATION SYSTEM FOR NEW BRUNSWICK

4.1 Overview

This proposal for a MLES for New Brunswick reflects the identified land-related issues, the information requirements of decision-makers, and the resource assessment procedures outlined in the previous section. Its major features are:

1. It considers the agri-food and forestry sectors.

2. It accommodates all three approaches for resource assessment outlined in Section 3.

3. The two sectors are linked via the land available for primary production.

4. It provides a framework for articulating the data requirements for each approach to resource assessment in both the agricultural and forestry sectors. A comparison of these requirements to available information can be used to indicate where there is sufficient data to develop particular aspects of the system, and to isolate areas where data deficiencies will need to be overcome.

5. Portions of the system can be implemented as data and analytical procedures become available. Hence, it would be feasible to construct the system in an incremental fashion, and address some questions before the system is fully developed.

6. Many elements of the system could be developed simultaneously, thereby minimizing the length of the development period.

7. The system is designed so that assessments of the agricultural and forestry sector can be conducted either independently or concurrently, depending upon the user's needs.

8. It should be possible to link the New Brunswick system to systems operating at a broader (e.g. national) scale.

The remainder of Section 4 examines the prospects for implementing each approach to resource assessment for both the agricultural and forestry sectors. Sections 4.2 through 4.4 each address one of the approaches to resource assessment and outline the elements within it and its analytical capabilities. Section 4 concludes with an assessment of the availability of the required data and recommendations for constructing a MLES.

4.2 Information on the Resource Base

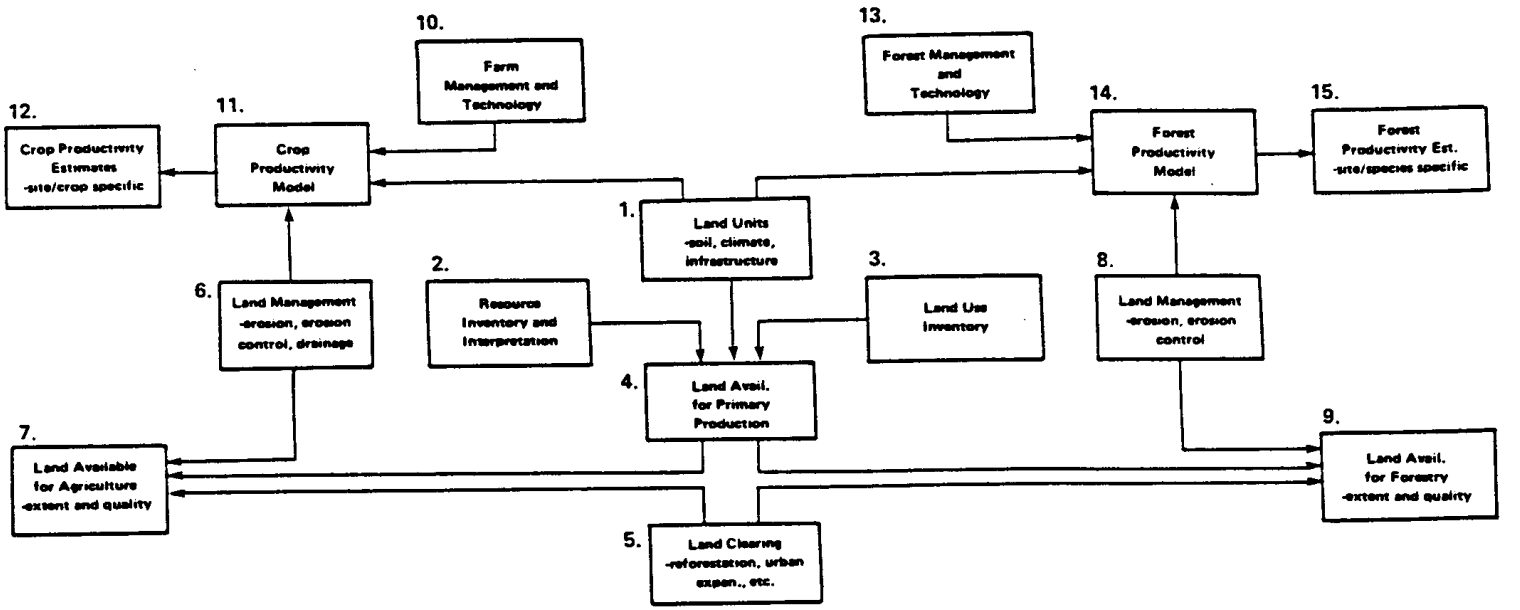
The "Information on the Resource Base" approach is comprised of two types of information (Figure 2): land availability and productivity. The issues to be addressed indicate that the land units will need to be defined according to the soil and climatic conditions which influence crop and forest productivities, and aspects of infrastructure (i.e. tenure and location) which effectively limit either the area available for production to each sector or productivity (Figure 2 - Box 1). Estimates of the area of each land unit available for primary production (Box 4) could be derived from existing inventories of biophysical resources and land use (Boxes 2 and 3 respectively). By considering these data relative to other factors such as land clearing, reforestation, land requirements for uses other than agriculture and forestry (Box 5) and land management practices (Boxes 6 and 8), it would then be feasible to estimate the extent and quality of lands available for agricultural and forestry production (Boxes 7 and 9 respectively).

Infrastructure and current land use would be used to designate those lands that are already committed to one of the two sectors, and those lands where land use change might occur. Crown lands are already committed to forestry production and it is unlikely that this will change substantially. Existing patterns of land use in the large freehold areas effectively designate the long-term use of these lands by each sector. The use of the small freehold lands by each sector may change considerably over the long-term. Thus the land availability portion of the information base would store several estimates of the availability of land for each sector, with each estimate reflecting an alternative set of assumptions regarding the disposition of the small freehold lands. If required, adjustments in the availability of crown lands and large freehold lands could be incorporated. Of course, the data management system would ensure that all estimates of land availability did not exceed the potential supply of land to primary production.

In the agricultural component of the system, a crop productivity model (Box 11) would integrate data on land quality, land management and technology (Boxes 1, 6, and 10 respectively), and estimate the productivity of different land units for the specific crops identified in Section 2 (Box 12). Similar procedures would be required in the forestry component (Boxes 1, 8, 13 and 14) in order to estimate the productivity of particular land units for alternative tree species. Several sets of productivity estimates would be required, with each set reflecting alternative conditions relating to management and technology.

Information on the availability and productivity of lands in New Brunswick for agriculture and forestry would assist resource analysts in identifying the extent to which the resource base is being utilized. By including infrastructure in the classification of land units, it would be possible to delimit the location of underutilized land resources relative to existing areas of production and processing facilities. Also, the development of productivity models for crops and forestry would facilitate gauging the effects of changes in biophysical (e.g. climate, drainage, degradation, and so on) and socio-economic conditions (e.g. production, management, technology, and so on) on long-term yield levels. All of these data would assist resource analysts in making qualitative assessments of the long-term adequacy of New Brunswick's land resources for the production of food and forestry products.

FIGURE 2: A MULTISECTOR LAND EVALUATION SYSTEM FOR NEW BRUNSWICK: THE INFORMATION COMPONENT



4.3 Production Potential

The "Production Potential" approach to resource assessment estimates possible levels of production by integrating land availability and productivity estimates with data or assumptions on the distribution of land uses (Figure 3).

The forestry and agricultural components are linked explicitly via the estimates of land available for production in each sector. That is, the multisector land evaluation system would include an accounting facility to ensure that available land resources are assigned to one but not both sectors. Thus, once it is determined for a particular scenario that certain lands are available to one sector they would be excluded from the other. Of course it would be feasible to consider alternative assignments of land availability by specifying another scenario, and conducting assessments of production potential under that scenario for comparison.

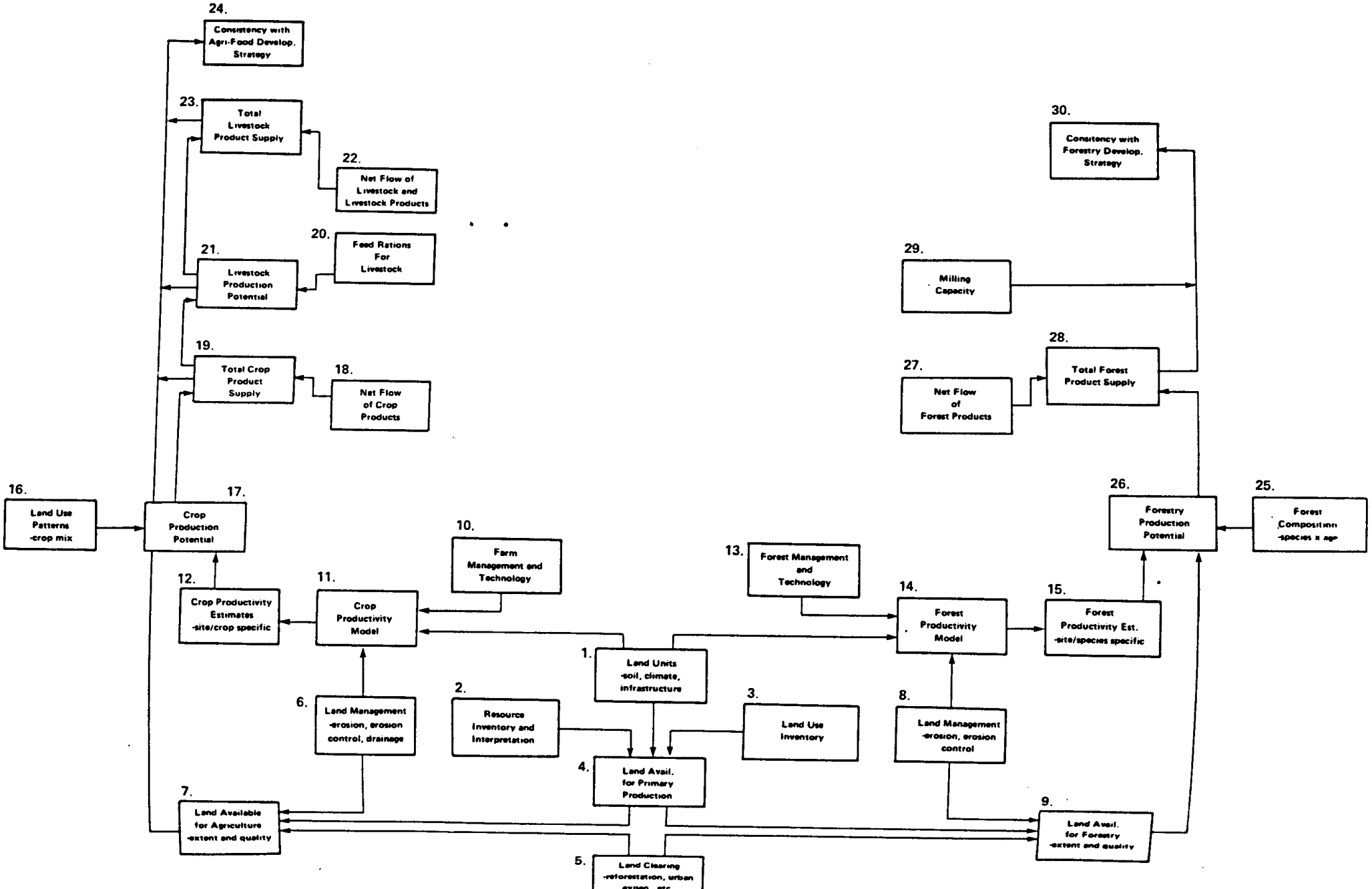
In the agricultural component of the system, estimates of the availability of land for crop production (Figure 3 - Box 7), crop productivity estimates (Box 12), and a predetermined assignment of crops to land units (Box 16) are utilized to estimate the production potential for crops (Box 17) in each region of the province. The land use patterns (i.e. crop mix) could be based upon an inventory of present land use (Box 3) and possible shifts from these, or it could reflect an independent analysis of trends in long term land use.

In order to determine the total supply of crop products (Box 19), it would be necessary to make assumptions about the movement of crop products in and out of New Brunswick (Box 18). These data could be used in conjunction with data on the rate at which feed stuffs are (or might be) converted into livestock products (Box 20), and thereby gauge the production potential for livestock products (Box 21). Of course, these estimates would be calculated on a regional basis since forages are not typically shipped long distances. By extending the analysis to consider the possible movement of livestock and livestock products at both the interprovincial and international scale (Box 22), it would be feasible to estimate maximum supply levels for livestock products (Box 23).

The final product from the agricultural component is a measure of the extent to which the assumed land use patterns and associated potential for agricultural production are consistent with long-term development strategies for the agri-food sector (Box 24). A wide range of scenarios can be considered by adjusting any of the input parameters (i.e. land availability, productivity, land use patterns, commodity flows and feed-to-livestock product conversion rates). A comparative assessment of production potential under each scenario would permit resource analysts to ascertain those scenarios which would and would not be compatible with development strategies, and to judge the trade-offs associated with pursuing one scenario over another.

The forestry component functions in a similar fashion to the agricultural component and has, to a large extent, already been implemented by the New Brunswick Ministry of Natural Resources. Central to the procedure for

FIGURE 3: A MULTISECTOR LAND EVALUATION SYSTEM FOR NEW BRUNSWICK: ASSESSING PRODUCTION POTENTIAL



estimating production potential for forestry products on a regional basis (Box 26) are data on land availability (Box 9), productivity (Box 15) and assumptions about the use of land for forestry (Box 25). The appropriate indicator of land use for the forestry component is forest composition based upon the current distribution of tree species and age. The effects of alternative management practices on production potential could be assessed by making appropriate adjustments to the forest composition, forest productivity and/or land availability data.

Maximum supply of forest products (Box 28) can be estimated as a function of production potential and the movement of forest products in and out of New Brunswick (Box 27). Total supply of forest products in each region could be compared to the milling capacity (Box 29) to determine those regions in which there would (or would not) be sufficient supply to sustain viable milling operations. This would assist resource analysts in judging the degree to which particular scenarios would be consistent with development strategies for the forestry sector (Box 30). It would also be feasible to extend the analyses to consider the effects of alternative scenarios on employment opportunities in each region.

While the assessments of the long-term adequacy of the resource base for agricultural and forestry production are conducted independently, they are linked via the land available for production to each sector. Thus, the concurrent opportunities for development in the agri-food and forestry sectors (Box 31) can be ascertained by considering the outputs from the agricultural and forestry components of the system.

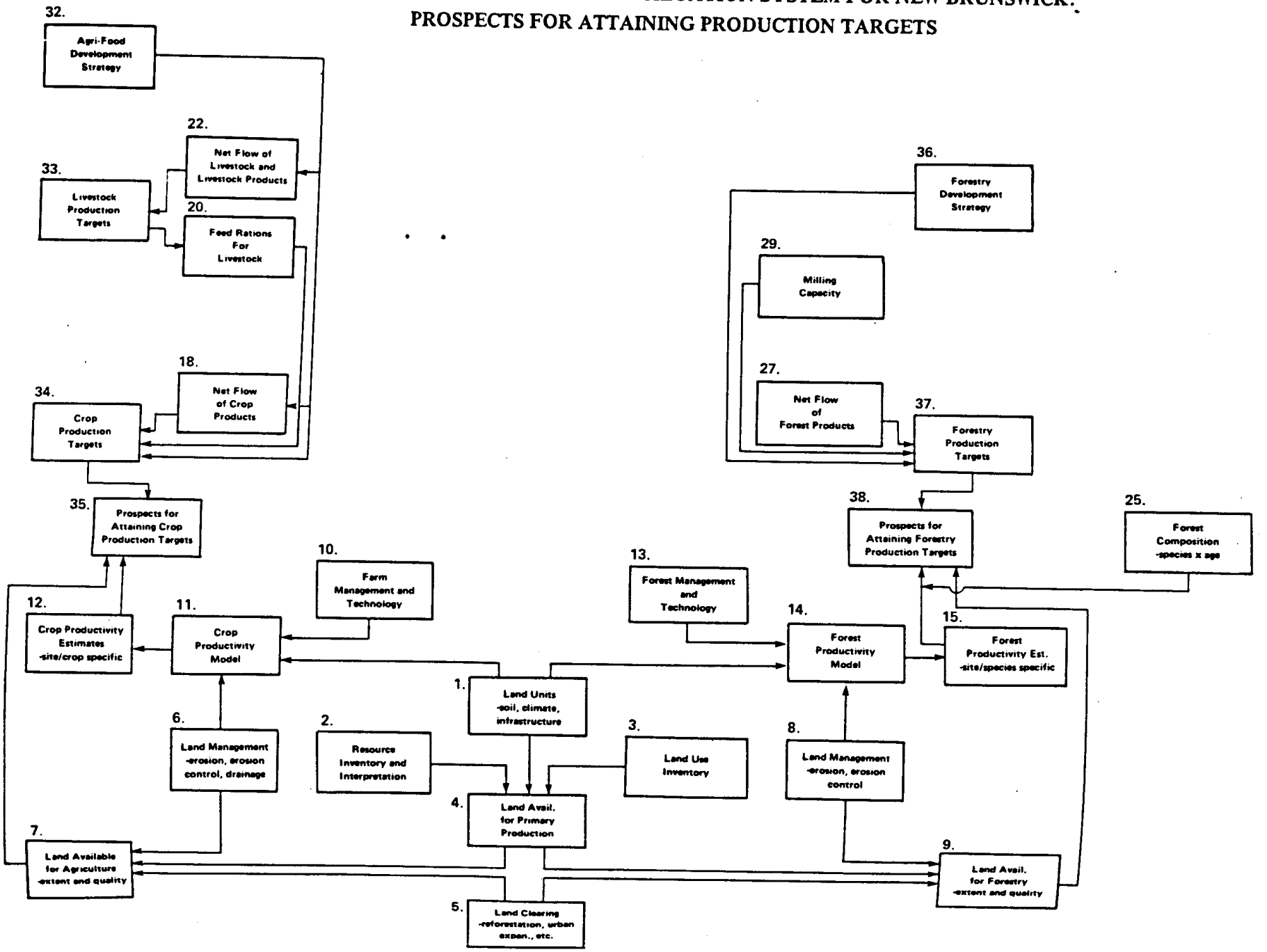
Analyses of the production potential in the agricultural and forestry sectors would assist resource analysts in addressing issues relating to the possible supply of commodities from each sector on a regional basis. It would provide quantitative assessments of production prospects under specified sets of conditions or scenarios. A comparison of assessments under different scenarios would facilitate a systematic evaluation of the trade-offs involved with particular strategies for land use planning and resource development. Linking the agricultural and forestry components via the availability of land resources to each sector facilitates the tailoring of the analyses to the needs of particular users. Analyses can be conducted for one sector independent of the other or the concurrent opportunities for production can be gauged.

4.4 Prospects for Attaining Production Targets

The "Prospects for Attaining Production Targets" approach to resource assessment utilizes much of the data required to conduct assessments of production potential, but the flow of information and analytical procedures are different (Figure 4). This approach is based upon prodedures which directly and systematically integrate data on resource availability and productivity with data on production levels.

The agricultural and forestry components of the system are constructed independently of one another, but their development and operation are co-ordinated through the availability of land for production purposes. The area of land available to each sector (Figure 4 - Boxes 7 and 9) would be related to current land use (Box 3) and separate analyses of possible trends in land

FIGURE 4: A MULTISECTOR LAND EVALUATION SYSTEM FOR NEW BRUNSWICK: PROSPECTS FOR ATTAINING PRODUCTION TARGETS



clearing, reforestation and future requirements for land by other uses (Box 5).

In the agricultural component, these estimates of land availability are combined with data on crop productivity (Box 12) and levels or targets for crop production (Box 34). Initially current levels of production could be used. Future targets for crop production however could be estimated given changes in provincial demand and development strategies for the agri-food sector (Box 32), and adjustments in the international and interprovincial movement of livestock, livestock products and crop products (Boxes 18, 20, 22, and 33).

Ascertaining the prospects for attaining crop production targets (Box 35) would require mathematical programming procedures to integrate data on resource availability, productivity, and regional and provincial targets for production. Resource analysts would then be able to judge for particular scenarios whether it would or would not be feasible to meet all the targets for production given the available resources. Scenarios reflecting alternative development strategies or changes in supply side conditions could be considered by adjusting the appropriate input parameters. This would facilitate assessments of the sensitivity of attaining production targets to specified changes in conditions.

In the forestry component, estimates of forest productivity (Box 15) would need to be considered relative to forest composition (Box 25) in order to develop annual yield levels. Forestry production targets (Box 37) could be estimated as a function of development strategies for the forestry sector (Box 36), milling capacity (Box 29) and the movement of forest products in and out of New Brunswick (Box 27). Of course, each of these parameters could be adjusted to reflect events such as rationalization in the forestry sector, regional development initiatives, and so on. Mathematical programming procedures could be used to integrate data on resource availability, forest productivity and production targets, and thereby quantify the prospects for attaining production targets in the forestry sector (Box 38).

Since assessments of the prospects for attaining production targets in each of the agricultural and forestry components of the system (Boxes 35 and 38) are linked via the land available for production in each sector, the concurrent opportunities for development in the 2 sectors can be measured by aggregating the independent assessments of production prospects. This would allow resource analysts to assess directly the implications of particular development policies within and among sectors.

4.5 Data Requirements and Availability

4.5.1 Land Units and Productivities

The envisaged applications of the MLES for New Brunswick indicate that the land units will need to include biophysical and socio-economic dimensions. The crucial biophysical characteristics include those aspects of soils and climate which influence the productivity of the resource base for agriculture and for forestry, whereas tenure and geographic location are the important socio-economic criteria which effectively limit either the area of land available for production or productivity.

Ideally crop and forest productivity models would be used to estimate yields for each land unit. This approach is favoured for land evaluation purposes because it facilitates the estimation of yields given long-term assumptions with respect to agricultural technology and management. Hence, further refinement of the particular aspects of climate, soil, tenure and geographic location for which data would be required depends upon the form and structure of productivity models for each sector. Unfortunately these productivity models have not been implemented for either sector in New Brunswick, and therefore assessments of data requirements and the suitability of available data sources are necessarily tentative. In the remainder of this section an approach to productivity modelling and its data requirements are outlined, and the available data are assessed relative to this approach.

The crop-weather analysis approach to productivity modelling developed by de Wit (1965) for the FAO has many characteristics which are suitable for broadscale evaluations, including its applicability to a wide range of crops and environmental conditions. Agriculture Canada (Stewart, 1981) has adapted these procedures to Canadian environmental and farm management conditions, and the resulting model (the FAO/LRRI model) is comprised of two components. The photosynthetic component of the model estimates the capacity of particular crops to capture and transform incoming solar radiation into biomass, and the useable portion of the plant is reported as constraint-free dry matter yield. The agroclimatic-edaphic component estimates the extent to which climatic and soil conditions combine to reduce constraint-free yields. This component has been refined by the LEG (1984b), and the output from this component, anticipated dry matter yields, represents yield levels that could be expected over the long-term given optimal farm management. Furthermore, it should be possible to add a third component which would relate socio-economic conditions to yield levels, and thereby estimate the influence of factors such as tenure, management skills and technology on long-term yields.

More recently, de Wit's approach to productivity modelling has been adapted to tree growth (Clark, 1984). Once again, the model has two components: a photosynthetic component and an agroclimatic-edaphic component. Preliminary findings from this research are encouraging, and indicate that prevailing climatic conditions are the chief determinants of tree growth, whereas agroclimatic and edaphic conditions can be viewed as localized factors affecting productivity within a given climatic region.

The geographic scale at which de Wit's approach to productivity modelling is implemented depends upon the intended use of the yield estimates. Stewart, the LEG, and Clark were all interested in broadscale assessments and therefore data inputs were compiled at the scale of 1:5M. This scale is not consistent with the intended use of the MLES for New Brunswick and therefore it will not be feasible to compile the required yield estimates from these analyses. Nevertheless, the approaches implemented by Stewart, the LEG, and Clark indicate the climatic and edaphic data required to model yields.

Implementation of the photosynthetic component for both the crop and forest productivity models requires data on maximum and minimum air temperature, and incoming global solar radiation. Climatic data reported by

van Groenewoud (1983) and Dzikowski et al. (1984) should be sufficient. Monthly means for maximum and minimum temperatures can be used to estimate daily values, and information on incoming solar radiation can be derived from sunshine hours.

The agroclimatic-edaphic component requires data on precipitation during the growing season, the extent to which soil moisture is recharged during the winter and spring, moisture losses through potential evapotranspiration, and the extent to which soils impede root development (i.e. density, toxicity, depth to compact layer and drainage). The agroclimatic data are either available or can be inferred from available sources. It is doubtful however that all of the soil data could be compiled for all of New Brunswick at this time. Estimating the capacity of the soil to retain moisture and release it for plant growth requires data on soil texture, volume of coarse fragments, dry bulk density and depth to ground water. Data on volume of coarse fragments and dry bulk density are not readily available for all of the province.

The socio-economic dimension of the land units would reflect the extent to which geographic location limits the area available for primary production, and the degree to which tenure influences resource availability and expected levels of productivity. In forestry, the location of mills constrains the area that is economically viable for the production of forest products, and productivity levels are substantially higher on the highly managed crown and large freehold lands than on the nonindustrial woodlots that are typical of small freehold lands. Potato production is also constrained by the location of processing plants, and livestock feeds must be produced in close proximity to the livestock.

For the purposes of the MLES for New Brunswick, geographic location can be incorporated within the land units in two ways. The grid system employed by the Department of Natural Resources for estimating production potential for forestry is of sufficient detail to address all of the issues outlined in Section 2. Mills, potato processing plants and livestock producing regions could be located using this grid system, and appropriate distance decay functions could be developed for each activity. Alternatively, parish boundaries could be used to demarcate geographic regions which are in close proximity to mills, potato processing plants and livestock producing areas. In order to maximize the usefulness of existing information sources, it would probably be worthwhile to establish a link between the grid system and parish system.

Tenure can effectively be included within the land units via the existing three-tiered classification system. Crown lands and large freehold lands isolate the well-managed industrial forested lands, whereas the small freehold lands identify the area available for private woodlots and for crop production.

In addition to defining the land units according to specific aspects of climate, soil, geographic location and tenure, it will also be necessary to estimate the availability of each land unit for agriculture and for forestry. Environment Canada's Rural Land Analysis Program (RLAP) could be used as a basis for estimating availability of land to each resource sector, and ths information source could be supplemented with information available from the New Brunswick Forest Inventory.

4.5.2 Production Levels

Agricultural Products:

The base data for production of agricultural products can be compiled from existing data sources, and would include provincial consumption, movement of agricultural products between New Brunswick and other provinces, international exports and imports, and the conversion of livestock feeds to livestock products. For potatoes and livestock feeds, regional production levels reflecting existing processing facilities and livestock producing regions respectively would also be required.

Future levels of production would take into account possible changes in population, in consumption patterns, in the interprovincial and international movement of agricultural products and in the rate at which feed crops are converted into livestock products. Provincial projections for agricultural production can be derived from the Agri-Food Development Subsiduary Agreement (Agriculture Canada, 1984) and the Agri-Food Strategy for Canada (Agriculture Canada, 1981). Of course regional levels of production could be adjusted to depict new processing facilities or shifts in livestock production.

Forestry Products:

The base data for forestry production can be compiled from the milling capacity of existing mills. These data would be prepared for the province as a whole, and for supply regions for particular mills.

One of the long-term objectives for New Brunswick's forestry sector is to maintain existing mills. Hence, the current milling capacity on a provincial and regional basis represents a reasonable estimate of future targets for forestry production. Of course, it would be possible to adjust these levels to reflect rationalization or expansion in either the pulp and paper or saw log sectors.

4.6 Recommendations for the Development of a Multisector Land Evaluation System in New Brunswick

1. It is apparent that economic development in New Brunswick will continue to rely heavily on the forestry and agri-food sectors. A fully operational multisector land evaluation system (MLES) for New Brunswick would assist resource and policy analysts by providing assessments of the concurrent opportunities for forestry and agricultural production, and of the extent to which changes in the biophysical and socio-economic conditions would affect production prospects. Thus, it is recommended that a MLES for New Brunswick be constructed.

2. The structure proposed in this report for a MLES for New Brunswick has been shown to be practicable and has been endorsed by representatives from provincial Departments of Natural Resources, and Agricultural and Rural Development. Therefore, it is recommended that a MLES be developed around this framework.

3. Decisions affecting the long-term use of New Brunswick's land resources are being made in the absence of an analytical system that can measure the aggregated impact of several independent courses of action. It is recommended that the construction of a MLES for New Brunswick commence as soon as possible.

4. Many of the existing data sources are not consistent with the proposed structure for a New Brunswick MLES. Nevertheless, a first approximation of the data base could be compiled either by modifying the available data or by supplementing these with data from independent sources. Therefore it is recommended that a prototype MLES be constructed. This would permit an assessment of some of the issues at the earliest possible date, and facilitate construction of the system. The forestry component of the prototype could employ the data base and analytical procedures implemented by the New Brunswick Department of Natural Resources. The agricultural component would utilize reported data on land use and crop yields, and where necessary these data would be supplemented by expert opinion.

5. Implementation of all facets of the proposed structure for a MLES for New Brunswick and its efficient application should be guided by an interdisciplinary team of scientists. Without such a co-ordinating unit it is extremely unlikely that the necessary data would be generated or compiled in an appropriate form, and it is even more unlikely that the pertinent tools for data management and multisector analysis would be constructed. The expertise is available, but for constructing and implementing a MLES, this expertise needs to be co-ordinated. It is recommended that this team be established as soon as possible and include scientists with expertise in the following areas: co-ordination of interdisciplinary projects, land resource science, crop productivity modelling, forest productivity modelling, commodity demand forecasting, policy formulation, and systems design and programming.

5 IMPLICATIONS OF LAND EVALUATION SYSTEMS AT THE NATIONAL LEVEL

5.1 Overview

The New Brunswick pilot has shown that a multisector approach to resource assessment is needed and that it would be feasible to construct a land evaluation system with a capacity to incorporate several sectors simultaneously. One of the major uses of such a system would be to gauge the overall impacts of alternative development thrusts in two or more primary sectors on options for land use and on aggregate socio-economic benefits to society.

Preliminary evidence (Environment Canada, 1981; Simpson-Lewis et al., 1983) suggests that there is an urgent need at the national level for analytical systems which could assess concurrent prospects for production in two or more primary resource sectors. The approaches introduced in this report are sufficiently general that they could be applied at any geographic scale, and therefore they represent guidelines for a Canada-wide multisector land evaluation system. It would be premature however to begin construction of a national system without a thorough examination of how such a system would be employed by resource and policy analysts.

The LEG and Agriculture Canada are in the early stages of developing the agricultural component on a Canadian Land Evaluation System (CLES) (LEG, 1983a). The major use of this system will be to measure the extent to which the resource base constrains agri-food development options. Once the agricultural component is operational, it will have the capacity to assess production prospects given changes in climatic conditions, land degradation and land improvements, and adjustments to broadscale socio-economic conditions such as development of international markets and shifts in interprovincial trade.

Since the LEG is in the early stages of developing a CLES, it should be feasible to expand this effort to include other sectors in a cost-effective manner. Clark's (1984) adaptation of de Wit's crop productivity model to tree growth is encouraging in two respects. First, it indicates tentatively that the agricultural and forestry components of a national MLES would be able to share a common land resource information base. This consistency would reduce data collection costs and simplify data managemet and analytical procedures. Second, there is a great deal of similarity in approaches employed by Clark and the LEG (1984b) in measuring the extent to which edaphic conditions limit tree and crop yields respectively. Hence it should be feasible to add a forestry component to the system under construction.

It would appear that there are at least two options for developing MLES's with Canada-wide capabilities. One approach would involve constructing independent provincial systems which would be co-ordinated at the national level. The other approach would be to construct a highly aggregated national system which would be subdivided into provincial or regional components. These two options are expanded upon in the remainder of this section.

5.2 Co-ordinated Provincial Systems

This option would involve the construction of a series of provincial systems which would be linked nationally. Each provincial system would be an independent unit, and in many respects be similar to the system proposed for New Brunswick. The units of analysis would in all likelihood be relatively disaggregated and therefore permit detailed assessments of production prospects and economic opportunities in each sector, and for the province as a whole. At a minimum, the national co-ordinating mechanism would aggregate the findings from each provincial system. It would be feasible however to construct a more sophisticated co-ordinating mechanism using an inter-regional approach to resource analysis.

Implementing this option would require an interdisciplinary team in each province as well as a national co-ordinating unit. This approach would be very effective in the sense that it would maximize the use of specialists in each province. Furthermore, these systems could be used to provide the detailed types of analyses that are required to resolve land use planning conflicts at the provincial level, and, by aggregating the findings, these systems could service the needs of decision-makers responsible for formulating policies at the national level.

The principal limitation of constructing independent provincial systems which would eventually be housed under a national umbrella would be the costs associated with all aspects of the project. It would be very costly to establish and maintain the interdisciplinary teams and a national co-ordinating unit through the design, construction and application phases. The co-ordinating unit would need to ensure that the provincial systems were developed in a compatible fashion. Whether or not these costs would be prohibitive would depend to a large extent upon the intended use. That is, if this system is to be used for resource assessment at the national and provincial levels, then the benefits of a series of provincial systems linked nationally might outweigh the costs.

5.3 One National System

An alternative is to construct a national system which would have embedded in it provincial boundaries. The units of analysis would be highly aggregated, and therefore this system would be well-suited for gauging the extent to which the resource base limits opportunities for futher development and for broadscale socio-economic assessments at the national level. This option would assist resource analysts at the federal level by indicating those regions of Canada in which there exist the greatest opportunities for expanding production in the agricultural and forestry sectors, and those regions where developments in one sector would seriously impinge upon prospects for the other. At the provincial level, these findings would provide guidelines within which provincial policies might be formed, rather than a detailed assessment of policy alternatives.

The construction of an operational system with multisector capacity would require an interdisciplinary team with expertise in the following areas: project co-ordination, productivity modelling in the agricultural and forestry sectors, commodity demand forecasting, and systems design. In addition, this core of expertise could draw upon resources in each region as required.

It would be considerably less expensive to construct, maintain and apply a highly aggregated national system than a series of provincial systems that could be linked. Fewer personnel would be required. The aggregated structure should keep the costs of the data collection and compilation tasks down to a minimum, and it should be less expensive to maintain and operate a system with a smaller number of units.

The decision regarding which of these two options would be better rests largely upon the envisaged use of the system. If this system is to assist resource analysts in assessing the extent to which the resource base constrains concurrent opportunities for production in the agricultural and forestry sectors in different regions throughout Canada, then a national system which distinguishes provinces would be the appropriate option. On the other hand, analysis which would provide details on the prospects for increasing production in each sector and on the socio-economic benefits that would be expected with alternative policy thrusts would require a series of provincial systems that would be linked nationally. Clearly a thorough examination of the need and intended use of a multisector land evaluation system at the national level is a prerequisite to decisions regarding the suitability of alternative approaches.

REFERENCES

Agriculture Canada and New Brunswick Department of Agriculture and Rural Development. 1984. Agri-food development subsiduary agreement 1984-1989. Fredericton.

Agriculture Canada. 1981. Challenge for growth: An agri-food strategy for Canada. Ottawa.

Clark, J.S. 1984. Utilization of soil survey information for forestry. Presented to the Canadian Forest Inventory Committee, May 14-18, 1984. Harrison Hotsprings.

de Wit, C.T. 1965. Photosynthesis of leaf canopies. Agric. Res. Report 663. Centre for Agr. Publ. and Docu. Pudoc.

Dzikowski, P.A., G. Kirby, G. Read and W.G. Richards. 1984. The climate for agriculture in Atlantic Canada. Draft manuscript of Agdex No. 070, Atlantic Advisory Committee on Agrometeorology. Fredericton.

Environment Canada. 1981. Federal policy on land use. Ottawa.

Land Evaluation Group. 1984a. Recommended structure for the Canadian land evaluation system and development of prototypes. Publication No. LEG-21. University School of Rural Planning and Development, University of Guelph. Guelph.

_____. 1984b. Assessments of available biophysical resource inventories and crop productivity estimates. Publication No. LEG-20. University School of Rural Planning and Development, University of Guelph. Guelph.

_____. 1984c. Analysis of the production possibilities of Ontario agriculture, Volume II: Prospects for growth in Ontario's agri-food sector under alternative conditions of supply and demand. Publication No. LEG-18. University School of Rural Planning and Development, University of Guelph. Guelph.

_____. 1983. Analysis of the production possibilities of Ontario agriculture, Volume I: Regional assessments of the prospects for sustainable agricultural production. Publication No. LEG-16. University School of Rural Planning and Development, University of Guelph. Guelph.

Simpson-Lewis, W., R. McKechnie and V. Neimanis. 1983. Stress on land in Canada. Lands Directorate, Environment Canada. Ottawa.

Stewart, R.B. 1981. Modelling methodology for assessing crop production potentials in Canada. Technical Bulletin No. 96. Land Resource Research Institute, Agriculture Canada. Ottawa.

van Groenewoud, H. 1983. Summary of climatic data pertaining to the climatic regions of New Brunswick. Maritimes Forest Research Centre, CFS, Department of the Environment. Fredericton.

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No. 39: Wetlands in the Montreal Region 1966-1981. J. Champagne and M. Melançon, 1985. En 73-4/39. ISBN 0-662-53591-X.

No. 40: The Eastern Ontario Subsidiary Agreement Drainage Program: Impacts on Land Resource a Preliminary Appraisal. C.P. Cecile, M.J. Bardecki and E.A. Snell, 1985. En 73-4/40E. ISBN 0-662-13882-1.