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Fraser River Indicator Study

Selection and Modeling of Sustainability Indicators for the Fraser River Basin

Technical Supplement

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Annex A

A Synthesis of Sustainability Goals and an Indicator Framework

SYNTHESIS OF SUSTAINABILITY GOALS

An indicator framework was developed from a synthesis of stated goals for sustainability as expressed by various studies or reports whose spatial area of concern included the Fraser River Basin. Goals for sustainability were considered from seven sources: (i) the British Columbia Commission on Resources and Environment (CORE); (ii) the British Columbia Round Table on the Environment and the Economy; (iii) Environment Canada State of the Environment Reporting; (iv) the British Columbia Ministry of Environment, Lands, and Parks; (v) the British Columbia Ministry of Health and Minister Responsible for Seniors; (vi) the Sustainability Reporting Task Force of the Fraser River Management Program; and (vii) the Westwater Research Centre's (University of British Columbia) Fraser River Basin Project. It is within the context of the issues addressed by these organizations that this Project's framework for indicator selection and modeling is synthesized. This annex presents a summary of stated goals for sustainability as expressed by various studies or reports whose spatial area of concern includes the Fraser River Basin. The full development of the indicator framework is subsequently discussed.

Summary of goals

A.) Commission on Resources and Environment (1994). *Finding common ground: a shared vision for land use in British Columbia.* Victoria, B.C.: Committee on Resources and Environment.

Resource Lands:

1.) to achieve the sustainable economic development of resource lands, through land use decisions that promote and encourage such development.

2.) to identify and assess areas of significant resource use potential, and ensure that the use of such areas reflects a balanced and full consideration of:

- -the inherent capabilities of the land, water, and air
- -economic, environmental, and social needs
- -opportunities for integrated management

3.) to apply integrated management of natural resource lands for multiple values, wherever compatible. To minimize conflicts between incompatible land uses, and minimize negative impacts of resource development/uses on adjacent areas.

4.) to establish a secure resource land base that can provide an abundant and sustainable supply of raw materials and other economic resources. To identify areas that are particularly suitable for:

- -commercial forestry
- -agriculture/rangeland/food production
- -energy, minerals, aggregate, and petroleum resources
- -fisheries
- -aquaculture
- -trapping, hunting, gathering
- -tourism

-other economic uses

and to ensure that such areas are maintained for such uses.

Specifically, to identify:

-a commercial forest land base

-an agricultural land reserve

and ensure the long-term designation of such lands for forestry and agricultural purposes, respectively.

5.) to ensure opportunities for exploration and development of subsurface resources.

6.) to maintain and enhance recreational values on natural resource lands.

7.) to enhance the productivity of appropriate resource lands and waters, in order to achieve increased economic and social benefits.

8.) to manage resource lands in accordance with the principles of resource stewardship, sustainable use, and ecosystem management. To maintain the long-term health and productivity of the ecosystems and support natural resource-based industries.

Human Settlement:

9.) to avoid the settlement of valuable resource lands and environmentally sensitive areas.

10.) to identify and designate sufficient suitable land for long-term settlement purposes. To ensure that adequate inventories of suitable land for future industrial, commercial, residential, and infrastructure development are available, and protected from incompatible uses.

11.) to avoid urban sprawl and ribbon development. To ensure that development takes place in areas where adequate public facilities and services exist, or can be provided in a timely, economic, and efficient manner.

12.) to encourage settlement patterns that reduce the need for private automobile use, and that foster the conservation and efficient use of energy.

13.) to preserve and expand community recreation parks and natural areas networks

14.) to encourage settlement patterns that foster a good quality of life and positive social interactions. To provide an equitable geographical distribution of social and other services.

15.) to preserve and enhance the distinctiveness of rural communities. To maintain their viability, social structure, and infrastructure.

16.) to protect life and property from natural hazards and disasters, avoiding development that is potentially unsafe for human occupation.

17.) to promote adequate, affordable, and appropriate housing.

18.) to ensure that the plans of local governments and the province are consistent with each other, and with the Provincial Land Use Goals.

Protected Areas:

19.) to protect viable, representative examples of the natural diversity of the province, representative of the major terrestrial, marine, and freshwater ecosystems, the characteristic habitats, hydrology, and landforms, and the characteristic backcountry recreational and cultural heritage of each ecosection.

20.) to protect the special natural, cultural heritage and recreational features of the province, including rare and endangered species and critical habitats, outstanding or unique botanical, zoological, geological, and paleontological features, outstanding or fragile cultural features, and outstanding outdoor recreational features such as trails.

Coastal and Marine Areas:

21.) to ensure that the development of coastal and marine areas is planned and managed sustainably, and:

-gives priority to coastal-dependent uses, over competing, non-coastal dependent uses.
-protects ecosystem functions and significant habitat for fish and other wildlife.
-maintain the scenic beauty and natural character of shorelines.
-maintains and enhances public access to shorelines, where such access does not compromise ecosystem functioning.

22.) to make the planning and management of land and water uses in coastal and marine areas integrated and consistent, across jurisdictions.

Transportation:

23.) to integrate transportation and utility planning with land use planning.

24.) to provide an integrated, multi-modal transportation system that:

-facilitates the economic and social development of the province, while respecting environmental and human settlement goals.
-is safe, efficient, convenient, and economic.
-minimizes energy consumption and air pollution.
-minimizes automobile commuting, reduces the need for private automobile use in daily life, and encourages the use of public transit and non-motorized transport.
-makes efficient use of utility and transportation facilities and corridors.
-avoids transportation projects which encourage or subsidize inappropriate land development.

Energy:

25.) to make proactive land use decisions that provide for energy supply, and promote the efficient use and conservation of energy. To promote the use of clean and renewable energy sources.

Sustainable Economic Development:

26.) to seek full employment, and to equitably meet human needs.

27.) to promote land uses that support "value-added" enterprises that enhance employment.

28.) to reduce uncertainty with respect to land use and land user rights, in order to encourage a stable investment climate.

29.) to promote diverse and regionally balanced economic development that supports stable, healthy, and vibrant communities.

30.) to coordinate provincial, regional, and community economic development initiatives with land use plans.

31.) to coordinate infrastructure development planning with land use plans.

32.) to streamline regulatory and permitting mechanisms, so that such mechanisms achieve their purposes efficiently and predictably, and without unnecessary cost to the public or private sector.

33.) to ensure that government land use expenditures do not exceed the taxpayer's ability to pay.

Sustainable Environment:

34.) to protect the natural and economic productivity of soils, by minimizing activities that cause soil degradation and loss.

35.) to protect the quality and quantity of ground and surface water. To maintain healthy aquatic ecosystems, and instream flows that protect fisheries. To encourage the conservation and efficient use of water, while meeting the long-term needs of agriculture, industry, energy production, and human settlement.

36.) to maintain the recreational, spiritual, and cultural values of water. To maintain and enhance public access to water bodies and shorelines, where environmentally sustainable.
37.) to maintain the diversity and abundance of native species and their natural habitats throughout British Columbia. To recover native endangered, threatened, and vulnerable species and ecosystems.
38.) to reduce conflicts between wildlife and human activities, while ensuring a variety of opportunities for the use and enjoyment of wild plants and animals.
39.) to ensure that environmentally sensitive areas are identified in all land use plans, and are appropriately managed to respect their sensitivity and maintain their inherent values.
40.) to make proactive land use decisions that prevent or reduce pollution and its impacts. To encourage waste reduction, reuse and recycling.
41.) to promote the restoration of degraded soil, water, air, and ecosystems.

Outdoor Recreation:

42.) to ensure that the full range of outdoor recreation opportunities are available, and that special recreation values are identified and maintained, in all land use zones.

Cultural Heritage:

43.) to maintain good stewardship of, and where appropriate, beneficial use of, land, sites, and structures with cultural, traditional, historical, spiritual, archaeological, or architectural significance.
44.) to support aboriginal peoples' objectives of maintaining their heritage.

Aboriginal Peoples:

45.) to ensure that land use decisions do not infringe on aboriginal rights or prejudice treaty negotiations. To ensure that planning and management is conducted cooperatively with aboriginal peoples, where their rights or interests may be affected.

B.) Commission on Resources and Environment (1994). *Cariboo-Chilcotin land use plan.* Victoria, B.C.: Commission on Resources and Environment.

Social:

1.) preserve lifestyle by ensuring: stable employment, a high standard of living, a high quality environment, and continued opportunity to make choices.
2.) maintain community stability by managing change, ensuring a social safety net, developing effective programs to remove barriers created by job loss, and creating well-paying jobs.
3.) promote stewardship of the land base for sustainability and community stability.
4.) develop effective compensation, mitigation, and transition strategy policies.
5.) facilitate community control, empowerment, and self-determination while respecting the ability of surrounding communities to do the same.
6.) work with communities to identify and address local issues related to social, economic, and environmental factors.
7.) increase citizen responsibility and accountability.
8.) ensure that the negative effects of land use decisions are minimized and that the costs and benefits are distributed equitably.

Economic:

9.) no net loss of jobs in any sector attributable to the Land Use Plan.
10.) address outstanding land use uncertainties and issues in the region.

11.) promote the best use of Crown land to maximize economic, social, and environmental benefits to the people of the province.
12.) ensure a fair return to the Crown for the use of public assets.
13.) ensure resource use policy development respects the importance of industry competitiveness.
14.) promote investor confidence as well as employment and economic stability.
15.) increase the security of the resource base for all resource-based industries including: forestry, agriculture, tourism, mining, fishing, trapping, and wildcraft.
16.) ensure access to and maintain the quality of resources needed to support economic activity.
17.) diversify the economy and enhance employment opportunities by:

-enhancing productivity of the forest land base (silviculture, rehabilitation, and reforestation).
-increase the number and size of community forest tenures and individual woodlot licenses.
-investing in value-added industries, particularly forestry.
-encourage innovative harvesting techniques.
-investing in transportation infrastructure.
-expending local agricultural markets.
-encourage continued growth in tourism industry.
-ensuring opportunities for small businesses.
-managing for integrated use of the land base.
-pursuing regional economic development initiatives.

18.) address the potential negative impacts of declining harvest levels due to elimination of beetle kill harvest, long term timber supply decline, land use decisions, and implementation of the Forestry Practices Code.
19.) distribute benefits and costs of resource extraction and management equitably between rural and urban communities.
20.) minimize the depletion of resource capital by ensuring maximum possible value is derived from extracted resources.
21.) conserve lands and waters which are in limited supply and are required for important economic uses such as agriculture.
22.) promote the management and allocation of land and water resources to enhance the growth, diversification, and viability of all economic sectors.

Environmental:

23.) protect representative samples of the region's ecological diversity, recreational, wilderness, and cultural heritage resources.
24.) establish a viable system of protected areas for terrestrial and aquatic ecosystems.
25.) protect rare, threatened, and endangered species.
26.) ensure viable fish and wildlife population.
27.) maintain habitats for mule deer, caribou, grizzly bear, and big horn sheep.
28.) consider the cumulative impacts of development on fish and wildlife habitat and populations.
29.) sustain the wetland and riparian habitats of the region.
30.) sustain the natural grasslands of the region, particularly the special wetland habitats within them.

31.) establish and maintain a management system to protect biological diversity across the entire landscape.
32.) use ecologically based management systems, for example, by using naturally occurring biophysical features such as watersheds as the basis for management decisions and forest harvesting regimes which are similar to natural disturbance regimes.
33.) manage rate and distribution of forest development in keeping with requirements of fish and wildlife and hydrological systems.
34.) manage development activities in order to minimize disruption of water quality and quantity.
35.) minimize the degree to which the environment is disturbed by human uses by exercising caution in the face of uncertainty.
36.) maintain the opportunity to study and enjoy natural ecosystems.
37.) protect the aesthetic qualities of the landscape.
38.) ensure controlled access to and use of environmentally sensitive areas.
39.) enhance the quality of soils, air, wildlife, ecosystems, and waters as well as water flow and quantity.
40.) ensure an access to a diversity of outdoor recreation activities.

Decision-Making Process:

41.) provide opportunities for meaningful participation of all interests in decision-making at all levels.
42.) ensure simplified, time-efficient, and coordinated review and approval processes.
43.) establish clear rites, responsibilities, and roles of resource users and government decision-makers, and clear management objectives for resources.
44.) ensure an understandable land designation system that can be effectively implemented.
45.) improve the quality of economic, social, and environmental data and identify and fill gaps.
46.) coordinate and simplify decision-making processes related to land use and resource management as well as the development of adjustment and mitigation transition strategies.
47.) carry out land use and resource management planning processes through cooperative, inter-agency initiatives, public consultation, and consensus-building.
48.) ensure planning processes are flexible and able to respond to changes over time.
49.) encourage understanding of and tolerance for the needs and perspectives of all sectors and ensure acknowledgment of shared responsibility for solving problems.

First Nations:

50.) ensure fairness to First Nations.
51.) promote new understandings and relationships with First Nations.
52.) encourage First Nations' participation in land use and resource management decision-making and ensure that such participation is without prejudice to First Nations' rights.

C.) British Columbia Round Table on the Environment and the Economy (1992). *Towards a strategy for sustainability*. Victoria, B.C.: British Columbia Round Table on the Environment and the Economy.

and

D.) British Columbia Round Table on the Environment and the Economy (1993). *Sustainability: from ideas to action.* Victoria, B.C.: British Columbia Round Table on the Environment and the Economy.

1.) a new order of urban design that reduces the need for energy-intensive transportation, integrates green space, and enhances our sense of community.
2.) forestry and agricultural practices that protect soil, water, and nutrient cycles.
3.) land-use planning that preserves prime agricultural and forest lands, and protects wilderness areas and wildlife habitat, while providing working capacity for development.
4.) a vibrant and dynamic economy, in which ingenuity is focused on qualitative -rather than quantitative- growth, and which the full value of environmental assets and the impacts of human activities are considered.
5.) a new harmony with First Nations people in which aboriginal rights and self-determination have been resolved.
6.) full and satisfying participation in decision-making, with local and individual empowerment.
7.) a social support structure that eliminates the fears of hunger, sickness, alienation, and lack of opportunities for education and personal fulfillment.
8.) health that is measured in degrees of wellness rather than sickness; a standard of living that is measured by quality of life rather than by level of consumption.

Principles:

9.) limit our impact on the living world to stay within its carrying capacity (its ability to renew itself from natural and human impacts).
10.) preserve and protect the environment (conserve life support systems, biological diversity, and renewable resources).
11.) hold to a minimum the depletion of non-renewable resources.
12.) promote long-term economic development that increases the benefits from a given stock of resources without drawing down on our stocks of environmental assets (through diversifying and making resource use more efficient).
13.) meet basic needs and aim for a fair distribution of the benefits and the costs of resource use and environmental protection.
14.) provide a system of decision-making and governance that is designed to address sustainability (is more proactive, participatory, long term).
15.) promote values that support sustainability (through information and education).

E.) British Columbia Round Table on the Environment and the Economy (1991). *Sustainable land and water use.* Victoria, B.C.: British Columbia Round Table on the Environment and the Economy.

-reiterates the previously noted objectives outlined by the B.C. Round Table, with additional management guidelines for land and water:
1.) maintain globally competitive industries.
2.) having stable communities.
3.) increasing the number of jobs per unit of resource extracted.
4.) limited use of pesticides.
5.) minimizing aesthetic impacts.

6.) preventing off-site damage.
7.) reducing energy use.
8.) maintaining biological diversity and stable ecosystems.
9.) limiting release of carbon dioxide.
10.) minimizing conflict between users of the environment.

F.) Environment Canada and British Columbia Ministry of Environment Lands and Parks (1992). *A state of the environment report: state of the environment for the lower Fraser River Basin* (SOE report #92-1). Ottawa, Canada: Ministry of Supply and Services, Canada.

1.) take account of the interactions between physical, biological, and human components of the environment in day-to-day decisions which affect the environment.
2.) recognize the environmental interdependencies between different areas of the Basin, between the Basin and the Fraser River and between the Basin and larger regional and world systems.
3.) consider the cumulative and additive effects over time of many small, incremental decisions on the long-term condition of the environment.
4.) accommodate unpredictable environmental events and uncertainty and provide a means of adapting to changes in the environment.
5.) encourage public involvement at a personal and community level in environmental protection and conservation.

G.) British Columbia Ministry of Environment, Lands, and Parks (1993). *Strategic Directions: 2000.* Victoria, B.C.: Ministry of Environment, Lands, and Parks.

1.) protection, conservation and restoration of a full range of biological and physical diversity native to British Columbia.
2.) clean, healthy and safe land, water and air for all living things.
3.) provision of social, economic and outdoor recreational opportunities within the constraints of maintaining a naturally diverse and healthy environment.

H.) British Columbia Ministry of Health and Ministry Responsible for Seniors (1993). *A report on the health of British Columbians: Provincial Health Officer's annual report, 1992.* Victoria, B.C.: British Columbia Ministry of Health and Minister Responsible for Seniors.

-uses a definition of health based on the World Health Organization's adoption:

"Health is the extent to which an individual or group is able, on the one hand, to realize aspirations and satisfy needs; and, on the other hand, to change or cope with the environment. Health is, therefore, seen as a resource for everyday life, not the objective of living; it is a positive concept emphasizing social and personal resources, as well as physical capacities."

-emphasizes the need to for action and improvements (which may be applicable to our exercise) to be made in the following:
1.) acknowledge the connection between socio-economic factors and health. Both at the provincial and community levels, we must devote more time, resources, and research efforts to reduce poverty and unemployment, achieving more equitable distribution of wealth, improving housing, and developing stronger social support networks.

2.) improve the unacceptable health status of Aboriginal people, with every effort to empower Aboriginal people's control over their lives and their futures.
3.) reduce low birth weight and infant mortality rates by providing comprehensive social supports to single parents living in poverty.
4.) reduce the number of unintended pregnancies, especially in our teenage population.
5.) all our children must be raised in an environment which will enable them to fully develop the coping and managing skills they need as adults.
6.) make bicycle helmets mandatory, enforce seatbelt laws, increase efforts to prevent drinking and driving, and introduce graduated licensing for new drivers.
7.) address the problem of youth suicides.
8.) continue efforts to reduce smoking and eliminate second-hand smoke in all public places.
9.) reduce the incidence of heart disease through comprehensive, community-based programs targeted at lifestyles, environmental, and socio-economic factors.

I.) British Columbia Ministry of Health and Ministry Responsible for Seniors (1994). *A report on the health of British Columbians: Provincial Health Officer's annual report, 1994.* Victoria, B.C.: British Columbia Ministry of Health and Minister Responsible for Seniors

-follows the direction provided by the 1992 report and presents clear recommended action statements along with preliminary work toward the adoption of an appropriate set of indicators for health. Various health goals are reflected throughout the document:
1.) ensure that all British Columbians have adequate income, employment opportunities, housing, food, and education, with a valued role to play in family, work and the community.
2.) ensure a safe, healthy and naturally diverse environment that enriches the lives of current and future generations.
3.) ensure there is wide public knowledge about the determinants of health and encourage public participation in informed decision making in all factors affecting population health. Strategies for ensuring public knowledge and encouraging public participation will need to recognize and be responsive to the diversity of people and communities in British Columbia.
4.) ensure the most effective use of societal resources to improve population health. This includes identifying effective health care interventions and being sure that there is equitable and optimal access to these services. It also will need to be recognized that hard choices will have to be made and that there may be ways of spending public money to improve health, that are more effective than health care (or traditional health promotion/disease prevention measures) e.g. relieving child poverty.
5.) reduce mortality/ morbidity from preventable causes.
6.) foster strong, empovered individuals in supportive and participatory communities.
7.) foster a safe, secure and non-violent environment in the home, school, workplace and communities in British Columbia.
8.) foster cooperation between all levels of government to resolve issues impacting the health of First Nations.

J.) Sustainability Reporting Task Force, Fraser Basin Management Program.

1.) to foster the conservation, maintenance, and enhancement of the ecological integrity, biodiversity, and productivity of natural processes and ecosystems of the Fraser.
2.) to promote responsible and cooperative use and management of resources in the Basin for meeting present and future human needs.
3.) to promote healthy, prosperous, and dynamic community life where community needs and aspirations are met.
4.) to promote equitable, planned growth and distribution of regional, economic, and social activity to ensure sustainability of the Basin.
5.) to improve and support the development of governmental and non-governmental institutions, their linkages and communications.

K.) Dorcey, Anthony H.J. (ed.) (1991). *Perspectives on sustainable development in water management: towards agreement in the Fraser River Basin.* Vancouver, B.C.: Westwater Research Centre, The University of British Columbia.

and

L.) Dorcey, Anthony H.J. and Griggs, Julian R. (eds.) (1991). *Water in sustainable development: exploring our common future in the Fraser River Basin.* Vancouver, B.C.: Westwater Research Centre, The University of British Columbia.

-places an emphasis on the evolving ethic relating economic, environmental, and social systems and including at least five ethical elements:
1.) maintaining ecological integrity and diversity.
2.) meeting basic human needs.
3.) keeping options open for future generations.
4.) reducing injustice.
5.) increasing self-determination.
-must enter discourse with a clear understanding of world views (i.e., technocentric vs. ecocentric) and the corresponding inclusion or hierarchy of economic, environmental, and social systems.

Synthesis of goals

There are two primary approaches that one can take in an attempt to synthesize the above information into a common set of goals: 1) start with broad goals and place each specific goal into the appropriate category, focusing more on the common desired features of the systems than the systems themselves; or 2) start with broad topic areas (e.g., resources, government, etc.) and place each specific goal into the appropriate category, focusing more on the systems they address than the common features. We will follow more or less the first method, with the exception that features of the natural environment are given status as a separate entity with specific desirable system features separate from the features of the human systems, although the need for an

emphasis on the critical links between systems is acknowledged. This should be seen as just a method for information synthesis.

Thus, from (K) and (L), let us start with a framework that include the dimensions of:

Natural systems:
1.) ecosystem integrity and diversity
Human systems:
2.) human needs and development (social and economic)
3.) options
4.) distributions
5.) empowerment and decision-making

——————————→ tracked over time.

We have then defined a broad set of five 'goals' (Box A.1). *These five categories are then used to aid the specification of an indicator framework, which will then serve as a general guideline for indicator selection. It is important to note that each indicator that is eventually selected will not be linked back to a specific goal (see following discussion).*

Box A.1. An Initial Synthesis of Sustainability Goals

1.) Ecosystem integrity and diversity.

2.) Human needs and Development.

3.) Options.

4.) Distributions.

5.) Empowerment and decision-making.

The common elements found within the summary of goals using this "features" method are as follows:

1.) ecosystem integrity and diversity
A.2, A.8, A.9, A.19, A.20, A.21, A.34, A.35, A.37, A.39, A.40, A.41, B.23, B.24, B.25, B.26, B.27, B.28, B.29, B.30, B.33, B.34, B.39, CD.2, CD.3, CD.4, CD.9, CD.10, E.4, E.6, E.8, E.9, F.2, G.1, G.2, I.2, J.1

2.) human needs and development (social and economic)
A.1, A.2, A.4, A.5, A.6, A.7, A.8, A.9, A.11, A.13, A.14, A.16, A.17, A.19, A.20, A.21, A.24, A.27, A.34, A.36, A.38, A.42, A.43, B.1, B.3, B.11, B.13, B.14, B.16, B.17, B.18, B.23,

B.37, B.38, B.40, CD.1, CD.3, CD.4, CD.8, CD.13, E.1, E.2, E.3, E.5, E.6, G.2, G.3, H.4, H.5, H.6, H.7, H.8, H.9, I.1, I.5, I.7, J.3

3.) options

A.10, A.12, A.24, A.25, A.35, A.40, B.1, B.20, B.21, B.36, CD.1, CD.9, CD.11, CD.12, E.7, E.9, G.1, I.2, J.2

4.) distribution

A.3, A.11, A.14, A.15, A.16, A.17, A.21, A.26, A.29, A.32, A.33, A.45, B.2, B.4, B.8, B.9, B.12, B.16, B.19, B.22, B.50, B.52, CD.7, CD.13, G.2, H.1, H.2, H.3, H.4, I.1, I.4, J.4

5.) empowerment and decision-making

A.2, A.3, A.18, A.22, A.23, A.28, A.30, A.31, A.32, A.44, A.45, B.5, B.6, B.7, B.10, B.15, B.31, B.32, B.35, B.41, B.42, B.43, B.44, B.45, B.46, B.47, B.48, B.49, B.51, B.52, CD.5, CD.6, CD.14, CD.15, E.10, F.1, F.3, F.4, F.5, H.2, I.3, I.6, J.2, J.5

DEVELOPMENT OF AN INDICATOR FRAMEWORK

There are two conceptual elements (or assumptions) of the approach used in this project that are different from many other indicator studies. These elements reflect: (i) flexibility in the set of values; and, (ii) decision-making using a process of 'procedural rationality'.

Flexibility in the value set raises a general issue of how values, goals, objectives, targets, and indicators are related. There exists a wide spectrum of methodologies that, explicitly or implicitly, reflect different assumptions regarding these relationships. At one extreme, indicators and targets are selected without prior thought to their inherent value-laden biases; such practice has, unfortunately, been relatively common. The resultant disagreements arising from this have often prompted a call for explicit specification of values and goals prior to indicator selection. At an opposite extreme, then, lies the position that values must be identified, such that an appropriate set of indicators can be selected that reflects performance in light of these values. The weakness of this latter approach, however, is that if there is no consensus on the value set then there is little hope for a consensus on indicator selection. In the case of the Fraser River Basin, the wide diversity of values and goals of various interest groups and decision-makers further confounds such an approach. The general tact taken within this project, therefore, is to select the indicator set and the modeling environment in a manner that they can flexibly accommodate a plurality of values or goals. It must be stressed that this is quite different from selecting a 'value-independent' set; the set chosen is selected with a view to accommodating most (but perhaps not all) of the values that may be of relevance.

Procedural rationality refers to the existence of a decision-making process that occurs within an environment of: (i) a plurality of goals and values; and, (ii) inherent uncertainty.[1] Traditional decision-making models generally assume that a set of well-defined constant goals exists, and that the impacts of various policies or decisions can be estimated. Such decision-making models

[1] The concept of 'procedural rationality' is described in more detail in Faucheux, S. and G. Froger (1995). Decision-making under environmental uncertainty. *Ecological Economics* 15(1): 29-42.

typically result in indicator specification and modeling approaches that rely on rationally selected targets within a framework of cost-benefit analysis (where there is a single objective) or 'multi-criteria analysis' (where there are multiple objectives). Many long-term sustainability issues do not, however, lend themselves well to such rational decision-making models; reality is in fact fraught with changing values and goals, and system dynamics typically exhibit massive complexity and uncertainty. In response to this reality, procedural rationality assumes the existence of long-term decision-making structures that may change the specific values, goals, or targets through time as previously uncertain outcomes become revealed. Decisions made at any point in time within such a structure, stated simply, attempt to 'satisfice' a set of prevailing goals at that time. Indicators used within such a structure must, therefore, also be capable of adapting to changing goals.

It is evident from the stated goals of the above agencies that there is a plurality of issue areas that need to be considered. These issues can be categorized according to the broad system that they address: (i) ecological (air, water, land, and biota); (ii) economic (production and consumption); (iii) social (cultural and human security); and, (iv) institutional. Further, each issue area has three primary dimensions: (i) present state of the system; (ii) intergenerational distribution ('options'); and, (iii) intragenerational distribution ('entitlement').[2] All of these issues and dimensions should be tracked through time (i.e., each indicator of a state, intergenerational distribution, or intragenerational distribution dimension is specific to one moment in time). Box A.2 shows the resultant matrix framework for the selection of a small set of indicators.

For clarification purposes, it is relevant to highlight a number of attributes of this framework:

(a) an indicator of 'entitlement' – whether it is economic entitlement or ecological entitlement (such as access to safe drinking water) – will often have important underlying social dimensions. The social aspects of sustainability will therefore be inherent throughout much of the indicator set.

(b) 'culture and human security' – within this framework – is interpreted in the broad sense and potentially includes, for example, religious freedoms, health, literacy, democratic freedoms, security of social structures (e.g., family units), and incidence of crime.

(c) 'institutional' issues give heed to the increasing concern within the literature for 'sustainable institutions.' Institutional issues within British Columbia, for example, potentially include private property rights, industrial concentration, taxation, and government function and accountability.

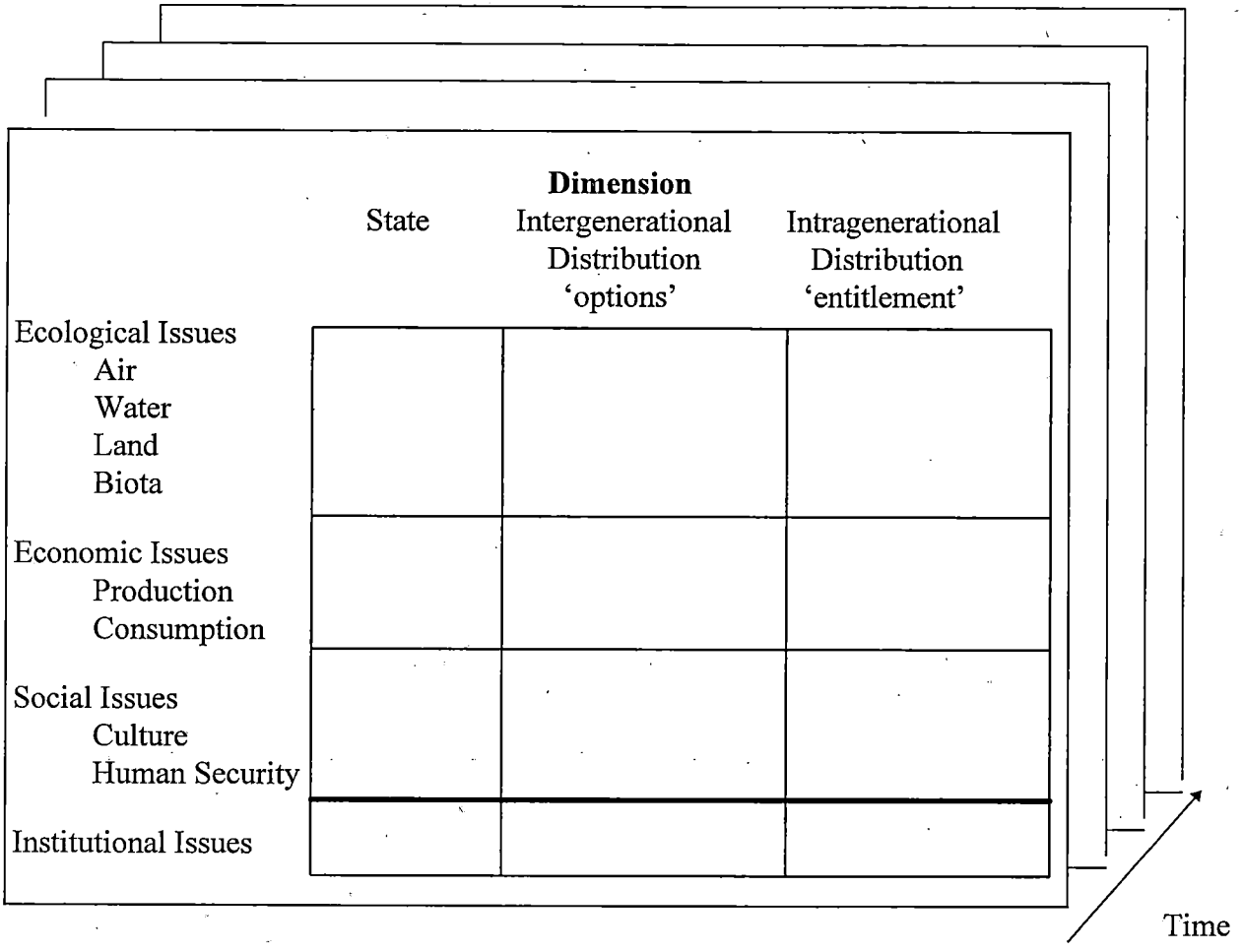
Consistent with not specifying linkages of indicators to specific goals, the project will focus on indicators that, while being critical to a particular identified issue, do not necessitate the adoption of a particular value judgment (e.g., this indicator must go up for the Fraser River basin to be sustainable). As noted previously, it could be argued that the mere selection of an indicator imposes some directional value judgment. This is not, however, necessarily the case; various stakeholders could share common concerns for an issue but differ markedly in their opinions of

[2] A fourth dimension – spatial distribution within the Fraser River Basin – is also identified. This dimension, however, is addressed in the modeling of the indicators.

the 'sustainable' state or distribution. For example, while everyone may agree that GDP is an important economic indicator, we might disagree as to whether GDP should be increasing, stable, fluctuating, or decreasing. The exercise will be to select indicators that are important to a plurality of viewpoints, and not to judge what is an appropriate level or direction for an indicator. Moreover, this position lends itself well to the modeling exercise, which can then be used to illustrate the trade-offs among various positions.

A second aspect of the indicator selection is that it will concentrate on indicators that are 'multiple-telling' through covering more than one of the issue areas. Also, in recognition of the 'stress-response' function duality, some of the selected indicators for data collection will focus on 'stress' and others on 'response'; that is, indicators will represent human activity stressors, physical or chemical stressors to the environment, or will represent biological responses (both by humans and natural biota) to those stressors.

Box A.2. An Indicator Framework



Annex B

Resources, Information Issues, and Constraints

RESOURCES

Selected References

The following represent sources of considerable bibliographic and summary information, from which specific databases and resources can be identified:

Dorcey, Anthony H. J. and Griggs, Julian R. (eds.,1991). *Water in Sustainable Development: Exploring Our Common Future in the Fraser River Basin.* Vancouver, B.C.: Westwater Research Center, University of British Columbia.

Fraser Basin Management Board (1995). *State of the Fraser Basin: Assessing Progress Towards Sustainability.* Vancouver, B.C.: Fraser Basin Management Program.

Missler, Heidi (1992). *A Bibliography of Scientific Information on Fraser River Basin Environmental Quality.* Prepared for Conservation and Protection, Environment Canada. Vancouver, B.C.: Environmental Conservation Directorate, Pacific and Yukon Region, Environment Canada.

(1994). *A Bibliography of Scientific Information on Fraser River Basin Environmental Quality: 1994 Supplemental.* Prepared for Conservation and Protection, Environment Canada. Vancouver, B.C.: Environmental Conservation Directorate, Pacific and Yukon Region, Environment Canada.

Reis, Kelly (1994). *An Investigation of the Present State of Ecosystem Monitoring and Research in the Fraser Basin.* Vancouver, B.C.: Ecosystem Monitoring and Research Steering Committee, Fraser Basin Management Program.

Resources Inventory Committee (1992a). *Report of the Fisheries Inventory Task Force on Fisheries Conservation and Management Inventories for the Future.* Victoria, B.C.: Resources Inventory Committee.

(1992b). *Report of the Timber Inventory Task Force on the Current Timber Inventory with Recommendations for the Future.* Victoria, B.C.: Resources Inventory Committee.

(1992c). *Report of the Water and Watershed Task Force for the Resources Inventory Committee.* Victoria, B.C.: Resources Inventory Committee.

(1992d). *Inventory of Existing Biological Diversity Databases for British Columbia.* Victoria, B.C.: Resources Inventory Committee.

(1993a). *Description of British Columbia Air Quality Monitoring Networks and Emissions Inventory.* Victoria, B.C.: Resources Inventory Committee.

(1993b). *Bibliography of Air Quality, British Columbia.* Victoria, B.C.: Resources Inventory Committee.

Statistics Canada (1994). *Human Activity and the Environment 1994.* Ottawa: Ministry of Industry, Science and Technology.

Statistics Canada and Environment Canada (1992). *Databases for Environmental Analysis: Government of Canada.* Ottawa: Ministry of Industry, Science and Technology.

Statistics Canada and Environment Canada (1994). *Databases for Environmental Analysis: Provincial and Territorial Governments.* Ottawa: Ministry of Industry, Science and Technology.

Organizations

The following organizations or programs have recently or are currently undergoing project activities directly concerned with the Fraser River which directly or indirectly confront the issue of sustainability (the information reported below obtained from various reports from the respective organizations):

Fraser Basin Ecosystem Study (Westwater Research Centre and the Sustainable Development Research Institute, U.B.C.)

-an interdisciplinary study of the ecosystem of the lower Fraser River Basin, which will focus research on addressing the structure and function of the current and possible future ecosystem, the nature of social/ biophysical/ economic constraints, and the necessary policy instruments and processes for sustainability. The project is sponsored primarily through the Tri-Council Secretariat (Eco-Research, Green Plan; project began 1993).

Fraser Basin Management Program

-the coordination of sustainable development initiatives to ensure the efficient function of activities and programs within the role of a governmental advisor (an offshoot of the Fraser River Action Plan). The program recently began the development of a set of indicators for reporting on progress towards sustainability in the Fraser River Basin (project began 1994). Their indicator work differs from our current project in that no modeling will be attempted by the FBMP and the selection of the appropriate indicator set will be influenced by the associated 'report card' objective.

Fraser River Action Plan (Environment Canada, Fisheries and Oceans Canada)

-achieving environmental improvements in the Fraser River Basin and to aid in the summarization of information and the development and implementation of a management plan. FRAP is sponsored through Canada's Green Plan (project began 1991).

Fraser River Estuary Management Program

-involved in state of the environment reporting for the lower Fraser River Basin (Lower Fraser Valley to the Strait of Georgia), to facilitate the generation of objective, accurate, and synthesized information (first state of the environment report published in 1988). The program is sponsored by a combination of governments of various levels and private stakeholders and represents a continuation of the work began by the Fraser River Estuary Study.

Fraser River Estuary Study

-involved with the development of an effective management plan for the Fraser River Estuary, and exploring issues of varying goals, objectives, positions, and concerns (program consisted of three phases: FRES I 1977-78, FRES II 1978-82, and FRES III 1983-84).

INFORMATION ISSUES AND CONSTRAINTS

Below we present a listing of potential data sources, along with notes concerning data and accessibility constraints. Specific potential sources of data of a point source nature or of limited spatial coverage are not identified, but are referenced in Missler (1992, 1994), Reis (1994), Resources Inventory Committee (1992a-d, 1993a-b), and Statistics Canada and Environment Canada (1992, 1994) as noted above. All other data sources, which can be aggregated according to the basin or sub-basin boundaries, are listed below.

Potential Data Source	Data Constraints	Accessibility Constraints
ECOLOGICAL DATA		
Air		
B.C. Ministry of Health and Ministry Responsible for Seniors, Program Standards and Information Management - hospital admission database includes information by principle diagnosis according to International Classification of Disease (ICD9).	- data compiled aggregated according to Local Health Areas (LHA), readily attrievable from 1986.	- data aggregation to basin or sub-basin must be done by user. - data provided free of charge. - user must be familiar with ICD9 coding to request information.
Reis (1994), Resources Inventory Committee (1992a-d, 1993a-b), and Statistics Canada and Environment Canada (1992, 1994) - variable.		
Water		
Statistics Canada, National Accounts and Environment Division - Census of Agriculture database includes information on irrigation, application of fertilizers,	- data compiled according to Census boundaries.	- data aggregation by basin and sub-basin by 'special

Potential Data Source	Data Constraints	Accessibility Constraints
and application of herbicides and pesticides.	- data can be aggregated to user-defined boundaries. - for most variables, data exists for Census years 1971, 1976, 1981, 1986, and 1991.	request' only. - data cost on a per Electoral Area (EA) basis. For the Fraser River Basin, the cost of one variable for one year ranges from $6 to $15 plus staff time.
Environment Canada, Ecosystem Science and Evaluation Branch - Municipal Water Use Database (MUD) includes information on water supply and water treatment by municipality with a population of 1000 or more.	- data compiled with record of the sub-sub-basin location. - data available for the years 1983, 1986, 1989, and 1991.	- data provided free of charge on hardcopy output or diskette.
Reis (1994), Resources Inventory Committee (1992a-d, 1993a-b), and Statistics Canada and Environment Canada (1992, 1994) - variable.		
Land Statistics Canada, National Accounts and Environment Division - Census of Agriculture database includes land use, agricultural practices, conservation practices, and land potential.	- data compiled according to Census boundaries. - data can be aggregated to user-defined boundaries. - for most variables, data exists for Census years 1971, 1976, 1981, 1986, and 1991 (for conservation practices, data is only available for 1991; land potential data only available for 1989).	- data aggregation by basin and sub-basin by 'special request' only. - data cost- see above under water.
B.C. Ministry of Forests - data published in annual reports indicating harvesting practices, reforestation practices, pest infestations, and recreational forest use.	- data compiled according to Forest Regions (six for the province of B.C.). - data avaialable annually by fiscal year.	- data aggregation by basin or sub-basin questionable using Forest Region data; some data available by Forest District (much smaller level) but must be accessed through the regional offices and may be subject to confidentiality filters.
Reis (1994), Resources Inventory Committee (1992a-d, 1993a-b), and Statistics Canada and Environment Canada (1992, 1994) - variable.		

Potential Data Source	Data Constraints	Accessibility Constraints
Biota B.C. Ministry of Forests - data published in annual reports indicating harvesting practices, reforestation practices, pest infestations, and recreational forest use.	- data compiled according to Forest Regions (six for the province of B.C.). - data avaialable annually by fiscal year.	- data aggregation by basin or sub-basin questionable using Forest Region data; some data available by Forest District (much smaller level) but must be accessed through the regional offices and may be subject to confidentiality filters.
Reis (1994), Resources Inventory Committee (1992a-d, 1993a-b), and Statistics Canada and Environment Canada (1992, 1994) - variable.		
ECONOMIC DATA ***Production*** Statistics Canada, National Accounts & Environment Division - databases include: Labour Force Activity (LFA); Labour Force by Sector (LFSEC); Employment in Resource Dependent Industries (RESDEPE); Employment in Manufacturing and Number of Manufacturing Establishments (MFGW). - agricultural activity data available on the Census of Agriculture database (AG).	- data can be aggregated according to basin or sub-basin. - limited number of observations: LFA – 1971, 76, 81, 86, 91; LFSEC – 1981, 86, 91; RESDEPE – 1991 only; MFGW – 1986 only.	- data by basin or sub-basin available by 'special requests' only. - data cost on a per Electoral Area (EA) basis. For the FRB, the cost of one variable for one year ranges $6 – $15, plus staff time.
BC Stats, Data Dissemination - databases kept on building permits by type, dwelling starts, bankruptcies, establishment count by employment size, major projects inventory, and labour market/ force statistics.	- data can be aggregated to user-defined boundary as estimated form Census Divisions. - estimates available annually, most from 1980/81, but variable.	- data aggregation by user-defined boundary by 'special requests'. - no cost for data by Census Divisions, but costs for special aggregations highly variable, dependent upon labour requirements.
B.C. Ministry of Environment Lands and Parks, Municipal Waste Reduction Branch - data kept on municipal solid waste disposal and recycling by component.	- data available aggregated according to Census Divisions (Regional Districts). - data available only for the most recent years.	- data available free of charge in summary form. - data aggregation by user-defined boundaries must be done by end user.

Potential Data Source	Data Constraints	Accessibility Constraints
Consumption Statistics Canada, National Accounts & Environment Division - data kept on household and per capita income.	- income data collected by the Census Division can be aggregated according to basin or sub-basin.	- data by basin or sub-basin available by 'special requests' only. - data cost – as above under Production, plus an extra charge for years prior to 1991.
BC Stats, Data Dissemination - databases include: Household Spending (HS; incomes, total expenditures- food, tobacco, alcohol, shelter, household operations, household furnishings and equipment, clothing, transportation, health care and education, recreation, personal care, financial security and gifts, appliances, telephone, home entertainment, and vehicles), Neighbourhood Income and Demographies (NID; incomes, income distributions, income by gender).	- data can be aggregated to user-defined boundary as estimated form Census Divisions. - HS database aggregated to Census Divisions, but only available for 1987. - NID database available annually from income tax returns, aggregated according to Census Divisions.	- data by user-defined boundaries by 'special requests' only. - no cost for data by Census Division but costs for special aggregations highly variable, dependent upon labour requirements.
Environment Canada, Ecosystem Science and Evaluation Branch - Municipal Water Use Database (MUD) includes information on water supply and water treatment by municipality with a population of 1000 or more.	- data compiled with record of the sub-sub-basin location. - data available for the years 1983, 1986, 1989, and 1991.	- data provided free of charge on hardcopy output or diskette.
Statistics Canada, Small Area and Administrative Data Division - data regarding income (from income tax returns), economic dependency (transfer payments, U.I. benefits, Family Allowance, CPP, Old Age Security, etc.), and inter-regional migrations.	- data avaialble aggragated according to postal codes. - data available annually, but over a variable time-series depending on the nature of the data request.	- aggregation by use-defined boundaries available by 'special requests'. - access of data and aggregations subject to user fees.
SOCIAL DATA ***Culture and Human Security*** B.C. Stats, Data Dissemination - databases include: Census of Population and Housing (CPH; population- gender and age structure -marital status, mother tongue, number and composition of people in private households, detailed family structure, home language, religion, and ethnic origin), Migration by Age Group (MAG), Vital Statistics (VS; births, deaths,	- data can be aggregated to user-defined boundary as estimated from Census Divisions. - CPH data aggregated to Census Divisions and available by Census years since 1971 (5	- data by user-defined boundaries by 'special requests' only. - no cost for data by Census Divisions, but costs for special aggregations highly

Potential Data Source	Data Constraints	Accessibility Constraints
and marriages), and Demographies (ethnic origin, family structure, crime rates, education attainment, mortality rates, and child care).	year intervals) for most variables. - MAG data aggregated to Census Divisions and available annually from 1981/82. - VS data aggregated to Census Divisions or Local Health Area (see Vital Stats office) and available annually. .- Demographies aggregated to Census Divisions, and available annually but with limited and variable time-series.	variable, dependent upon labour requirements.
<u>Canada Mortgage and Housing Corporation, Statistical Survey Division</u> - Housing Market Information System (HMIS) includes information on housing, such as structures, distribution, price, and financing (location, dwelling type, date started, number of units, finance type, date completed, price).	- data available nationally, referenced by province and municipality. - data available from 1940 to the present, being updated monthly or quarterly.	- data available on output tables, free of charge for data which is already compiled (data compilation charge depends on the request). - data reported in *Canadian Housing Statistics* (annual), *Statistical Handbook Tables* (monthly for each municipality), and *Starts and Completions* (annual).
<u>Statistics Canada, Small Area and Administrative Data Division</u> - data regarding income (from income tax returns), economic dependency (transfer payments, U.I. benefits, Family Allowance, CPP, Old Age Security, etc.), and interregional migrations.	- data avaialble aggragated according to postal codes. - data available annually, but over a variable time-series depending on the nature of the data request.	- aggregation by use-defined boundaries available by 'special requests'. - access of data and aggregations subject to user fees.
<u>B.C. Ministry of Health and Ministry Responsible for Seniors, Vital Statistics Division</u> - data available on death rates (by cause), birth rates, and marriage rates.	- data available aggregated according to Local Health Areas. - data available annually.	- aggreagation by user defined boundaries must be carried-out by end user. - data provided free of charge.
<u>B.C. Ministry of Health and Ministry Responsible for Seniors, Program Standards and Information Management</u> - hospital admission database includes information	- data compiled aggregated	- data aggregation to basin

Potential Data Source	Data Constraints	Accessibility Constraints
by principle diagnosis according to International Classification of Disease (ICD9).	according to Local Health Areas (LHA), readily attrievable from 1986.	or sub-basin must be done by end user. - data provided free of charge. - user must be familiar with ICD9 coding to request information.

Annex C

Selected Indicators for the Fraser River Basin

The selection of indicators of sustainability for the Fraser River Basin followed four main idealized criteria (Box C.1): (i) ability to aggregate meaningfully to the basin and sub-basin levels; (ii) availability of a comprehensive annual time series; (iii) rationale of the indicator linkage with an appropriate dimension of an issue area (see Box A.2); and (iv), cost and accessibility of the data. It was often necessary to compromise the first two of the criteria in order to obtain a representative indicator set. Specifically, compromising criteria (i) meant using site-specific or 'hot spot' data which may only be partially representative of the region, and may make inter-regional comparisons questionable. Compromising criteria (ii) meant using data which were not available annually or data which were only available for recent years. Refer to Annex B for the data sources considered and selected.

Box C.1. Idealized Criteria for Indicator Selection

(i) Ability to aggregate the data meaningfully to the basin and sub-basin boundaries (data being inclusive of the whole region within the boundary or being reasonably representative).

(ii) Availability of a comprehensive annual time series (ideally from 1971 through 1991).

(iii) Rationale of the indicator linkage with an appropriate dimension of an issue area.

(iv) Cost and availability of the data.

Table C.1 shows the selected indicators for the Fraser River Indicator Study, followed by an outline of the rationale (issue linkage) behind the selection of each indicator (Table C.2) as it ties to a dimension of a particular issue area (Box A.2). The issue linkages outlined in Table C.2 are not intended to suggest the only possible rationale behind the indicator selection (e.g., the intensity of fertilizer application in agriculture may be seen as either an indicator of the depletion of the natural soil nutrient base (a negative) or the enhancement of production capabilities (a positive)); in fact, many of the indicators are compatible with differing value sets, and thus are consistent with our earlier comments regarding the accommodation of differing values and goals. Nonetheless, the selected set of indicators is believed to be reasonable and sufficient to encompass the issues and dimensions outlined in Box A.2.

Prior to the presentation of each indicator, a profile of the population and structure of the labour force is shown. Each selected indicator, as outlined in Table C.2, is subsequently presented separately, indicating the data source and specific characteristics and limitations. 1991 values for the Fraser Basin, each of the four sub-basins (Nechako, Upper Fraser, Thompson, and Fraser), and the Fraser Sub-sub-basin 8MH (Lower Mainland area) are presented graphically. Site specific data which do not lend themselves to aggregation are noted. Data supplied according to other boundaries (i.e., Census Divisions, Local Health Areas (LHA), Forest Regions, Forest Districts, and municipality) required disaggregation and reconstruction to approximate the basin aggregations. How this was reconciled is noted below. Also, the correlational analyses, as reported later in this document, utilized indicator values for the Salmon Arm/ Shuswap region

(Sub-sub-basin 8LE) and the Okanagan-Similkameen-Boundary region (Sub-sub-basins 8NL, 8NM, and 8NN). How the calculations of indicator values for these regions was conducted is also noted.

Census Division data were reconciled according to the following:

Nechako Sub-basin (8J):
- Bulkley-Nechako (Regional District #51)

Upper Fraser Sub-basin (8K):
- Fraser-Fort George (R.D.#53)
- 1/2 of Cariboo (R.D.#41)

Thompson Sub-basin (8L):
- Thompson-Nicola (R.D.#33)
- North Okanagan (R.D.#37)
- Columbia-Shuswap (R.D.#39)

Fraser Sub-basin (8M):
- Fraser-Cheam (R.D.#9)
- Central Fraser Valley (R.D.#11)
- Dewdney-Alouette (R.D.#13)
- Greater Vancouver (R.D.#15)
- Squamish-Lillooet (R.D.#31)
- 1/2 of Cariboo (R.D.#41)

Fraser Sub-sub-basin 8MH:
- Central Fraser Valley (R.D.#11)
- Dewdney-Alouette (R.D.#13)
- Greater Vancouver (R.D.#15)

Sub-sub-basin 8LE:
- Columbia-Shuswap (R.D.#39)

Sub-sub-basin 8NL:
- Okanagan-Similkameen (R.D.#7)

Sub-sub-basin 8NM:
- Okanagan-Similkameen (R.D.#7), Central Okanagan (R.D.#35), and North Okanagan (R.D.#37)

Sub-sub-basin 8NN:
- Kootenay Boundary (R.D.#5)

Local Health Area data were reconciled according to the following:

Nechako Sub-basin (8J):
- LHA 55(93) and 56

Upper Fraser Sub-basin (8K):
- LHA 28 and 57

Thompson Sub-basin (8L):
- LHA 20, 24, 26, 30, 31, and 78

Fraser Sub-basin (8M):
LHA 27, 29, 32 through 43 (inclusive), 48, and 75
Fraser Sub-sub-basin 8MH:
LHA 33 through 43 (inclusive), and 75
Sub-sub-basin 8LE:
Salmon Arm (LHA#20)
Sub-sub-basin 8NL:
Keremeos (LHA#16) and Princeton (LHA#17)
Sub-sub-basin 8NM:
Armstrong-Spallumcheen (LHA#21), Vernon (LHA#22), Central Okanagan (LHA#23), Summerland (LHA#77), Penticton (LHA#15), and Southern Okanagan (LHA#14)
Sub-sub-basin 8NN:
Grand Forks (LHA#12) and Kettle Valley (LHA#13)

Forest Region data were reconciled according to the following:

Nechako Sub-basin (8J):
Prince Rupert and Prince George Forest Regions
Upper Fraser Sub-basin (8K):
Cariboo and Prince George Forest Regions
Thompson Sub-basin (8L):
Kamloops Forest Region
Fraser Sub-basin (8M):
Cariboo and Vancouver Forest Regions
Fraser Sub-sib-basin (8MH):
Vancouver Forest Region
Sub-sub-basin 8LE:
Kamloops Forest Region
Sub-sub-basin 8NL:
Kamloops Forest Region
Sub-sub-basin 8NM:
Kamloops Forest Region
Sub-sub-basin 8NN:
Nelson Forest Region

Forest District data were reconciled according to the following:

Nechako Sub-basin (8J):
Lakes (F.D.#21), Morice (F.D.#22), Vanderhoof (F.D.#44), and Fort St. James (F.D.#45)
Upper Fraser Sub-basin (8K):
Prince George (F.D.#41), Robson Valley (F.D.#43), Quesnel (F.D.#61), and Horsefly (F.D.#63)
Thompson Sub-basin (8L):

Clearwater (F.D.#31), Kamloops (F.D.#32), Salmon Arm (F.D.#33), Vernon (F.D.#34), Merritt (F.D.#36), and 100 Mile House (F.D.#64).

Fraser Sub-basin (8M):

Chilliwack (F.D.#11), Squamish (F.D.#13), Lillooet (F.D.#37), Williams Lake (F.D.#62), and Chilcotin (F.D.#65)

Fraser Sub-sub-basin 8MH:

Chilliwack (F.D.#11)

Sub-sub-basin 8LE:

Salmon Arm (F.D.#33)

Sub-sub-basin 8NL:

Merritt (F.D.#36)

Sub-sub-basin 8NM:

Penticton (F.D.#35) and Vernon (F.D.#34)

Sub-sub-basin 8NN:

Boundary (F.D.#56)

It is recognized that the Forest Regions represent relatively large aggregations which have large areas that lie outside the Fraser River Basin; thus, the data may not be completely representative of activity within the basin boundaries in question. In all cases where forestry data was used to construct an indicator, data by Forest District was used whenever possible; the specific source of the data is noted for each indicator individually.

Table C.1. Selected Indicators for the Fraser River Indicator Study

	State	Intergenerational Distribution (options)	Intragenerational Distribution (entitlement)
Air	-SO_2, CO, and ground level ozone* -respiratory disease incidence rate -[sectoral emissions]	-skin cancer incidence rate	-respiratory disease incidence rate by gender -skin cancer incidence rate by gender
Water	-[BOD generation] -[sectoral emissions]	-municipal wastewater treatment by type	-proportion of population served by municipal water
Land	-area of farmland -ratio of timber volume billed to area harvested	-intensity of agricultural fertilizer application -proportion of forest harvested by clear-cutting	-urban population partition
Biota	-recreational boat angler days*	-salmon escapement* -ratio of forest land area planted to harvested	-forest recreation site and trail use
Production	-labour force -unemployment rate	-bankruptcy rate -municipal solid waste disposal rate	-proportional employment in resource industry
Consumption	-water use -income	-water intensity -investment income	-income distribution
Culture	-ethnic diversity -religious diversity	-ethnic diversity -religious diversity	-educational attainment
Security	-crime rate -economic dependency -in migration rate -rate of death by external cause	-educational attainment -cancer incidence rate -live birth rate	-cancer incidence rate by gender -ratio of average house price to rental rate* -economic dependency by gender
Institutional	-proportional employment in public utilities and administration	-proportional employment in finance	-rate of home ownership -average rural farm size

notes: -indicators denoted with * are site specific.
-some indicators are "multiple-telling", yet their multiple placement is not necessarily noted.
-[ ] denotes indicators to be estimated during modeling process.

Table C.2. Outline of the Linkage Between Indicators and Issue Areas

Indicator	Issue Linkage
SO_2, CO, and ground level ozone	-contributing agents to acute environmental degradation.
respiratory disease incidence rate	-response to air-born contaminants.
sectoral emissions	-degree of taxation on the natural environmental assimilation abilities.
skin cancer incidence rate	-response to excessive radiation exposure partly due to long-term deterioration of ozone.
BOD generation	-degree of taxation on the natural environmental assimilation abilities and potential for hyperbiological activity.
municipal wastewater treatment by type	-degree of taxation on the natural environmental assimilation capacity.
proportion of population served by municipal water	-personal health.
area of farmland	-potential land area for agricultural production.
ratio of timber volume billed to area harvested	-efficiency of timber production.
intensity of agricultural fertilizer application	-potential depletion of natural soil nutrient base, or conversely, enhancement of productive capabilities.
proportion of forest harvested by clear cutting	-potential for soil erosion and loss of biotic base, or conversely, efficient use of a land resource.
urban population partition	-distribution and type of land use.
recreational boat angler days	-pressure on aquatic resource base.
salmon escapement	-potential for maintenance of fishery stocks.
ratio of forest land area planted to harvested	-potential for maintenance of forest stocks and/or transformation of the forest to monoculture.
forest recreational site and trail use	-direct access and exposure to the natural environment.

continued ...

Indicator	Issue Linkage
labour force	-production potential.
unemployment rate	-utilization of labour force.
bankruptcy rate	-stressor on future investment potential.
municipal solid waste disposal rate	-efficiency of resource use.
proportional employment in resource industry	-direct dependency on resource base.
water use	-taxation and use of the water resource base.
income	-potential for consumption.
water intensity	-income relation of water use for consumption.
investment income	-propensity to save and invest.
income distribution	-equitable distribution of the potential for consumption.
ethnic diversity	-cultural diversity and base for future generations.
religious diversity	-cultural diversity and base for future generations.
educational attainment	-exposure to diversity of culture and ideas, and security of future provisions.
crime rate	-personal safety.
economic dependency	-economic consumption security.
in migration rate	-neighbourhood stability.
rate of death by external cause	-personal safety.
cancer incidence rate	-uncertainty of long-term health risks.
live birth rate	-provision of future generations.
ratio of average house price to rental rate	-accessibility of secured home tenure.
proportional employment in public utilities and administration	-institutional ability for public sector provisions.
proportional employment in finance	-institutional ability to provide for savings and investment.
rate of home ownership	-personal home entitlement.
average farm size	-distribution of land entitlements.

Figure C.1. Population of the Fraser River Basin by Region, 1991, Showing the Urban and Rural Division

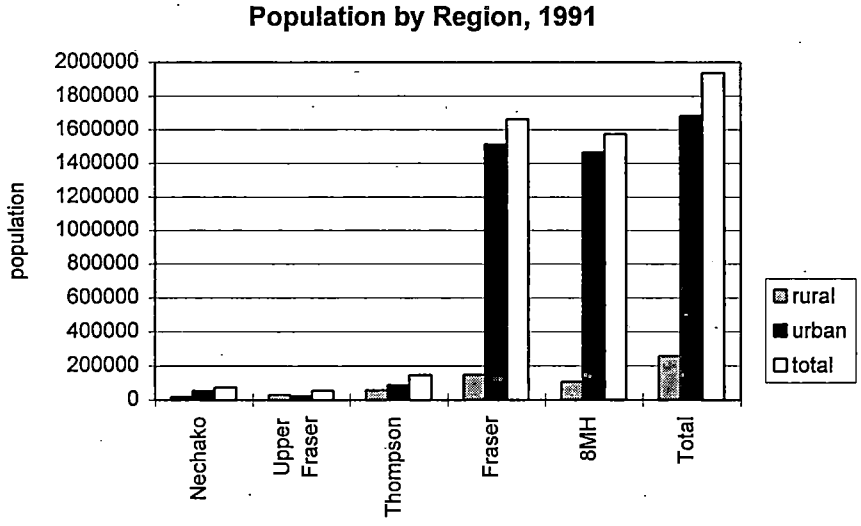


Figure C.2. Labour Force of the Fraser River Basin by Region, 1991, Showing Numbers Employed and Unemployed

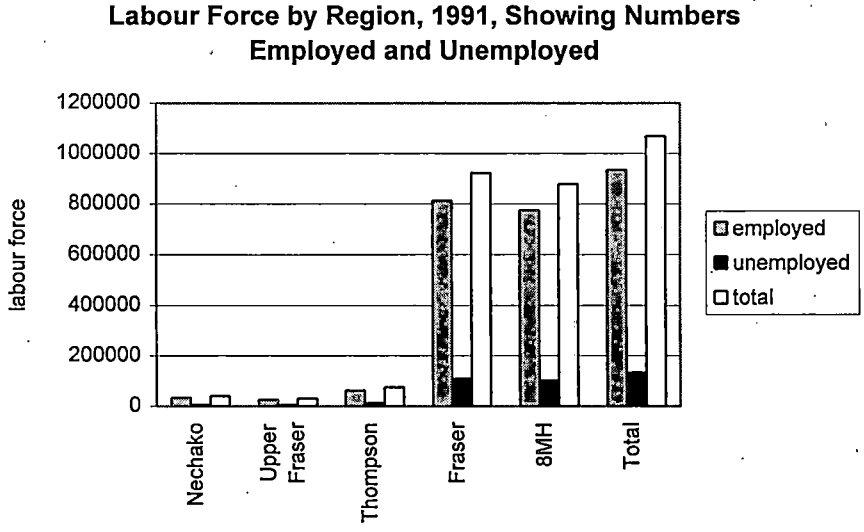
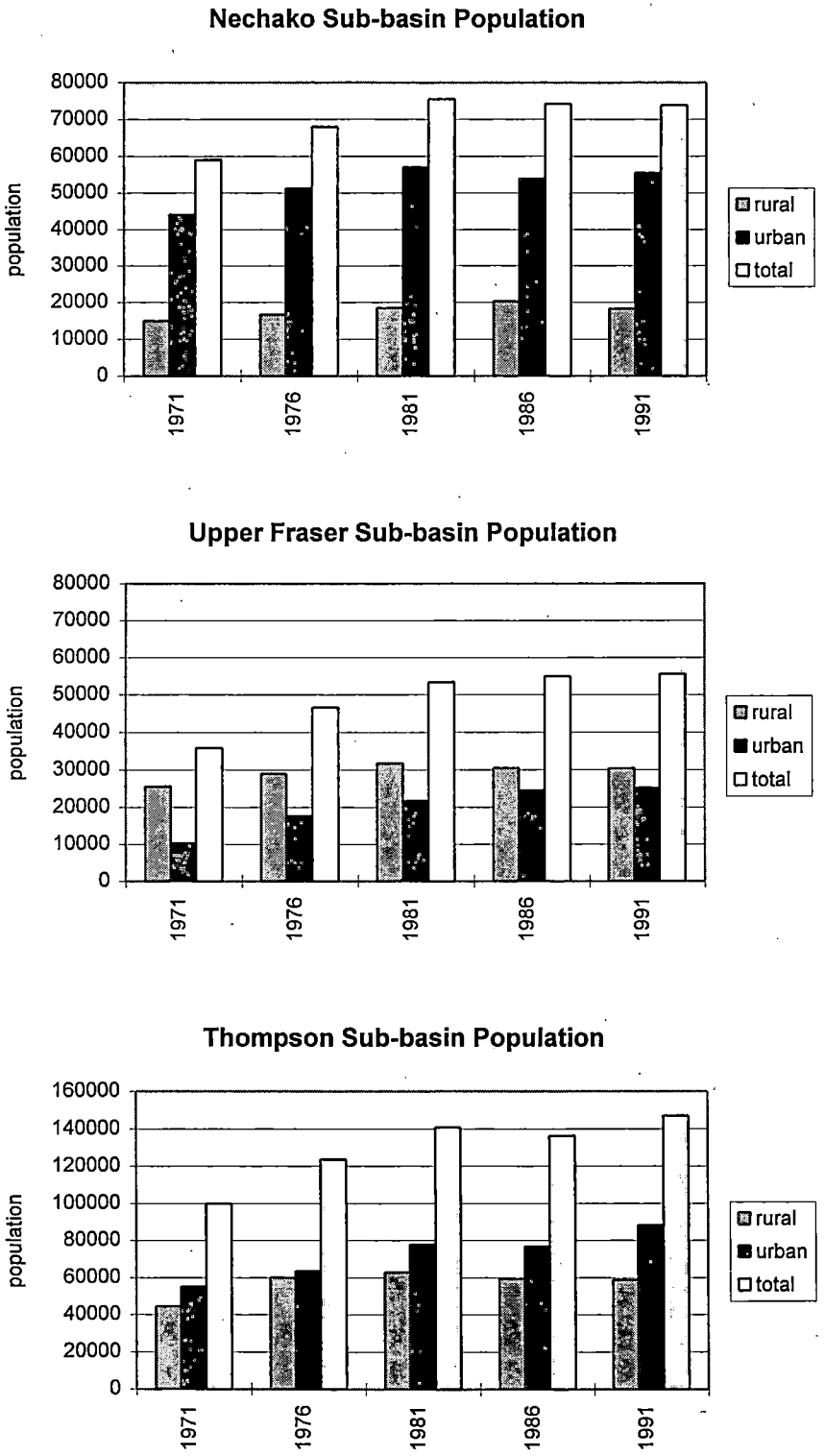
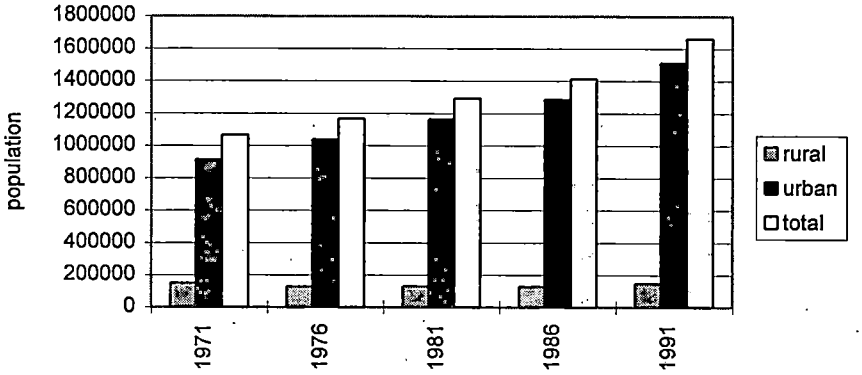


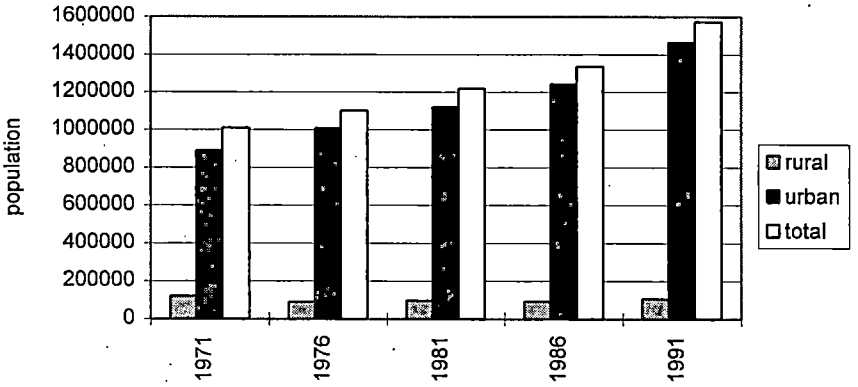
Figure C.3. Population of the Fraser River Basin by Region, for the Years 1971, 1976, 1981, 1986, and 1991 (Fraser Sub-sub-basin 8MH Consists of the Lower Mainland)



Fraser Sub-basin Population



Fraser Sub-sub-basin 8MH Population



Fraser Basin Population

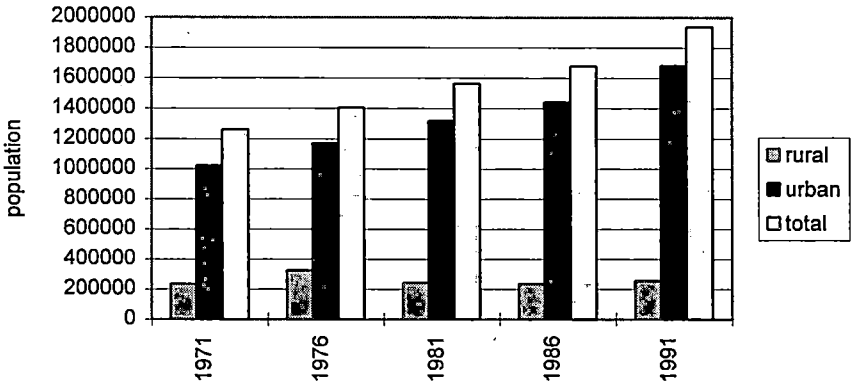
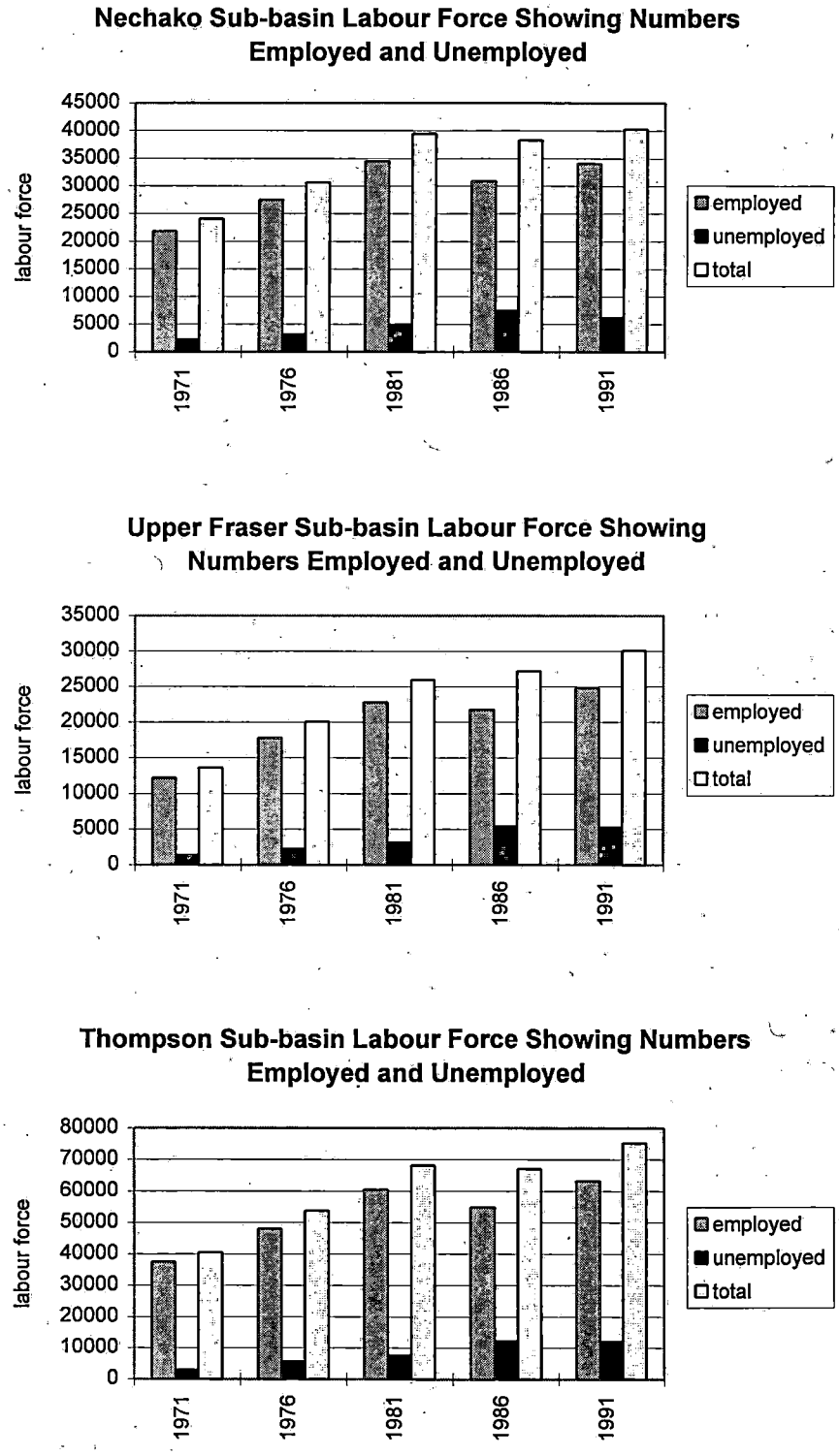
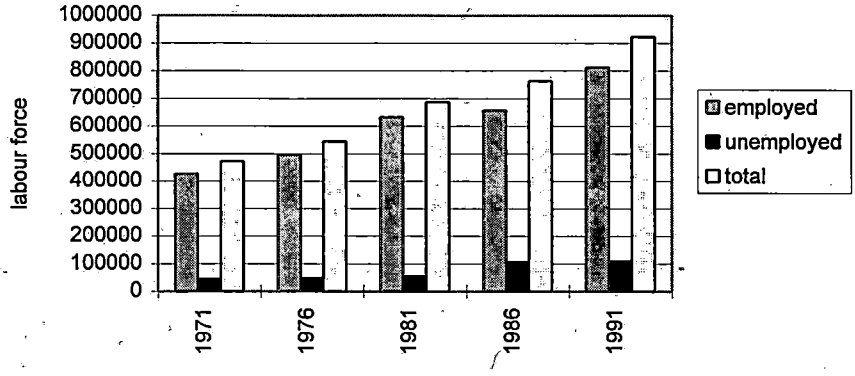


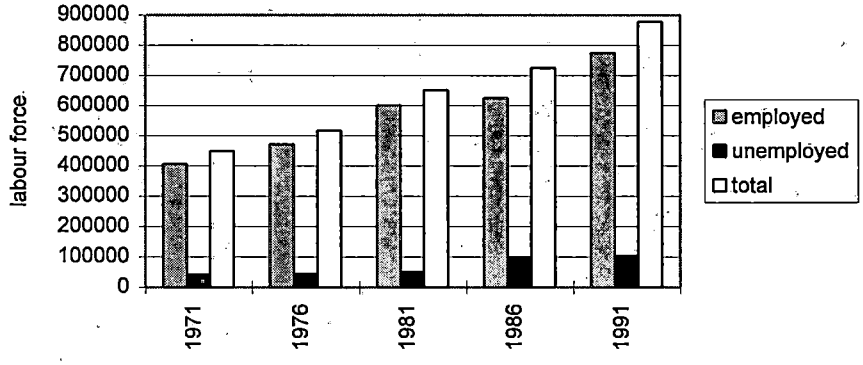
Figure C.4. Labour Force of the Fraser River Basin by Region Showing the Numbers Employed and Unemployed, for the Years 1971, 1976, 1981, 1986, and 1991 (Fraser Sub-sub-basin 8MH Consists of the Lower Mainland)



Fraser Sub-basin Labour Force Showing Numbers Employed and Unemployed



Fraser Sub-sub-basin 8MH Labour Force Showing Numbers Employed and Unemployed



Fraser Basin Labour Force Showing Numbers Employed and Unemployed

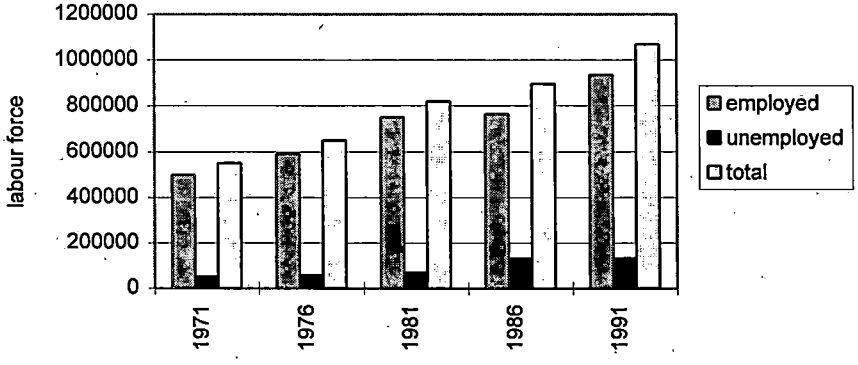
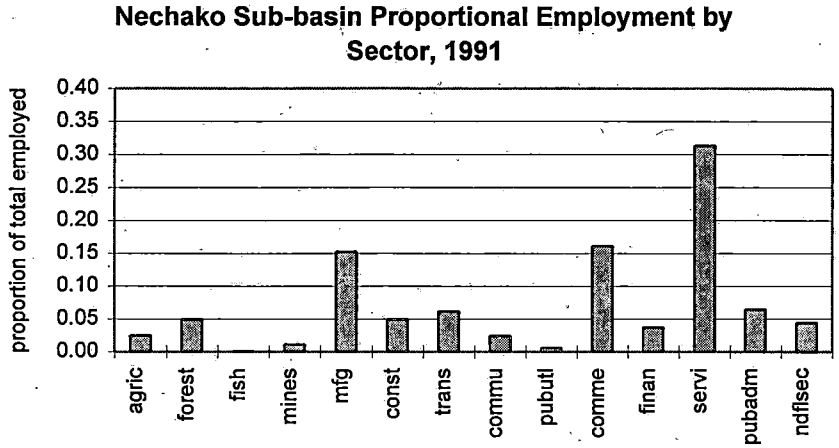
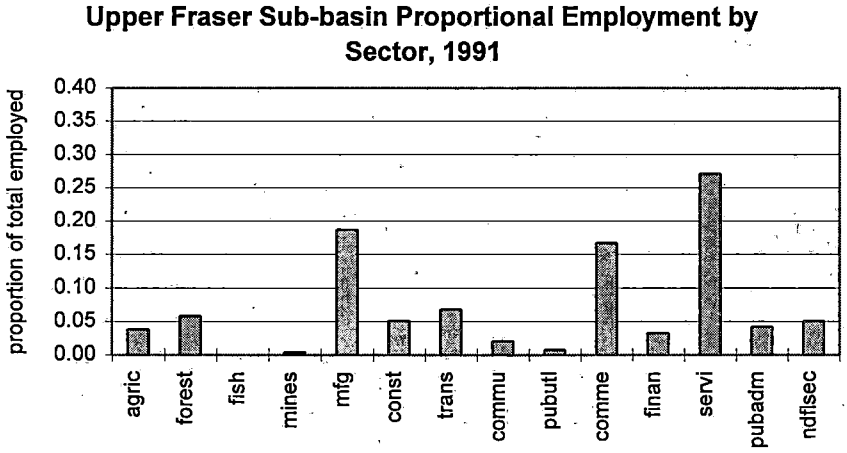
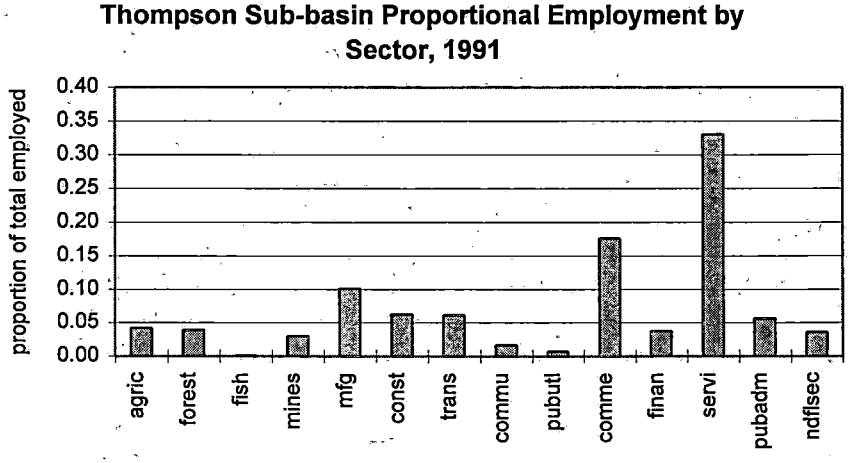


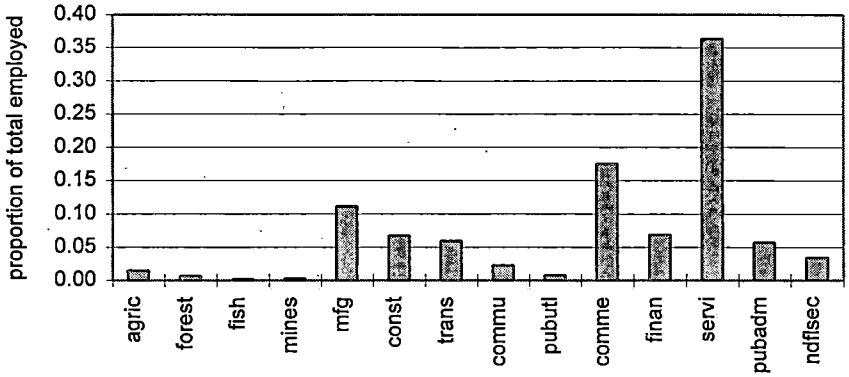
Figure C.5. Proportional Employment by Sector for the Fraser River Basin by Region, 1991 (Fraser Sub-sub-basin 8MH Consists of the Lower Mainland)



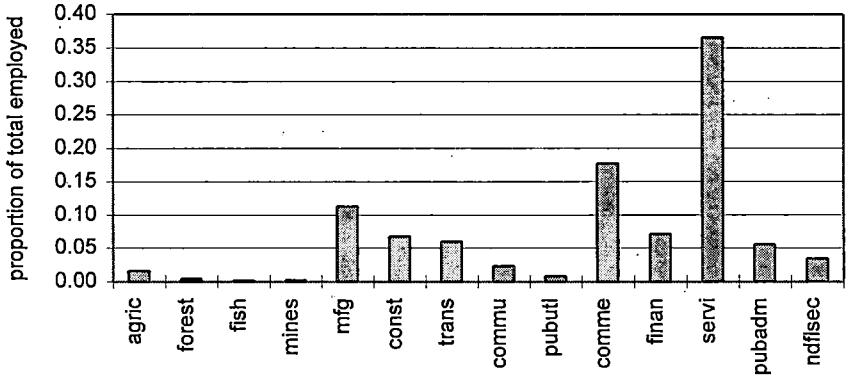




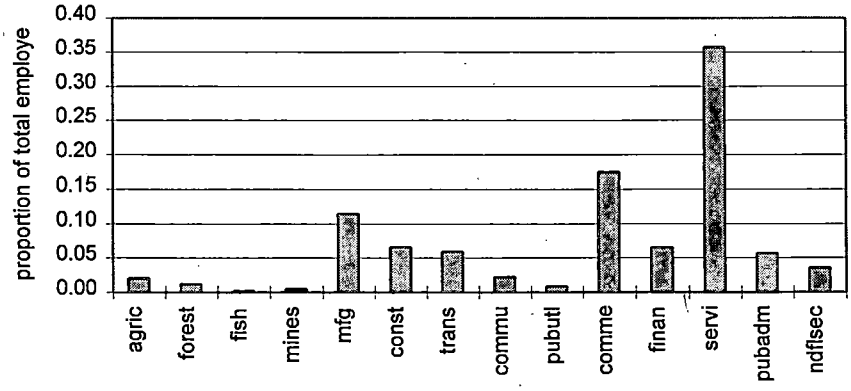
Fraser Sub-basin Proportional Employment by Sector, 1991



Fraser Sub-sub-basin 8MH Proportional Employment by Sector, 1991



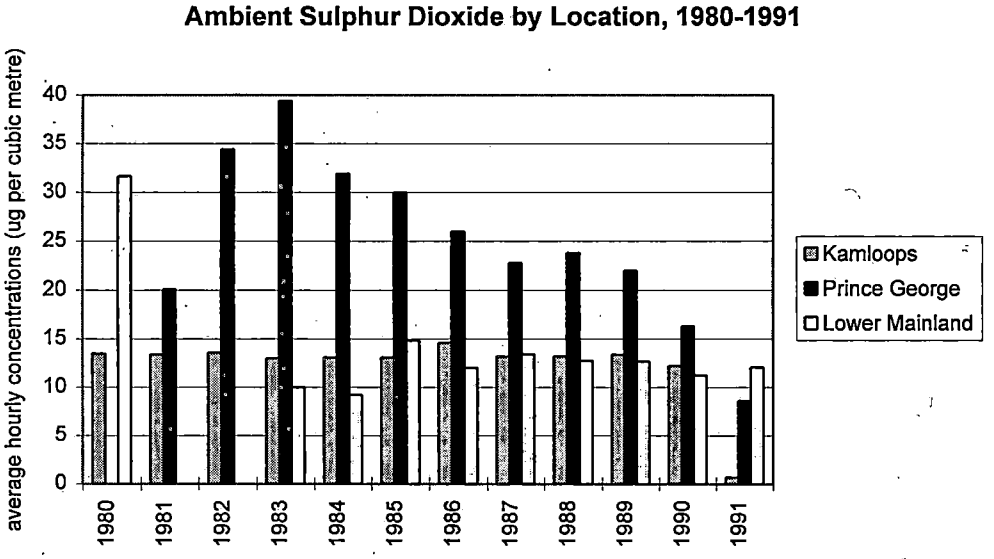
Fraser Basin Proportional Employment by Sector, 1991



Indicator: Ambient Sulphur Dioxide

Data Source: Air Resources Branch, B.C. Ministry of Environment, Lands, and Parks.

Data characteristics: Data was supplied for average hourly measured values of point source monitoring stations within the Lower Mainland (Fraser Sub-sub-basin 8MH), Kamloops (Thompson Sub-basin), and Prince George (Upper Fraser Sub-basin). Data was obtained for 1980 through 1991. Note that values are missing for the Lower Mainland for 1981 and 1982, and for Prince George for 1980. Units are in micrograms per cubic metre.

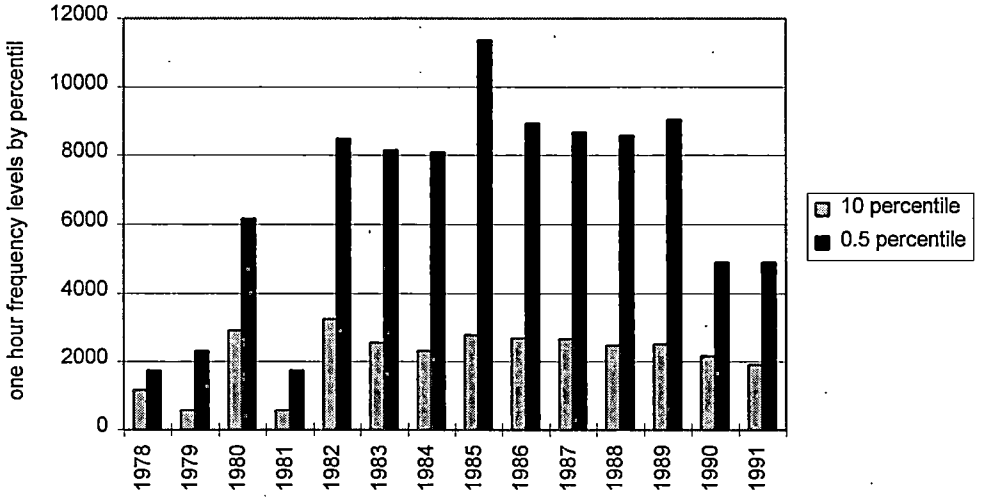


Indicator: Ambient Carbon Monoxide

Data Source: Air Resources Branch, B.C. Ministry of Environment, Lands, and Parks

Data characteristics: Data was supplied as one hour frequency levels by percentile for the Lower Mainland aggregate (Fraser Sub-sub-basin 8MH). Data was obtained for 1978 through 1991. Units are in micrograms per cubic metre.

Ambient Carbon Monoxide for the Lower Mainland, 1978-1991

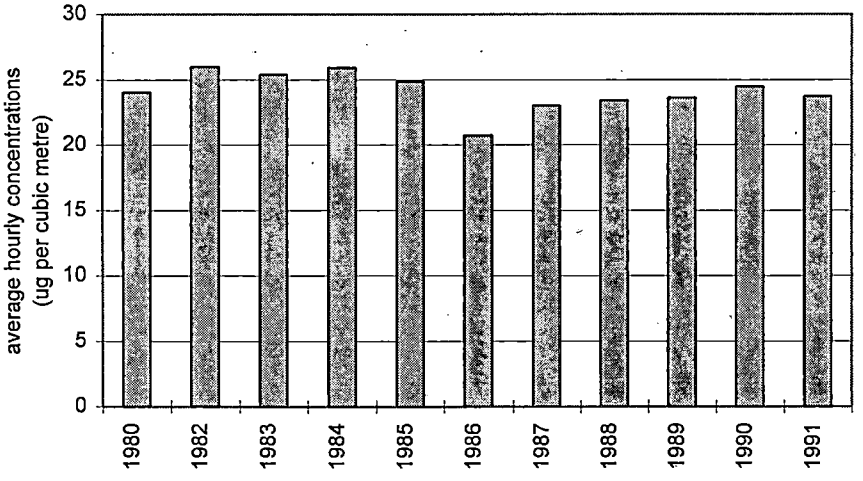


Indicator: Ambient Ground-level Ozone

Data Source: Air Resources Branch, B.C. Ministry of Environment, Lands, and Parks

Data characteristics: : Data was supplied for average measured values of point source monitoring stations within the Lower Mainland (Fraser Sub-sub-basin 8MH). Data was obtained for 1980, and 1982 through 1991. Units are in micrograms per cubic metre.

Ambient Ground-level Ozone for the Lower Mainland, 1980, 1982-1991

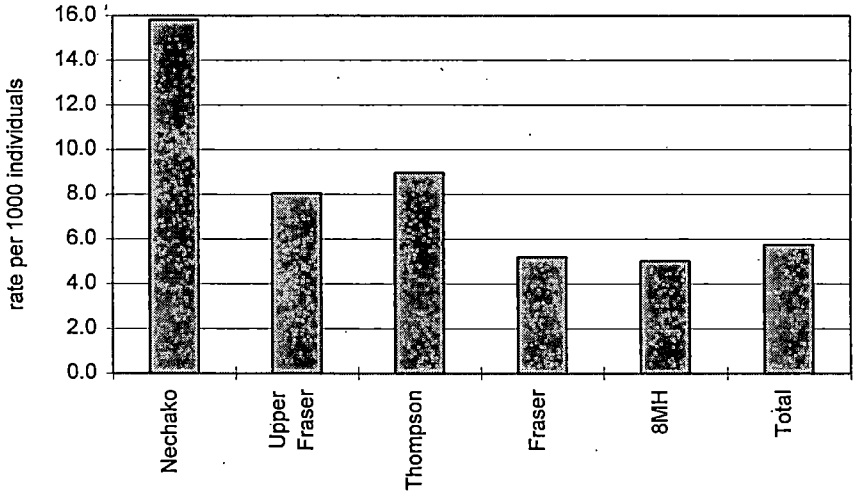


Indicator: Respiratory Disease Incidence Rate

Data Source: Program Standards and Information Management, B.C. Ministry of Health and Ministry Responsible for Seniors.

Data characteristics: Data supplied for selected ICD9 codes (480 through 508, 519.8 and 519.9 inclusive) by principle diagnosis upon admission to hospital, aggregated by Local Health Area of residence. Includes pneumonia, influenza, bronchitis, emphysema, asthma, pneumoconiosis (and others due to external agents), and others not elsewhere classified or specified. Incidence reported as per 1000 population. Multiple admissions of the same individual are regarded as multiple incidences. Cases not requiring hospitalization are excluded. Data was obtained for 1986 through 1991.

Respiratory Disease Incidence Rate by Region, 1991

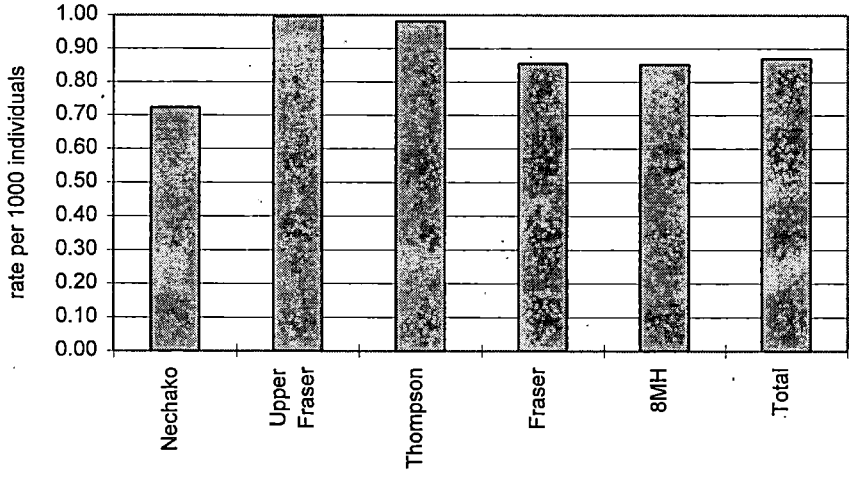


Indicator: Skin Cancer Incidence Rate

Data Source: Program Standards and Information Management, B.C. Ministry of Health and Ministry Responsible for Seniors.

Data characteristics: Data supplied for selected ICD9 code (172) by principle diagnosis upon admission to hospital, aggregated by Local Health Area (LHA) of residence. Incidence reported as per 1000 population. Multiple admissions of the same individual are regarded as multiple incidences. Cases not requiring hospitalization are excluded. Data was obtained for 1986 through 1991.

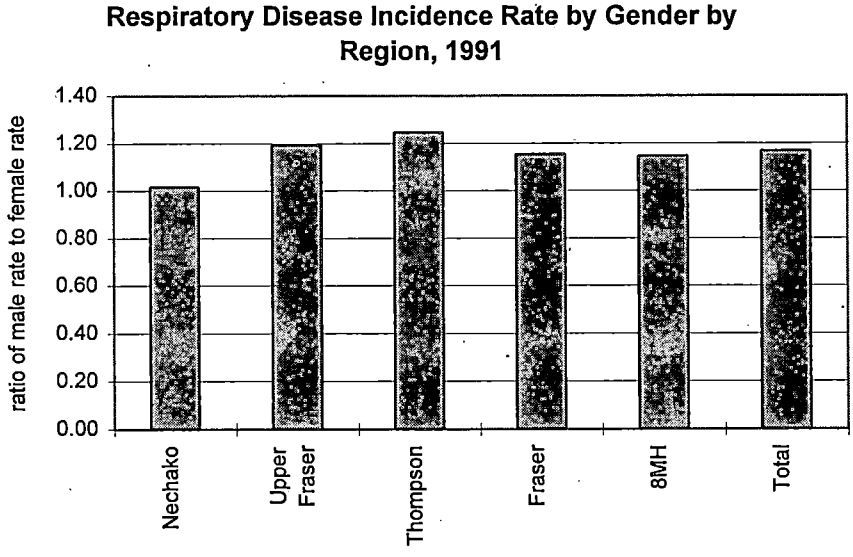
Skin Cancer Incidence Rate by Region, 1991



Indicator: Respiratory Disease Incidence Rate by Gender

Data Source: Program Standards and Information Management, B.C. Ministry of Health and Ministry Responsible for Seniors and Planning and Statistics Division, B.C. Ministry of Government Services.

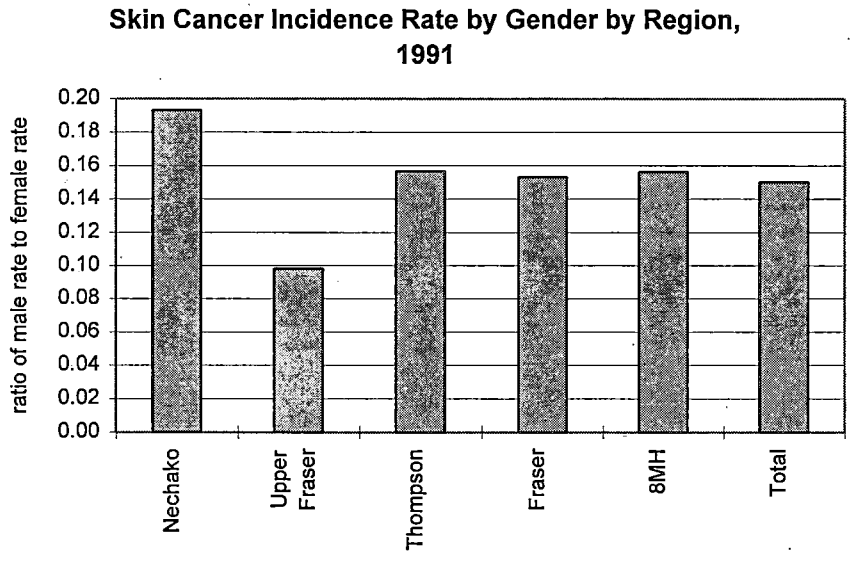
Data characteristics: Respiratory disease incidence rate by gender taken as the ratio of the male rate to the female rate (per 1000 individuals). Data supplied for selected ICD9 codes (480 through 508, 519.8 and 519.9 inclusive) by principle diagnosis upon admission to hospital, aggregated by Local Health Area of residence. Includes pneumonia, influenza, bronchitis, emphysema, asthma, pneumoconiosis (and others due to external agents), and others not elsewhere classified or specified. Multiple admissions of the same individual are regarded as multiple incidences. Cases not requiring hospitalization are excluded. Data was obtained for 1986 through 1991.



Indicator: Skin Cancer Incidence Rate by Gender

Data Source: Program Standards and Information Management, B.C. Ministry of Health and Ministry Responsible for Seniors and Planning and Statistics Division, B.C. Ministry of Government Services.

Data characteristics: Skin cancer incidence rate by gender taken as the ratio of the male rate to the female rate (per 1000 individuals). Data supplied for selected ICD9 code (172) by principle diagnosis upon admission to hospital, aggregated by Local Health Area (LHA) of residence. Multiple admissions of the same individual are regarded as multiple incidences. Cases not requiring hospitalization are excluded. Data was obtained for 1986 through 1991.

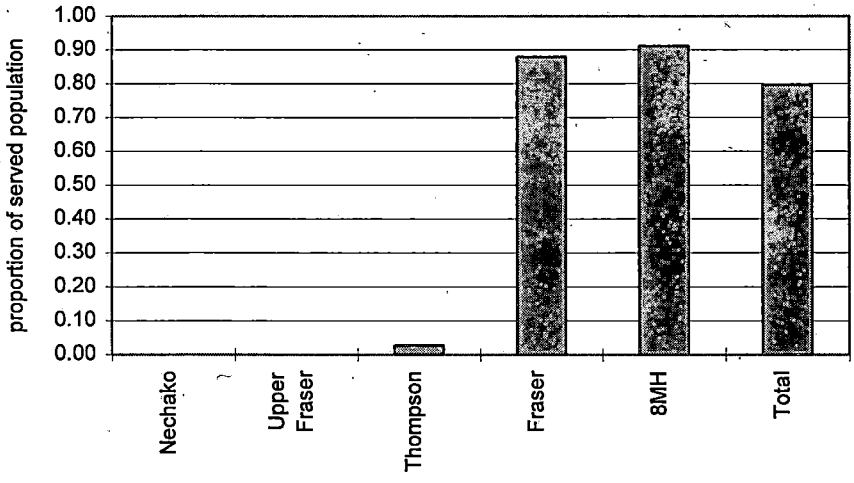


Indicator: Municipal Wastewater Treatment by Type

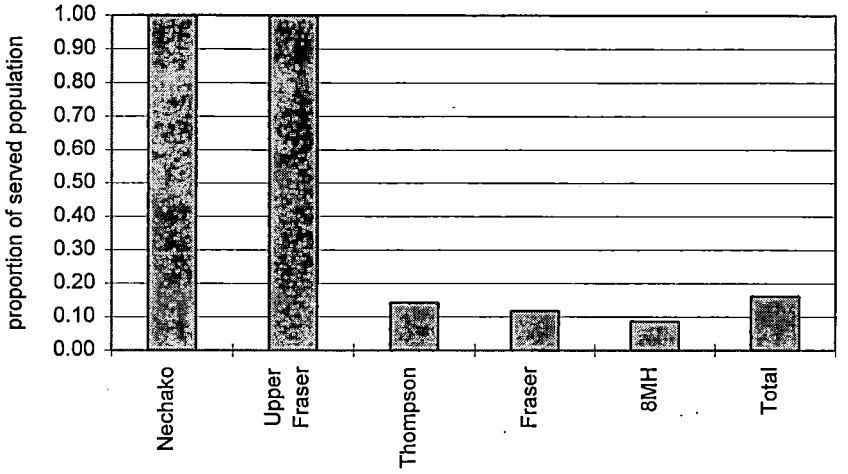
Data Source: Municipal Water Use Database (MUD), Environment Canada

Data characteristics: Data supplied for municipalities of a population of 1000 or over by sub-sub-basin location (using Environment Canada, Inland Waters Directorate boundaries). Primary, secondary (including waste stabilization ponds), and tertiary treatment by population served was noted as a proportion of the total population served with sewage treatment (does not include individually owned septic tanks or fields, or those not served with municipal sewage treatment). Data was obtained for 1983, 1986, 1989, and 1991.

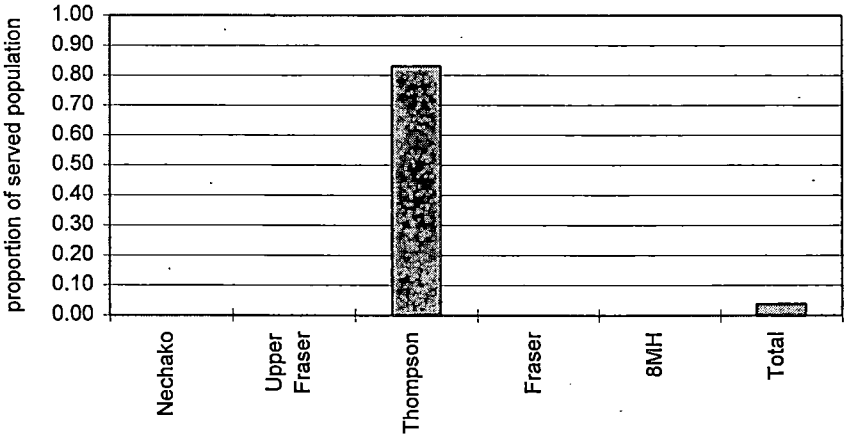
Primary Municipal Wastewater Treatment by Region, 1991



Secondary Municipal Wastewater Treatment by Region, 1991



Tertiary Municipal Wastewater Treatment by Region, 1991

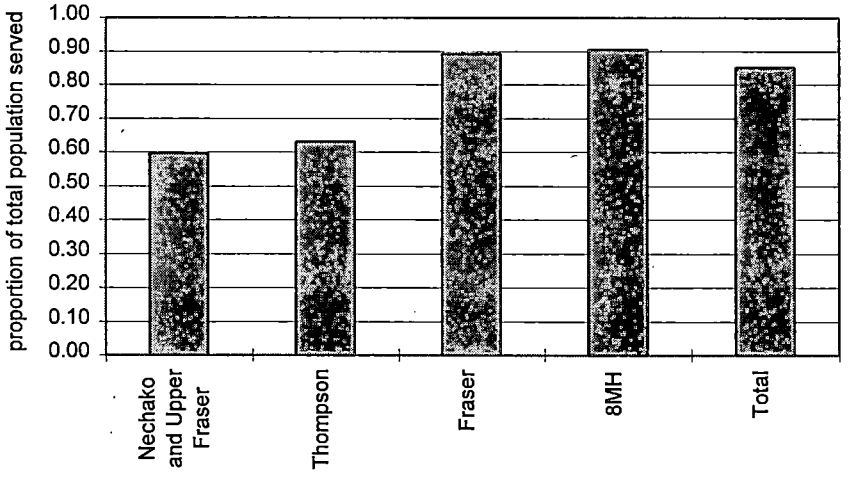


Indicator: Proportion of Population Served by Municipal Water

Data Source: Municipal Water Use Database (MUD), Environment Canada; Statistics Canada, System of National Accounts; and, Planning and Statistics Division, B.C. Ministry of Government Services.

Data characteristics: Data for population served by municipal water supplied for municipalities of a population of 1000 or over by sub-sub-basin location (using Environment Canada, Inland Waters Directorate boundaries). Data was obtained for 1983, 1986, 1989, and 1991. Data for total population supplied aggregated to basin, sub-basin, and sub-sub-basin boundaries for the years 1986 and 1991. Population figures for the years 1983 and 1989 (inter-Census years) were estimated by indexing to the appropriate Regional District population estimates. For the Upper Fraser Sub-basin, the total number of individuals served by water for the municipalities is greater than the total population for the sub-basin. This is likely due to the inclusion of all of the municipality of Prince George in the Upper Fraser Sub-basin, although part of its population lies in the Nechako Sub-basin. The data for the two sub-basins (Nechako and Upper Fraser) is thus combined into one figure.

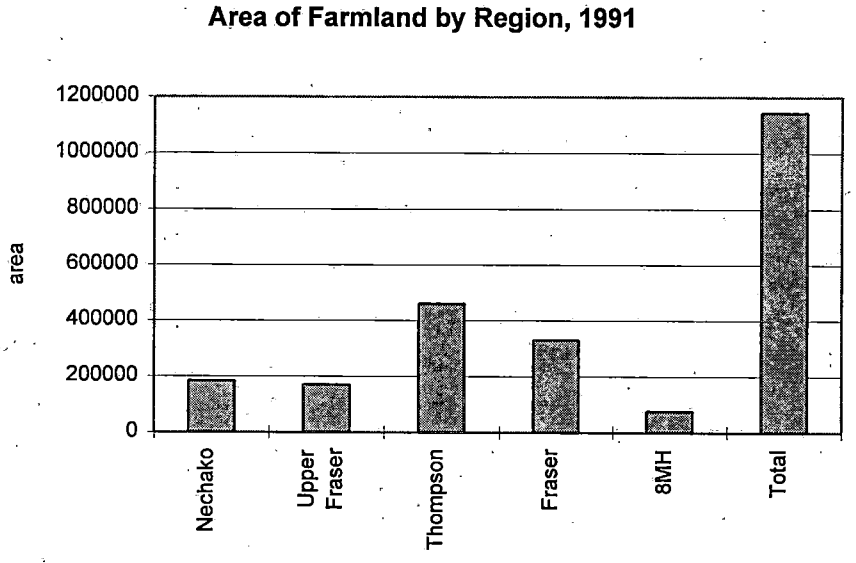
Proportion of Population Served by Municipal Water by Region, 1991



Indicator: Area of Farmland

Data Source: Statistics Canada, National Accounts and Environment Division

Data characteristics: Data supplied aggregated to basin, sub-basin, and sub-sub-basin 8MH as derived from the Census of Agriculture. Area of farmland is in hectares. Data was obtained for 1971, 1976, 1981, 1986, and 1991.

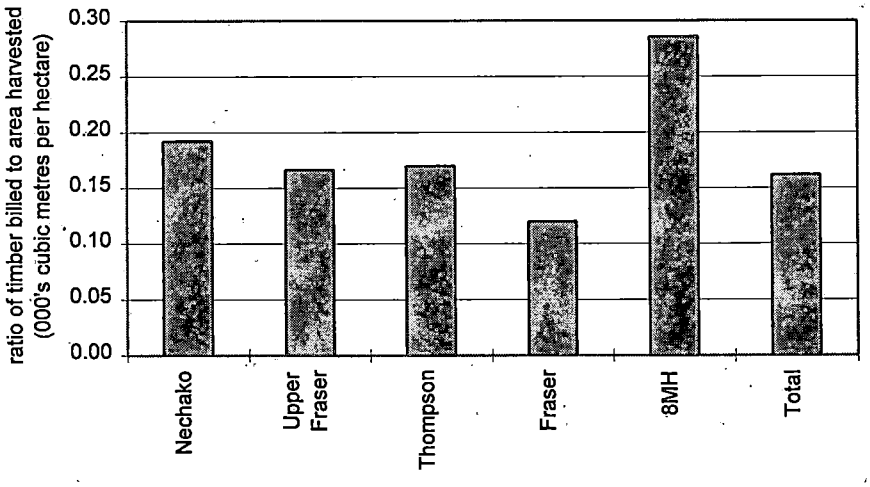


Indicator: Ratio of Timber Volume Billed to Area Harvested

Data Source: B.C. Ministry of Forests

Data characteristics: Data supplied aggregated to Forest Regions for the years 1986 through 1991. Use of such a large aggregation to approximate the conditions within the Fraser River Basin and its associated sub-basins and sub-sub-basins may be questionable. Data also supplied aggregated to Forest District (a smaller level of aggregation) for the year 1991. An equally weighted average of data from all Forest Regions which lie partially within the basin, sub-basin, or sub-sub-basin in question was taken for the years 1986 through 1991. Similarly, this was also done for all Forest Districts which lie within the boundaries in question for the year 1991. As the data based on Forest District administrative boundaries would be more reflective of the activity within the Fraser River Basin, the value of the indicator based on this data was taken and 1986 through 1990 values estimated by indexing to the annual changes calculated from the Forest Region data. Volume of timber is in thousands of cubic metres, and area harvested is in hectares- both for Crown Land. Volume of timber is for all timber harvests for which stumpage fees were collected. Note that this indicator will reflect natural productivity as well as efficiency of use.

Ratio of Timber Billed to Area Harvested by Region, 1991

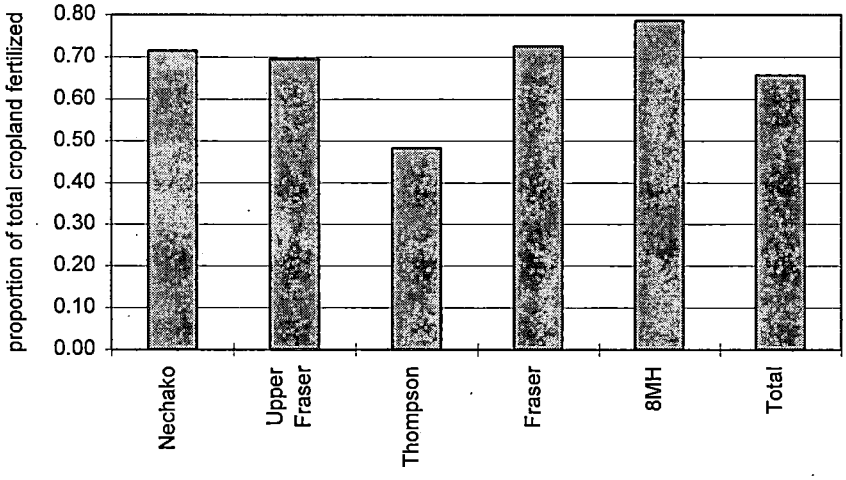


Indicator: Intensity of Agricultural Fertilizer Application

Data Source: Statistics Canada, National Accounts and Environment Division

Data characteristics: Data supplied aggregated to basin, sub-basin, and sub-sub-basin 8MH as derived from the Census of Agriculture. Intensity of agricultural fertilizer application is taken as total hectares fertilized as a proportion of total hectares of cropland. Data was obtained for 1971, 1981, 1986, and 1991.

Intensity of Agricultural Fertilizer Application by Region, 1991

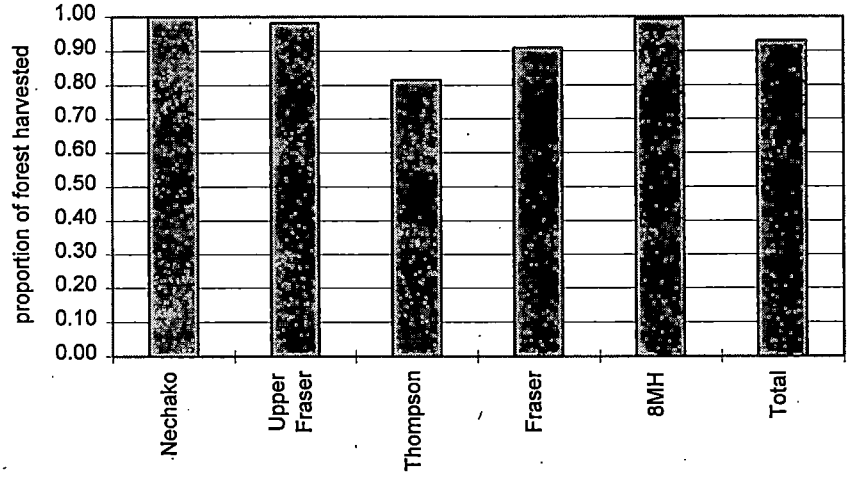


Indicator: Proportion of Forest Harvested by Clear-cutting

Data Source: B.C. Ministry of Forests.

Data characteristics: See **Ratio of Timber Volume Billed to Area Harvested** for data quality concerns. Data for this indicator was similarly calculated. Proportion of forest harvested by clear-cutting is in terms of area. Data was obtained for 1986 through 1991. Note that the selective logging statistics do not take into account varying and unregistered differences in intensities of the logging practices.

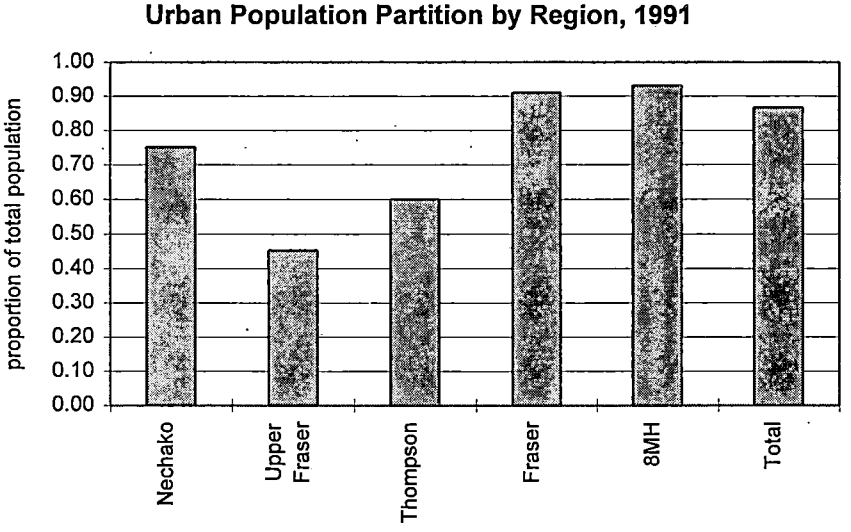
Proportion of Forest Harvested by Clear-cutting by Region, 1991



Indicator: Urban Population Partition

Data Source: Statistics Canada, National Accounts and Environment Division

Data characteristics: Data supplied aggregated to basin, sub-basin, and sub-sub-basin 8MH. Urban population partition taken as the proportion of the total population living in urban areas. Data was obtained for 1971, 1976, 1981, 1986, and 1991.

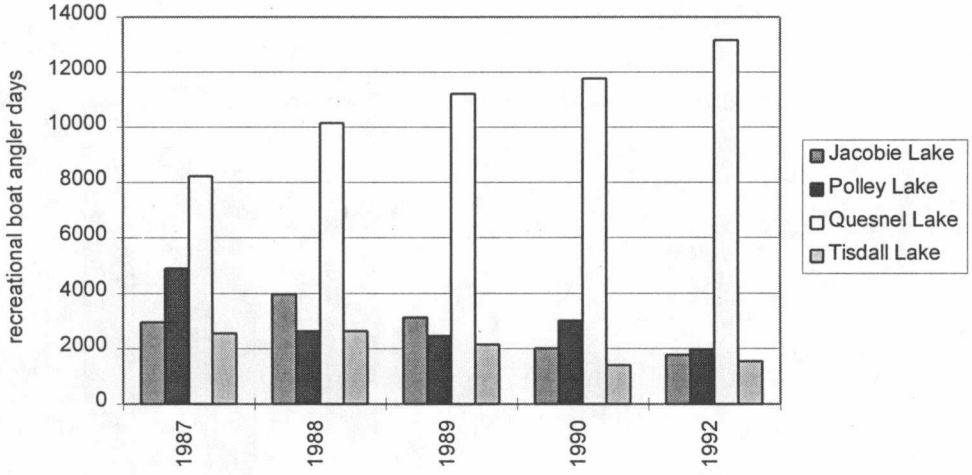


Indicator: Recreational Boat Angler Days

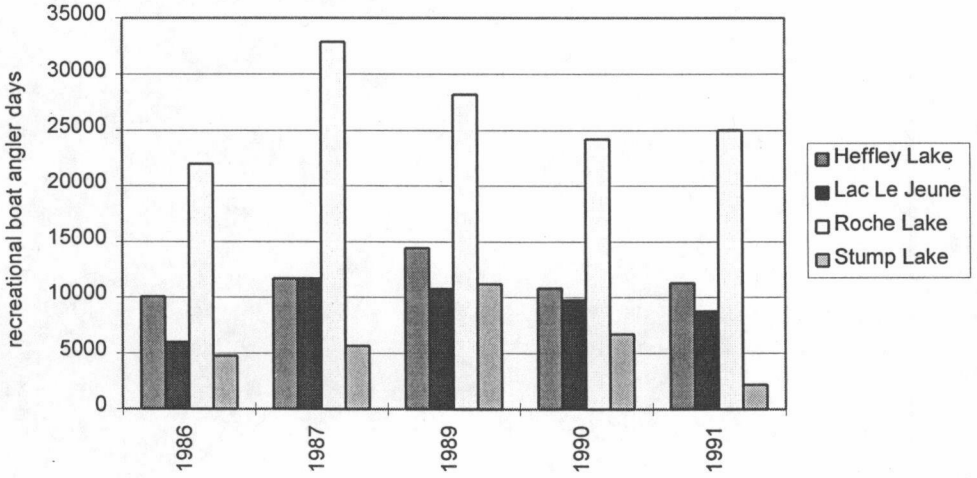
Data Source: Conservation Section, Fisheries Branch, B.C. Ministry of Environment, Lands, and Parks

Data characteristics: Data supplied for a sample of small lakes within the Fraser River Basin. Surveys were restricted to the Upper Fraser Sub-basin, Thompson Sub-basin, and northern regions of the Fraser Sub-basin. Recreational angler days estimates provided from periodic arial surveys. Due to results being highly dependent on the specific lake site chosen, data between lakes cannot be meaningfully aggregated, but can only be analyzed on a time-series basis for each lake in question. Data was obtained for 1986 through 1992, with years missing depending on the lake in question. Lakes were chosen based on the extent of angler activity, and for which data exists for five or more years.

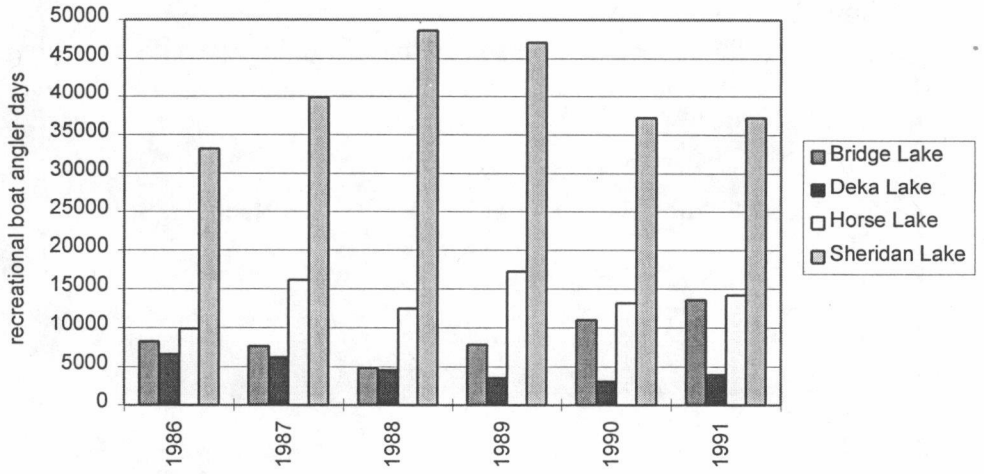
Recreational Boat Angler Days by Lake for the Upper Fraser Sub-basin, 1987-1990, and 1992



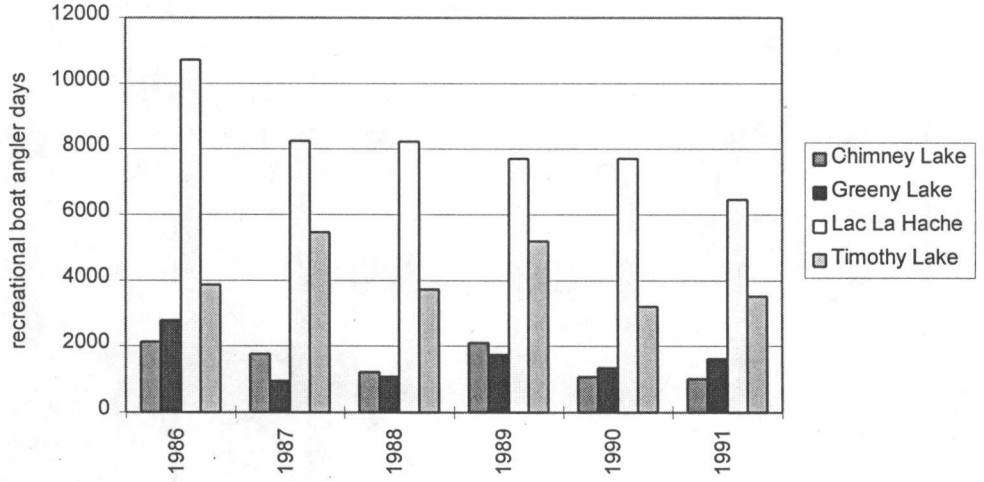
Recreational Boat Angler Days by Lake for the southern Thompson Sub-basin, 1986, 1987, and 1989-1991



Recreational Boat Angler Days by Lake for the northern Thompson Sub-basin, 1986-1991



Recreational Boat Angler Days by Lake for the northern Fraser Sub-basin, 1986-1991

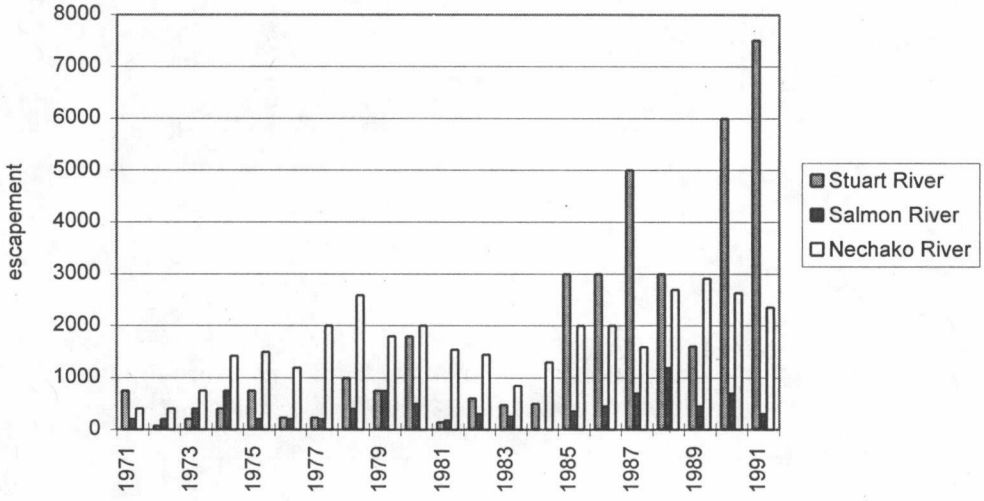


Indicator: Salmon Escapement

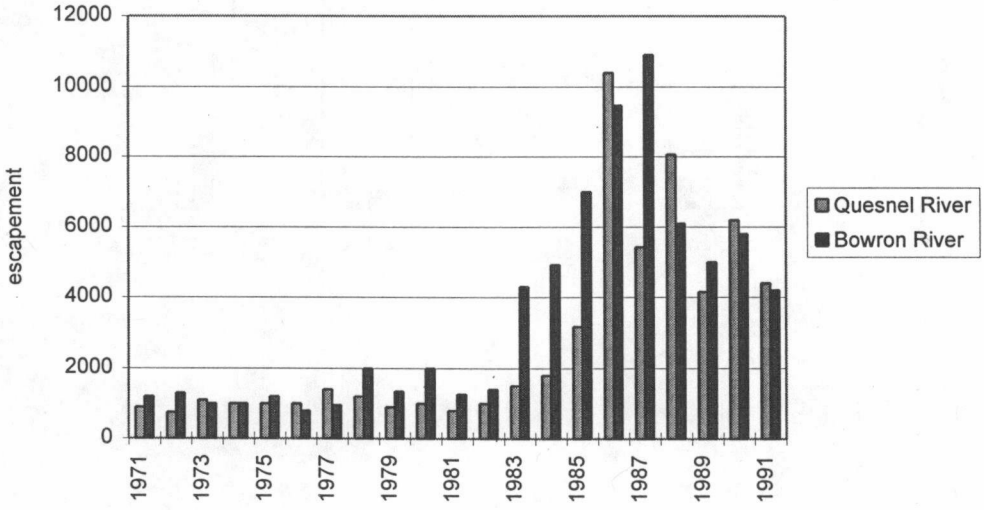
Data Source: Salmon Index Method Section, Pacific Biological Station, Department of Fisheries and Oceans

Data characteristics: Data supplied for selected sample streams within the Fraser River Basin and the sub-basins and sub-sub-basin of interest. Count estimates for salmon by species are not necessarily meaningfully comparable between streams as results are highly site-specific. Differences in counting methodology between years has an unknown effect on the reliability of within-stream comparisons. Data is presented for Chinook salmon counts by river. Data was obtained for 1971 through 1991.

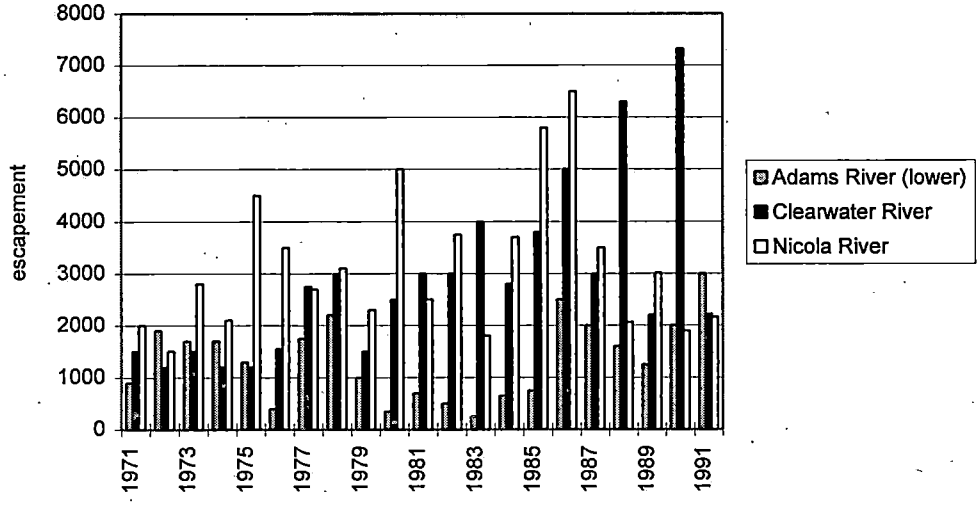
Chinook Salmon Escapement by River for the Nechako Sub-basin, 1971-1991



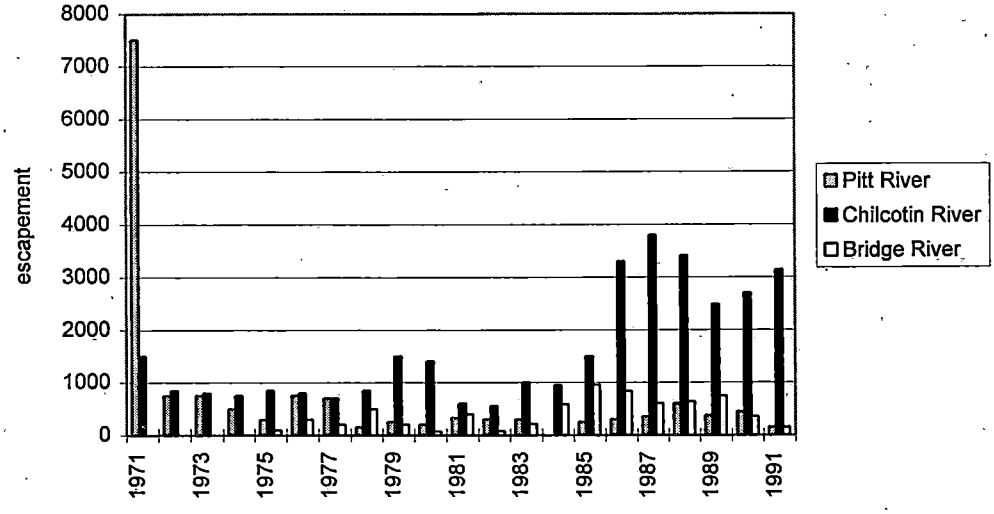
Chinook Salmon Escapement by River for the Upper Fraser Sub-basin, 1971-1991



Chinook Salmon Escapement by River for the Thompson Sub-basin, 1971-1991



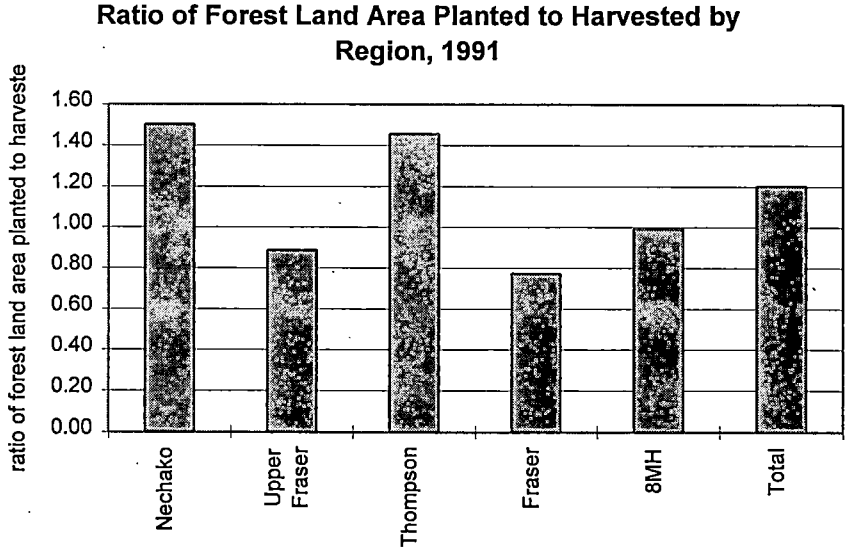
Chinook Salmon Escapement by River for the Fraser Sub-basin, 1971-1991



Indicator: Ratio of Forest Land Area Planted to Harvested

Data Source: B.C. Ministry of Forests

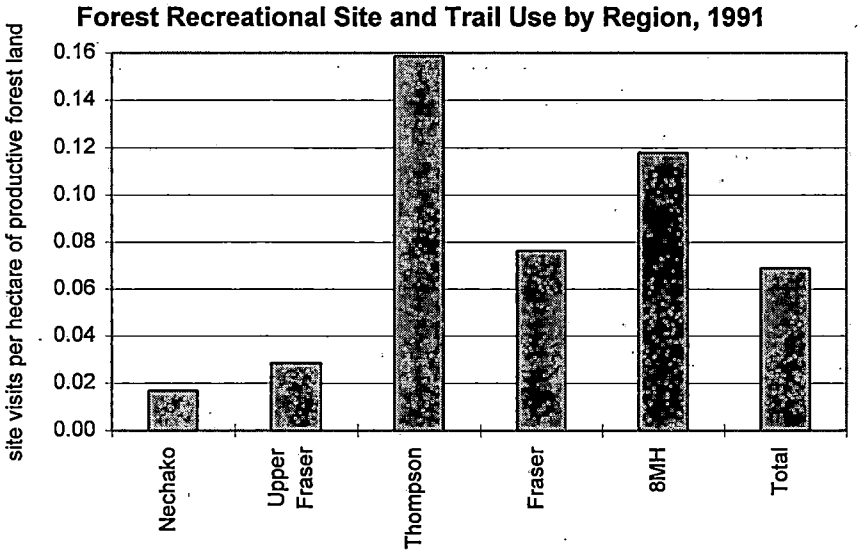
Data characteristics: See **Ratio of Timber Volume Billed to Area Harvested** for data quality concerns. It was not possible to use Forest District data in this case; thus, regional specificity may be suspect. Area harvested includes only forest clear-cut. Data was obtained for 1986 through 1991.



Indicator: Forest Recreational Site and Trail Use

Data Source: B.C. Ministry of Forests

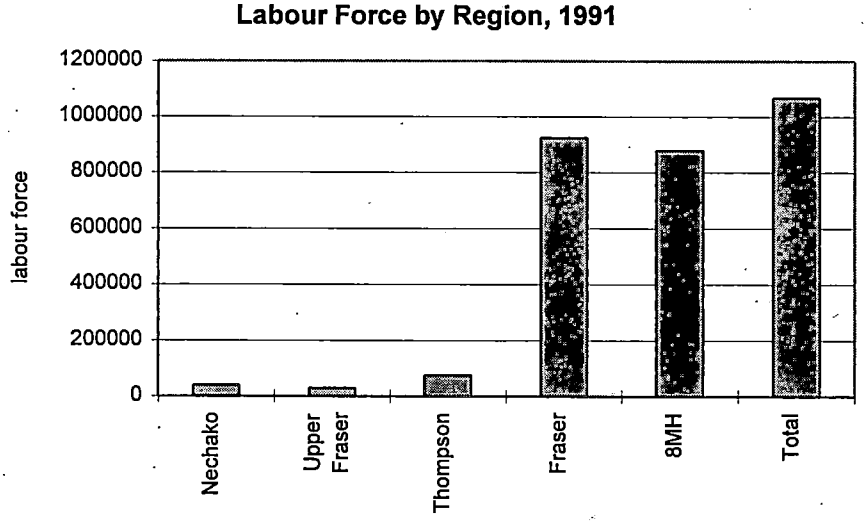
Data characteristics: See **Ratio of Timber Volume Billed to Area Harvested** for data quality concerns. It was not possible to use Forest District data in this case; thus, regional specificity may be suspect. Forest recreational site and trail use is taken as the ratio of site visits per hectare of productive forest land (productive forest land includes Timber Supply Areas and Tree Farm Licences where timber harvesting is partially or wholely restricted; forest recreational sites and trails include those "active and maintained" by the Forest Service). Data was obtained for 1986 through 1991.



Indicator: Labour Force

Data Source: Statistics Canada, National Accounts and Environment Division

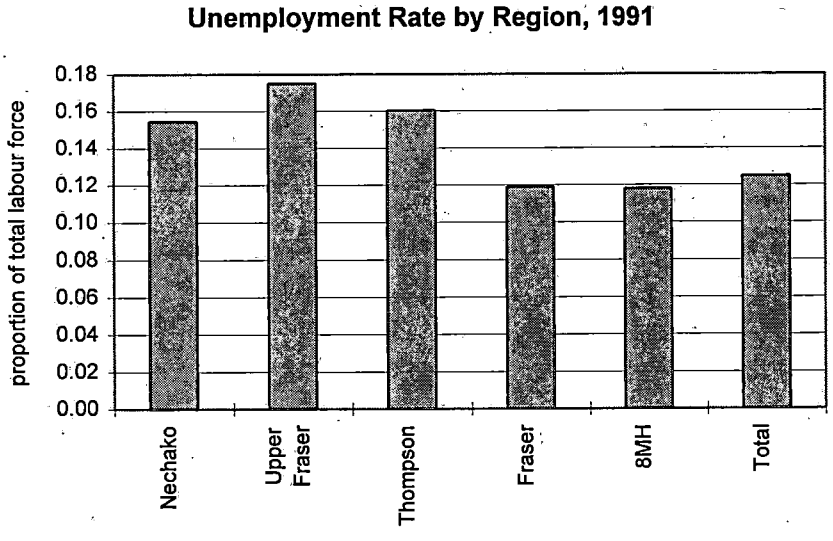
Data characteristics: Data supplied aggregated to basin, sub-basin, and sub-sub-basin 8MH. Labour force in terms of numbers of individuals. Data was obtained for 1971, 1976, 1981, 1986, and 1991.



Indicator: Unemployment Rate

Data Source: Statistics Canada, National Accounts and Environment Division

Data characteristics: Data supplied aggregated to basin, sub-basin, and sub-sub-basin 8MH. Unemployment rate taken as the ratio of the number unemployed to the size of the labour force. Data was obtained for 1971, 1976, 1981, 1986, and 1991.

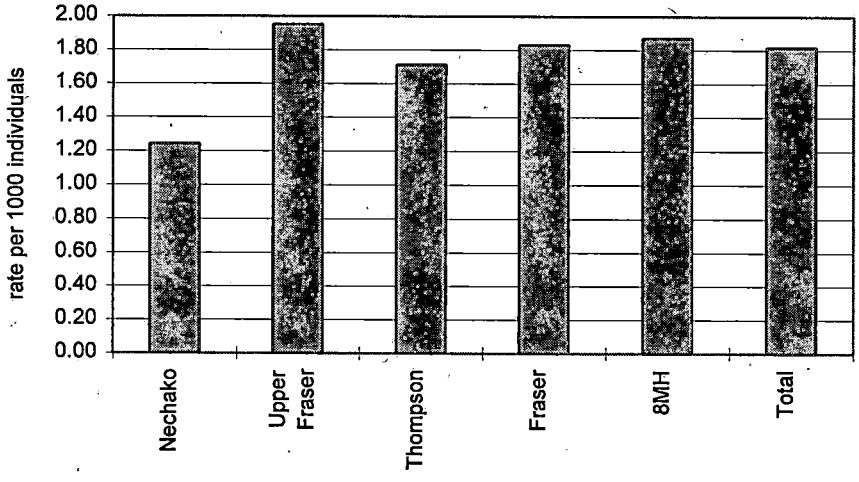


Indicator: Bankruptcy Rate

Data Source: Planning and Statistics Division, B.C. Ministry of Government Services as derived from data provided by Consumer and Corporate Affairs Canada

Data characteristics: Data supplied aggregated according to Census Divisions. Bankruptcy rate taken as the total number of business and consumer bankruptcies per 1000 individuals. Data was obtained for 1981 through 1991.

Bankruptcy Rate by Region, 1991

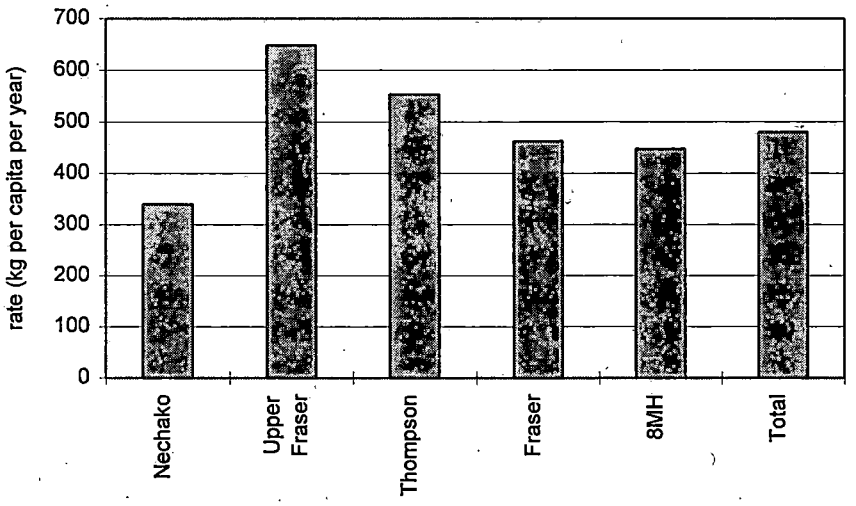


Indicator: Municipal Solid Waste Disposal Rate

Data Source: Municipal Waste Reduction Branch, Environment Protection Department, B.C. Ministry of Environment, Lands, and Parks

Data characteristics: Data supplied aggregated according to Census Divisions. Rate of solid waste disposal in terms of kilograms per capita per year. Note that rates will be affected by transient visitors (e.g., tourists) who are not included in the per capita figure yet contribute to municipal solid waste generation. Data was obtained for 1990 and 1991.

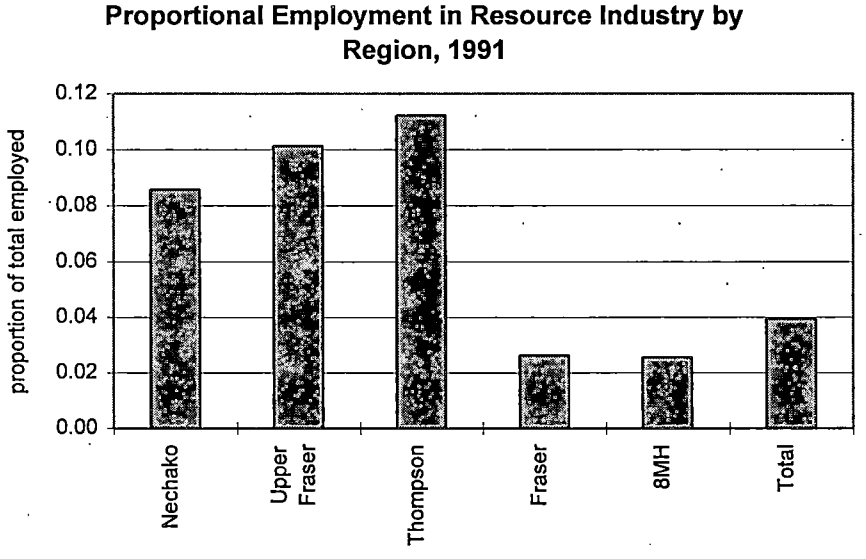
Municipal Solid Waste Disposal Rate by Region, 1991



Indicator: Proportional Employment In Resource Industry

Data Source: Statistics Canada, National Accounts and Environment Division

Data characteristics: Data supplied aggregated according to basin, sub-basin, and sub-sub-basin 8MH. Proportional employment in resource industry taken as the ratio of the total number employed in fisheries, forestry, mines, and agriculture to the total number employed in the region. Data was obtained for 1981 and 1991.

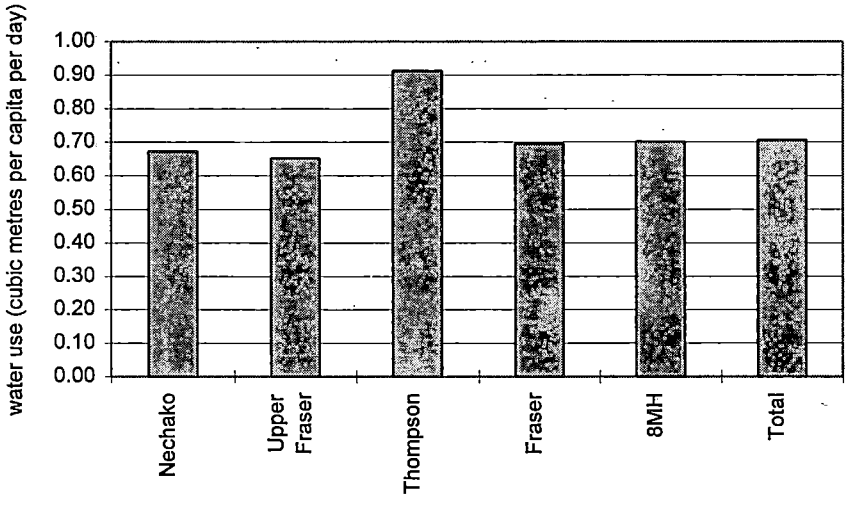


Indicator: Water Use

Data Source: Municipal Water Use Database (MUD), Environment Canada

Data characteristics: Data supplied for municipalities of a population of 1000 or over by sub-sub-basin location (using Environment Canada, Inland Waters Directorate boundaries). Water use in terms of the average daily flow of water supplied in cubic metres per capita per day. Data was obtained for 1981, 1986, 1989, and 1991.

Water Use by Region, 1991

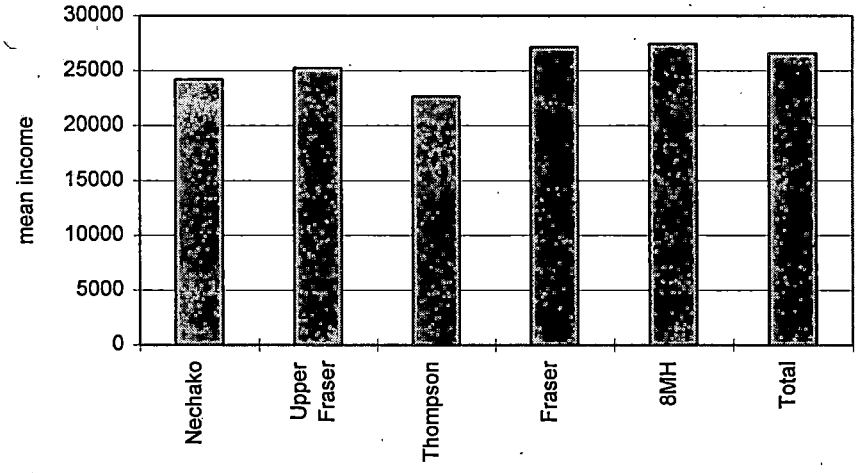


Indicator: Income

Data Source: Planning and Statistics Division, B.C. Ministry of Governement Services as derived from Revenue Canada taxation statistics.

Data characteristics: Data supplied aggregated to Census Divisions. Income calculated as the mean of the personal tax returns filed, using total income from all sources. All values are in current dollars. Data was obtained for 1976 through 1991.

Income by Region, 1991

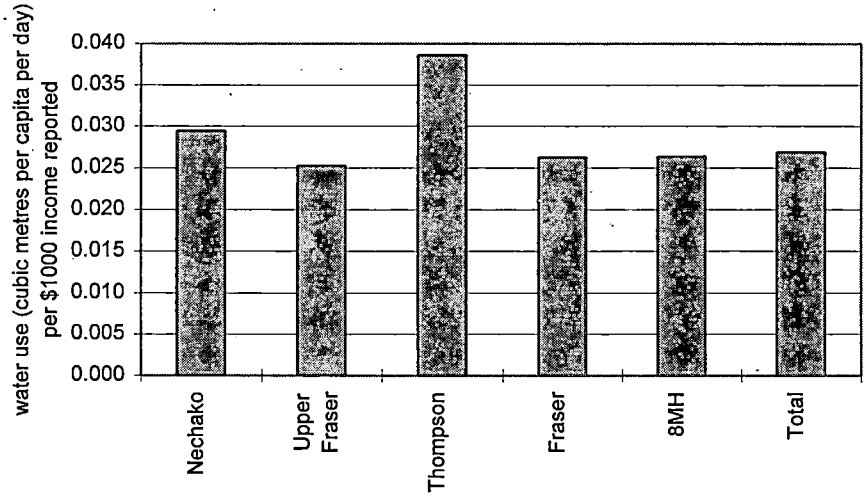


Indicator: Water Intensity

Data Source: Municipal Water Use Database (MUD), Environment Canada and Planning and Statistics Division, B.C. Ministry of Government Services as derived from Revenue Canada taxation statistics.

Data characteristics: Data for water use supplied for municipalities of a population of 1000 or over by sub-sub-basin location (using Environment Canada, Inland Waters Directorate boundaries). Income data provided by municipality, and includes income from all sources from personal income tax returns filed. Water intensity calculated as the water use (cubic metres per capita per day) per $1000 income reported. The exclusion of business income which is not reflected in personal income may distort the measure. Data was obtained for 1983, 1986, 1989, and 1991.

Water Intensity by Region, 1991

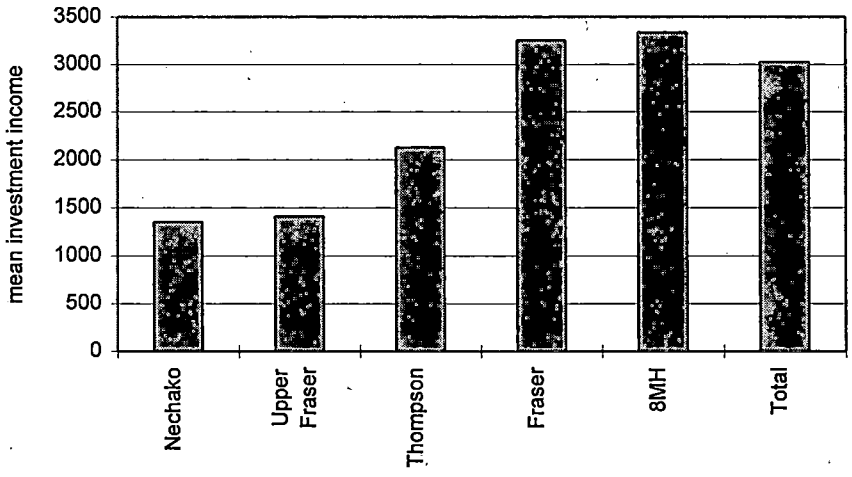


Indicator: Investment Income

Data Source: Planning and Statistics Division, B.C. Ministry of Governement Services as derived from Revenue Canada taxation statistics.

Data characteristics: Data supplied aggregated to Census Divisions. Income calculated as the mean of the personal tax returns filed, using investment income source. All values are in current dollars. Data was obtained for 1985 through 1991.

Investment Income by Region, 1991

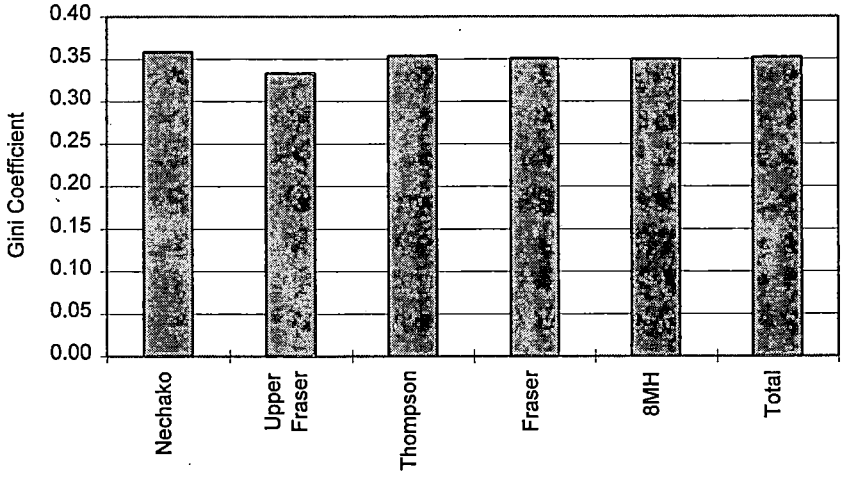


Indicator: Income Distribution

Data Source: Statistics Canada, National Accounts and Environment Division

Data characteristics: Data supplied aggregated to basin, sub-basins, and sub-sub-basins. A Gini Coefficient was calculated from data provided by income group of individuals in private households by assuming that the mean income for the individuals in each income group was the income midpoint of the group (less than zero income group mean income was taken as $-2500, and >$45000 income group mean income was taken as $47500). Data was obtained for 1981 and 1991.

Income Distribution by Region, 1991

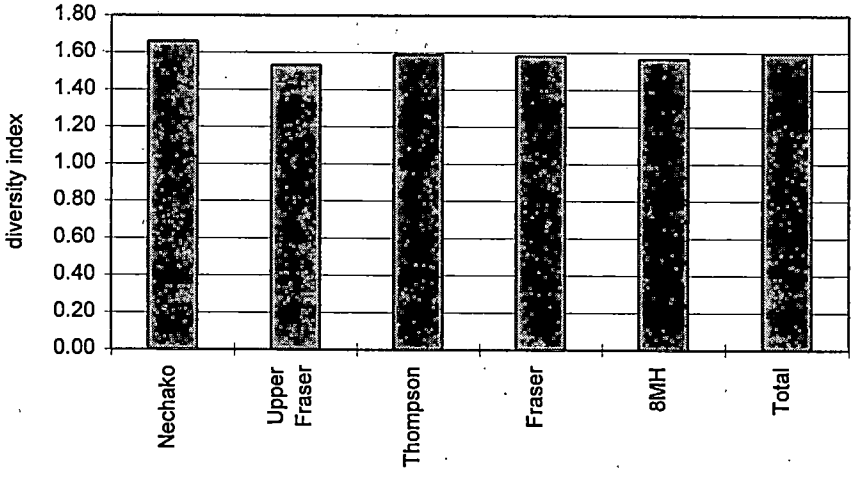


Indicator: Ethnic Diversity

Data Source: Planning and Statistics Division, B.C. Ministry of Government Services as derived from Census of Population

Data characteristics: Data supplied aggregated to Census Divisions. The proportion of individuals who registered as British, French, German, Italian, Aboriginal, Ukrainian, Dutch, Polish, other single ethnicities, and other multiple ethnicities was used to calculate a Shannon diversity index (using natural logs; weighs both the number of different registered ethnicities and the evenness of the distribution). It is acknowledged that the diversity index is highly dependent on the ethnic divisions registered, which may bias the results (e.g., categories of European origin dominate the Census). Data estimates may be off due to 'area suppression'. Data was obtained for 1981, 1986, and 1991.

Enthic Diversity by Region, 1991

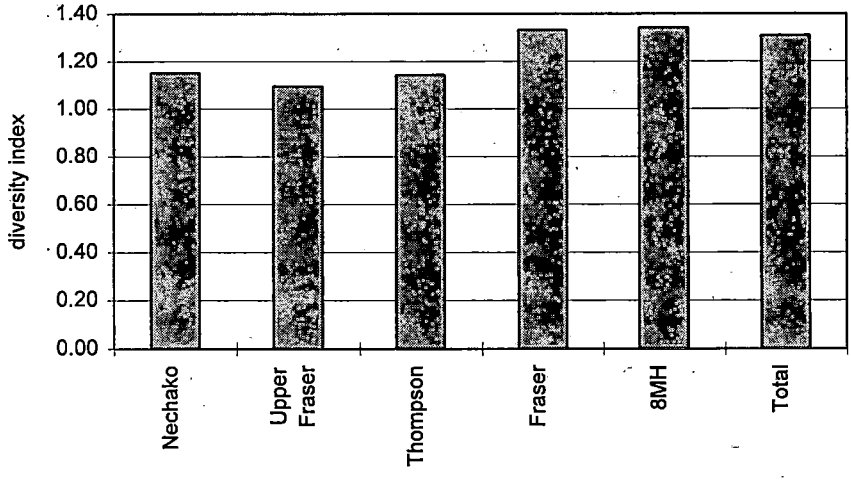


Indicator: Religious Diversity

Data Source: Planning and Statistics Division, B.C. Ministry of Government Services as derived from Census of Population

Data characteristics: Data supplied aggregated to Census Divisions. The proportion of individuals who registered as Catholic, Protestant, Eastern Orthodox, Jewish, Eastern non-Christian, no religion, and other religions was used to calculate a Shannon diversity index (using natural logs; weighs both the number of different registered religions and the evenness of the distribution). Again, it is acknowledged that the diversity index is highly dependent on the religion divisions registered, which may bias the results. Data estimates may be off due to 'area suppression'. Data was obtained for 1981 and 1991.

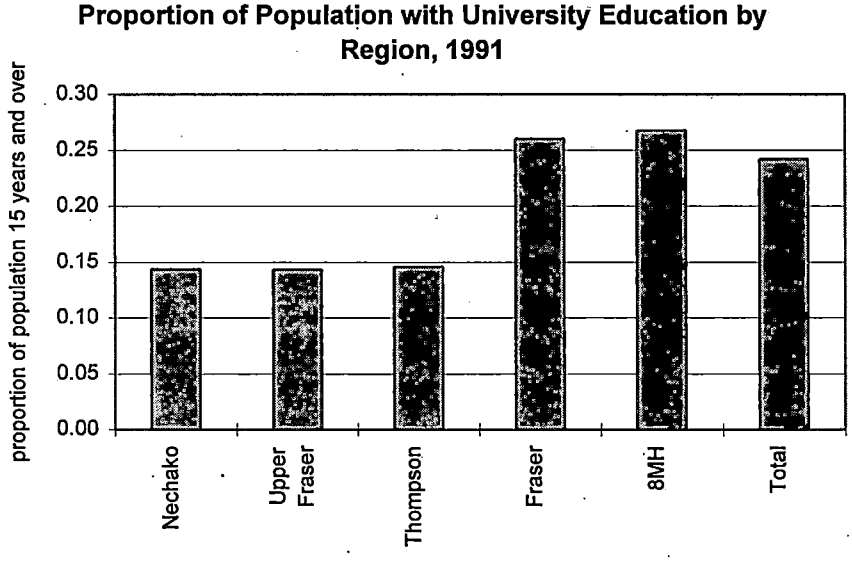
Religious Diversity by Region, 1991



Indicator: Educational Attainment

Data Source: Planning and Statistics Division, B.C. Ministry of Government Services as derived from the Census of Population

Data characteristics: Data supplied aggregated to Census Divisions. Educational attainment taken as the proportion of the population 15 years and over with university education (with or without degree) as the highest level of schooling and school attendance. Data estimates may be off due to 'area suppression'. Data was obtained for 1981, 1986, and 1991.

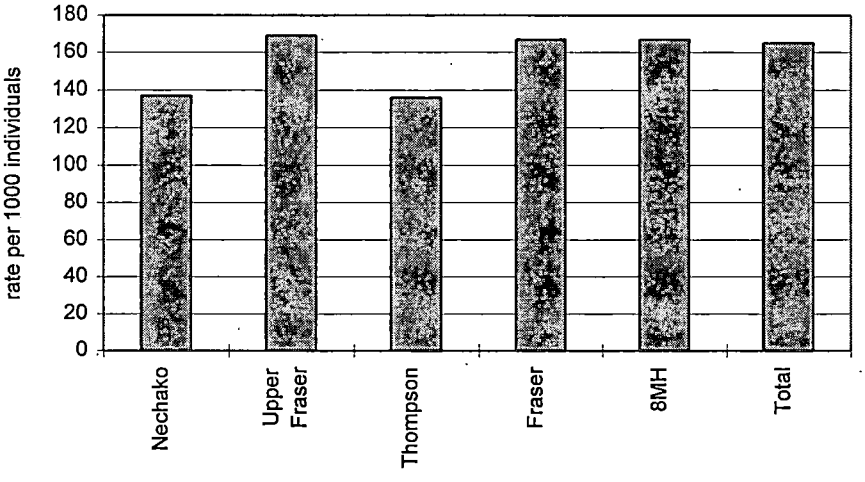


Indicator: Crime Rate

Data Source: Planning and Statistics Division, B.C. Ministry of Government Services as derived from B.C. Ministry of the Attorney General data

Data characteristics: Data supplied by policing jurisdiction (municipality and associated provincial regions). Crime rate taken as the number of criminal code offenses per 1000 resident population. Note that certain municipalities may register a higher crime rate, but this may reflect the attraction of the area for non-residents and not necessarily a lesser degree of human security. This problem is expected to be minimized given relatively large sub-basin and sub-sub-basin aggregations (e.g., individuals from Surrey and Richmond will congregate in Vancouver, whereas similar transient movement from outside the Lower Mainland is likely to be less significant). Data was obtained for 1984 through 1991.

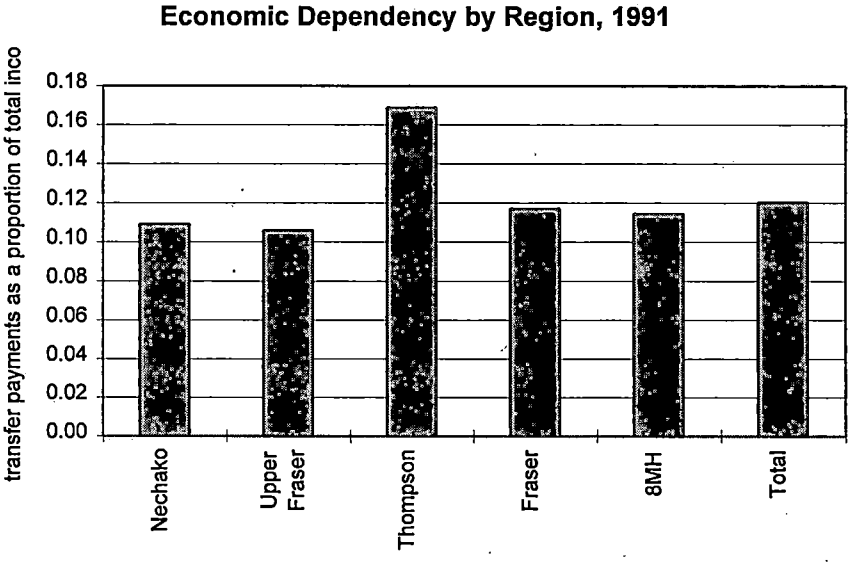
Crime Rate by Region, 1991



Indicator: Economic Dependency

Data Source: Small Area and Administrative Data Division, Statistics Canada

Data characteristics: Data supplied aggregated according to Census Divisions. Economic dependency taken as the ratio of the total transfer payments received to total income as reported in personal income returns (see previous Income indicator). Federal Sales Tax Credits, Goods and Services Tax Credits, Provincial Tax Credits, and non-taxable income was excluded from the transfers to maintain comparability between years (earlier years did not include some or all of these). Data was obtained for 1986, 1989, 1990, and 1991.

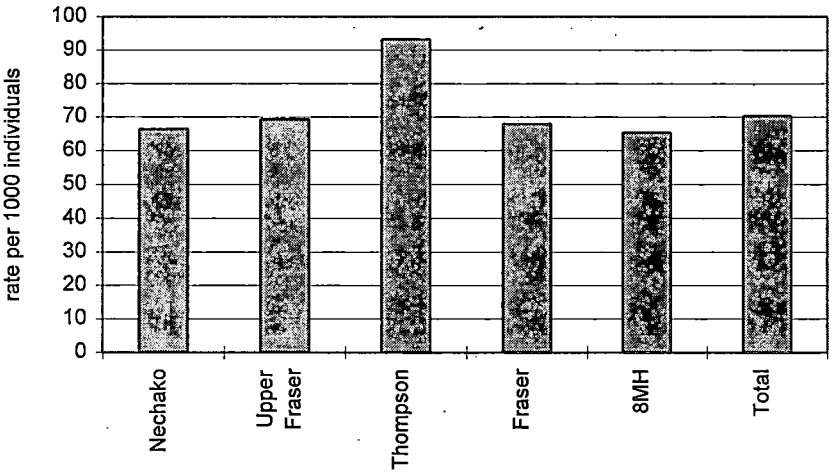


Indicator: In Migration Rate

Data Source: Planning and Statistics Division, B.C. Ministry of Government Services as derived from Small Area and Adminitrative Data Division, Statistics Canada

Data characteristics: Data supplied aggregated according to Census Divisions. In migration rate taken as the number of people moving into the area per 1000 resident population. Data was obtained for 1981 through 1991.

In Migration Rate by Region, 1991

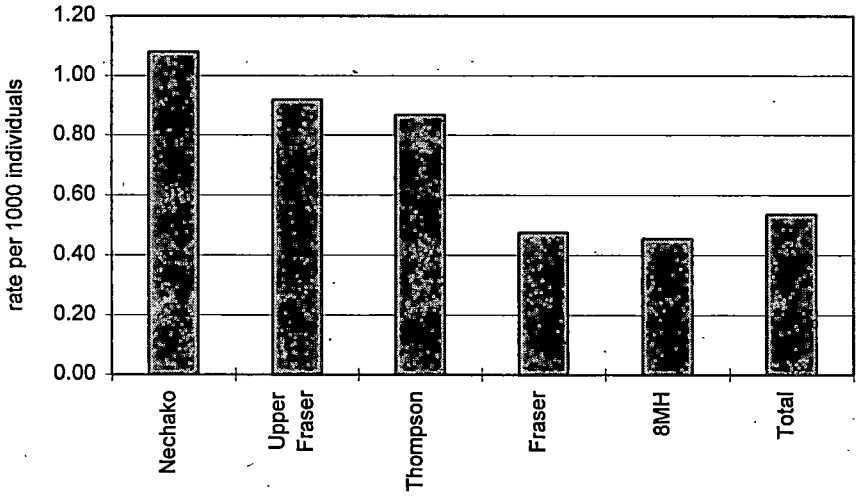


Indicator: Rate of Death by External Cause

Data Source: Vital Statistics Division, B.C. Ministry of Health and Ministry Responsible for Seniors

Data characteristics: Data supplied aggregated according to Local Health Area (LHA). Rate of death by external cause taken as the age standardized mortality rate (per 1000 population) due to accidents, suicide, and homicide. Data was obtained for 1987 through 1991.

Rate of Death by External Cause by Region, 1991

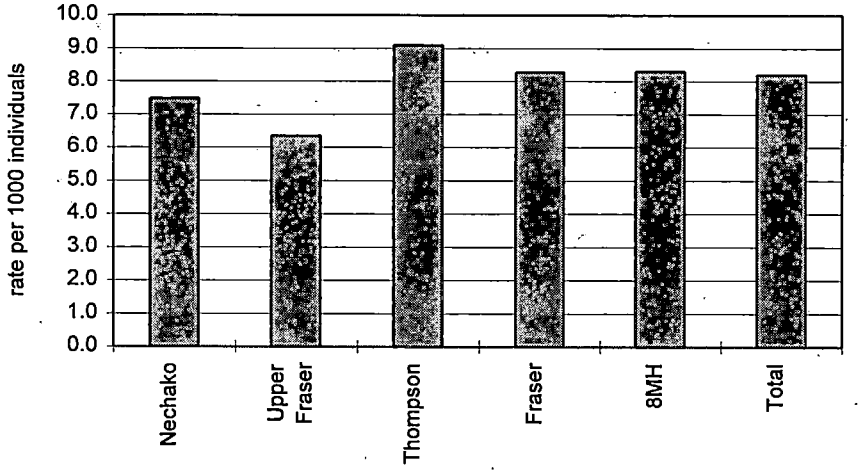


Indicator: Cancer Incidence Rate

Data Source: Program Standards and Information Management, B.C. Ministry of Health and Ministry Responsible for Seniors.

Data characteristics: Data supplied for selected ICD9 codes (140 through 239, inclusive) by principle diagnosis upon admission to hospital, aggregated by Local Health Area (LHA) of residence. Incidence reported as rate per 1000 population. Multiple admissions of the same individual are regarded as multiple incidences. Cases not requiring hospitalization are excluded. Data was obtained for 1986 through 1991.

Cancer Incidence Rate by Region, 1991

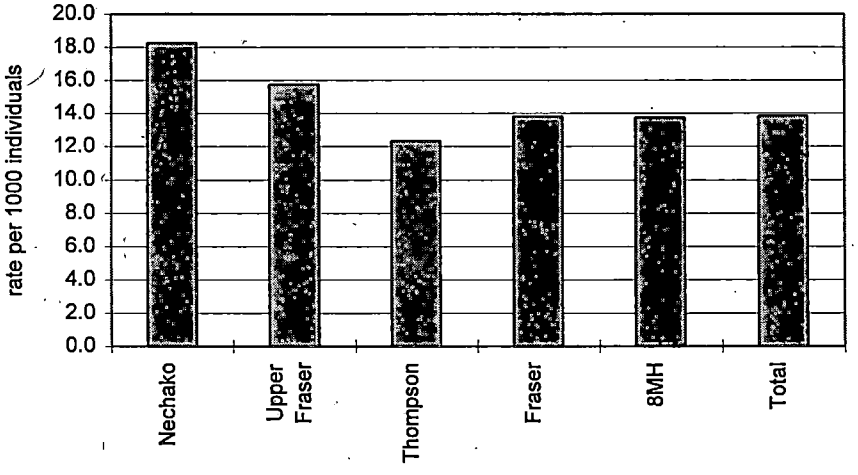


Indicator: Live Birth Rate

Data Source: Vital Statistics Division, B.C. Ministry of Health and Ministry Responsible for Seniors

Data characteristics: Data supplied aggregated to Census Divisions. Live birth rate per 1000 population. Data was obtained for 1984 through 1991.

Live Birth Rate by Region, 1991

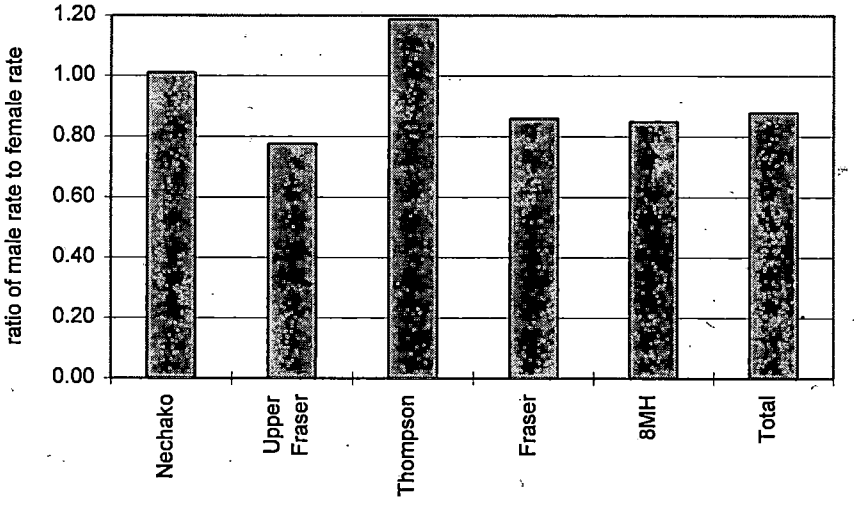


Indicator: Cancer Incidence Rate by Gender

Data Source: Program Standards and Information Management, B.C. Ministry of Health and Ministry Responsible for Seniors and Planning and Statistics Division, B.C. Ministry of Government Services.

Data characteristics: Cancer incidence rate by gender taken as the ratio of the male rate to the female rate. Data supplied for selected ICD9 codes (140 through 239, inclusive) by principle diagnosis upon admission to hospital, aggregated by Local Health Area (LHA) of residence. Incidence reported as rate per 1000 population. Multiple admissions of the same individual are regarded as multiple incidences. Cases not requiring hospitalization are excluded. Data was obtained for 1986 through 1991.

Cancer Incidence Rate by Gender by Region, 1991

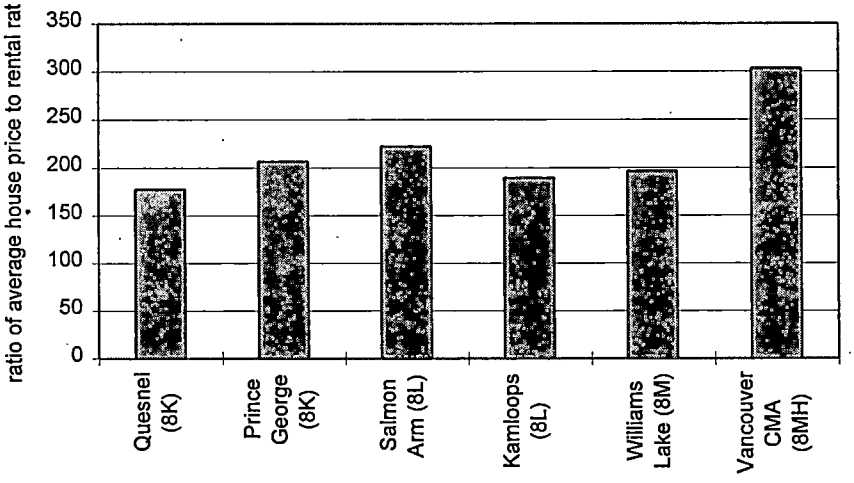


Indicator: Ratio of Average House Price to Rental Rate

Data Source: Canada Mortgage and Housing Corporation; Cariboo Real Estate Board; Okanagan-Mainline Real Estate Board; and, Royal LePage (*Survey of Canadian House Prices*).

Data characteristics: Mean rental rate is for a two bedroom apartment in a privately owned apartment structure for October of the given year, supplied by select municipality. Mean house prices for Vancouver CMA and Kamloops are for a detached bungalow for the fall of the given year. House prices for Vancouver CMA are taken as an equally weighted average of Vancouver Eastside, North Vancouver, West Vancouver, Richmond, and Surrey to reconcile with the rental rates reported for Vancouver CMA. Mean house prices for Quesnel and Williams Lake include detatched residential sales (excludes condominiums, duplexes, waterfront property, and acreages) for the month of December of the given year. Means house prices for Salmon Arm are based on regional information for residential sales (excludes condominiums) for the year (the region includes Salmon Arm, Sicamous, Sorrento, and Celista). In this latter case, data by municipality was not available. Differences in the data used for mean house price could not be avoided due to differences in statistical bookkeeping by the different agencies with regional jurisdiction. Data was obtained for 1987 through 1991 (with the exception of Quesnel, Williams Lake, and Prince George, for which data begins in 1988).

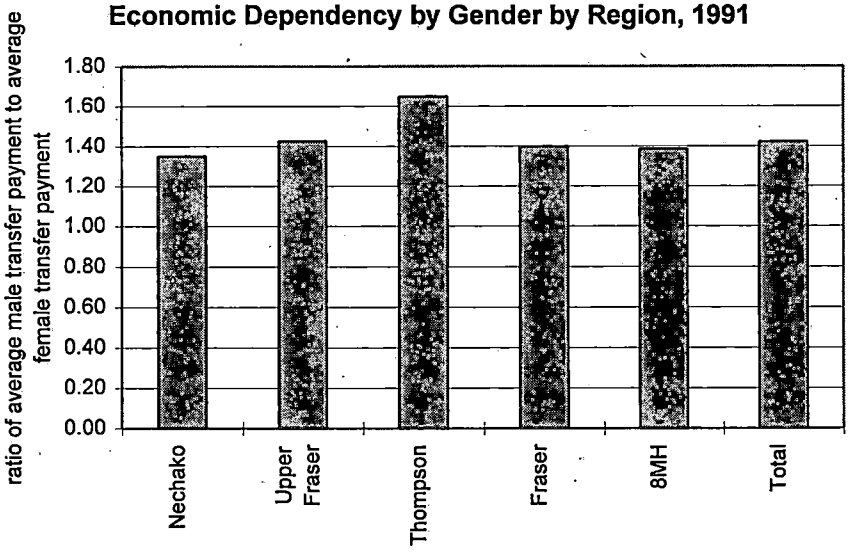
Ratio of Average House Price to Rental Rate by Selected Municipality, 1991



Indicator: Economic Dependency by Gender

Data Source: Small Area and Administrative Data Division, Statistics Canada

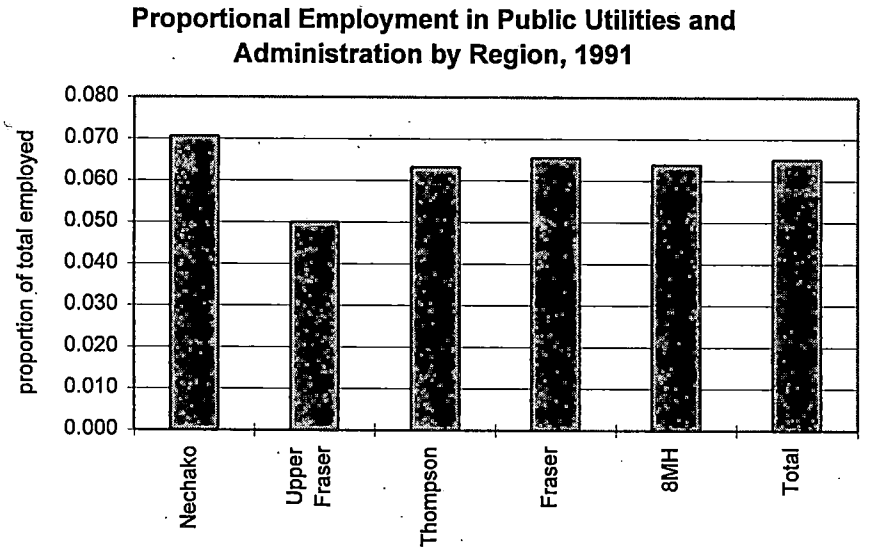
Data characteristics: Data supplied aggregated according to Census Divisions. Economic dependency taken as the ratio of the average transfer payment received by males to that received by females for those reporting transfer payments in returns filed. Federal Sales Tax Credits, Goods and Services Tax Credits, Provincial Tax Credits, and non-taxable income was excluded from the transfers to maintain comparability between years (earlier years did not include some or all of these). Data was obtained for 1986, 1989, 1990, and 1991.



Indicator: Proportional Employment in Public Utilities and Administration

Data Source: Statistics Canada, National Accounts and Environment Division

Data characteristics: Data supplied aggregated according to basin, sub-basin, and sub-sub-basin 8MH. Employment in public utilities and administration taken as a proportion of the total number employed. Data was obtained for 1981 and 1991.

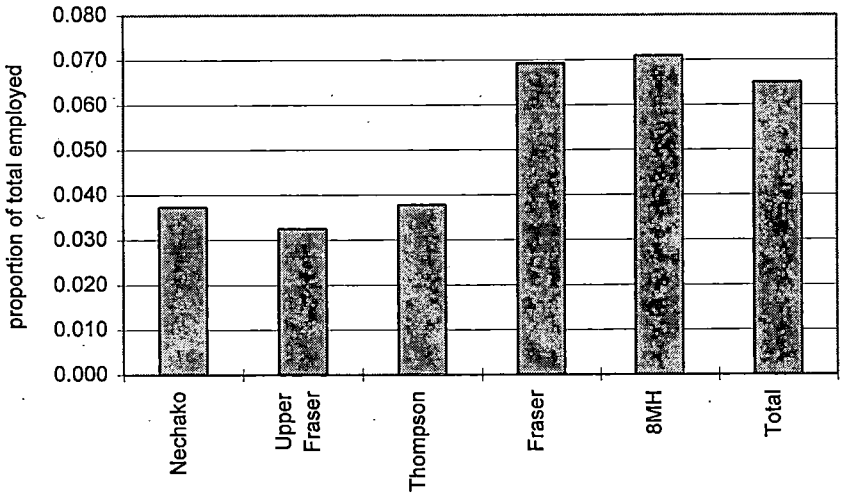


Indicator: Proportional Employment in Finance

Data Source: Statistics Canada, National Accounts and Environment Division

Data characteristics: Data supplied aggregated according to basin, sub-basin, and sub-sub-basin 8MH. Employment in finance taken as a proportion of the total number employed. Data was obtained for 1981 and 1991.

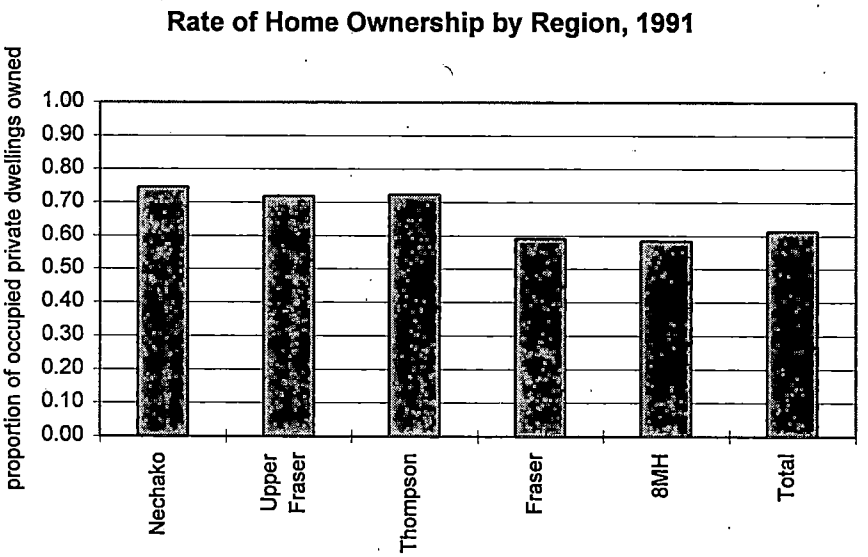
Proportional Employment in Finance by Region, 1991



Indicator: Rate of Home Ownership

Data Source: Planning and Statistics Division, B.C. Ministry of Government Services as derived from the Census of Population

Data characteristics: Data supplied aggregated to Census Divisions. Rate of home ownership taken as the proportion of occupied private dwellings which are owned, not including dwellings on reserves. Data estimates may be off due to 'area suppression'. Data was obtained for 1981, 1986, and 1991.

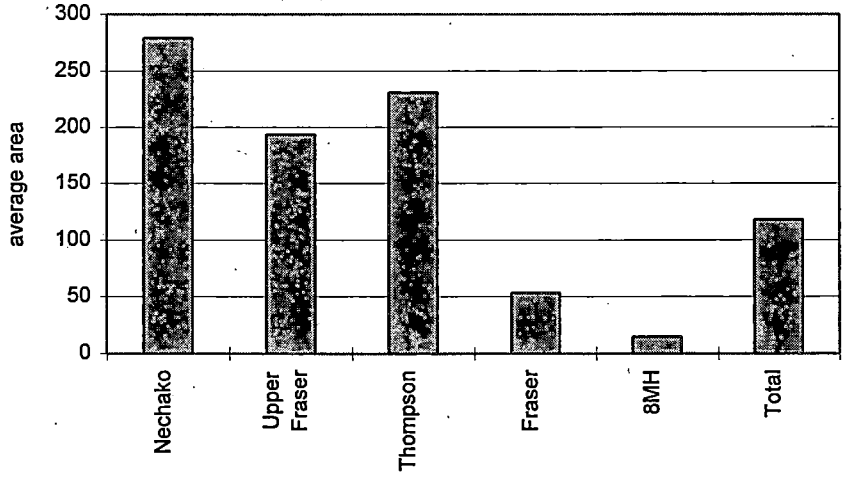


Indicator: Average Rural Farm Size

Data Source: Statistics Canada, National Accounts and Environment Division

Data characteristics: Data supplied aggregated according to basin, sub-basin, and sub-sub-basin 8MH as derived from the Census of Agriculture. Rural farm size is in hectares. Data was obtained for 1971, 1976, 1981, 1986, and 1991.

Average Rural Farm Size by Region, 1991



Annex D

Correlation Model Results

INTRODUCTION TO CORRELATION MODELS

Correlation models are among the most commonly used to describe linkages among indicators. These range from complicated multivariate econometric models to very simple models that track the correlation between two variables. In principle, they can be used to determine whether correlations are: (i) positive, negative or neutral; (ii) strong or weak; and, (iii) immediate or time delayed. Many such correlation models have underlying structural models that may attribute some cause-effect relationship, but the nature of the statistical techniques usually constrains such modeling exercises to describing coincidental correlations, from which the analyst must infer underlying structures given other knowledge or information.

The data requirements for correlation modeling can be substantial, as they require the availability of a statistically significant sample. Moreover, the underlying assumptions of the statistical analysis require that the variables being analysed are independently measured. To achieve this, data sets typically use a combination of 'cross-section' and time 'series' data. In the context of the Fraser River Basin, the time series is the historical record over which measurements have been made. The cross-sectional disaggregation is found at the sub-basin, or sub-sub-basin, level.

The principle advantage of the technique is that it permits simple pair-wise comparisons to be made relatively efficiently. These pair-wise comparisons can be used for any of the following:

- checking data reliability. In this context, correlation coefficients often point to incorrect data estimation where the correlations are counter-intuitive or otherwise anomalous.
- testing of linkage structure. Intuition often provides some hypothesis regarding the magnitude and direction of the linkages and simple correlation coefficients can provide some verification of these.
- defining an 'efficient' set of indicators. Where two indicators are consistently highly correlated, it may be necessary only to model carefully one of these.

The principle disadvantage of correlation modeling is that it may, at best, provide nothing more than an analysis of coincidental movements of variables. There is not necessarily any underlying causal structure that determines whether such variables are, in fact, systematically related. Also, data sets that reflect historical circumstances may not necessarily be relevant to future conditions. Formally, this means that the correlations are in fact dependent upon other external factors that may have a substantial bearing on the nature of the linkage.

Simple Correlation Models

The tables attached to this annex provide matrices of partial correlation coefficients between two sets of variables (Table D.1 provides definitions of the indicators). A high positive correlation coefficient indicates that the variables move together in the same direction. A high negative correlation indicates that the variables move in opposite directions. Small values (or zeroes) indicate that the variables are not directly related.

Two stages of correlation modeling were conducted for this research:

- Data Screening Stage. The primary purpose of the data screening stage was to check general data quality and coverage, focusing on 1991 information. Correlation coefficients were calculated for cross-sectional data at the sub-basin level for the year 1991. Table D.2 shows the correlation coefficients derived based on this screening. The analysis pointed to a number of limitations in the data. It has always been assumed that sectoral employment data were, in fact, somehow measured or estimated by existing conditions within the sub-sub-basins. Many of the correlation coefficients of these sectors to population are, however, exactly unity. It suggests that the total labour force data for each sub-sub-basin was simply allocated among the various sectors according to the provincial proportions. The possibility that this was because of Vancouver heavily skewing the statistics is discounted because the correlations were still almost unity even with Vancouver removed. As a consequence of this, subsequent analyses focused on a smaller subset of what were regarded as potentially more reliable data.
- Data Analysis Stage. This sample set looks at sub-sub-basin level disaggregation over the period 1971 to 1991 for 16 sub-sub-basins within the Fraser Basin and for 3 related sub-sub-basins just outside the Basin. The three external sub-sub-basins are in the Okanagan area and were thought to have a potential resemblance to those in the Shuswap Region, which was one of the subjects for a 'hotspot' analysis. The purpose of this more detailed analysis is to provide a basis for identifying pair-wise quantitative linkages and values in other model structures.

To summarize, partial correlation matrices are presented for the following data sets:

- Unscreened Data (Table D.2). Based on preliminary data for 1991.
- All Available Screened Data (Table D.3). Based on screened data for 4 sub-basins, 19 sub-sub-basins, and 5 potential time periods (1971, 1976, 1981, 1986, 1991).
- All Sub-sub-basins (Table D.4). Based on screened data 19 for sub-sub-basins and 5 potential time periods (1971, 1976, 1981, 1986, 1991).
- Cross-section for 1991 (Table D.5). Based on screened data for 4 sub-basins and 19 sub-sub-basins for the year 1991.
- Time-series for Hotspot (Table D.6). Based on screened data for 4 sub-sub-basins (8LE, 8NL, 8NM, 8NN) and 5 potential time periods (1971, 1976, 1981, 1986, 1991).

Multivariate Correlation Models

The pair-wise analyses were used to isolate potential linkages, which were then more formally explored through multivariate analyses that permitted isolating the effects of single variables while holding other variables constant. Such 'regression' analyses focused on approximately 20 indicators, using conventional techniques of linear regression.

Table D.7 provides a diagnostic summary of the results of these analyses, indicating the extent and nature of linkages within designated indicator 'sets'. The pooled database to which these regressions were applied was drawn from a maximum of 115 potentially independent observations.

Table D.1. Variable Definitions in Correlation Studies

Variable	Definition
AGRIC	Agriculture Labour Force
AOWNED	Farm Area Owned
AOWNEDSH	Proportion of Land Owned Privately
AREA	Area of Sub-basin
ARNTED	Farm Area Leased or Rented
ASMR	Age Standard Mortality Rate of Death by External Cause
BANKRUPT	Bankruptcy Rate
CANCRATE	Cancer Rate
COMME	Commerce Labour Force
COMMU	Communications Labour Force
CONST	Construction Labour Force
COUNT	Number of Farms
CRIME	Crime Rate
CRIMERATE	Crime Rate
CRPLND	Total Area of Cropland
EDUCATION	Proportion of +15 Population with Some University Education
EMPL	Employed Labour Force
EMPLOY	Employed Labour Force
ETHDIV	Ethnic Diversity Index
ETHNIC	Ethnic Diversity Index
FARMS	Number of Farms
FARMSIZE	Average Farm Size
FERTINTENS	Fertilizer Application Intensity
FINAN	Finance Labour Force
FINSHARE	Proportional Employment in Finance
FISH	Fishery Labour Force
FORBILLAREA	Ratio of Timber Area Billed to Area Harvested
FOREST	Forestry Labour Force
FORPLANHAR	Ratio of Forest Land Area Planted to Harvested
GARBRATE	Per Capita Production of Solid Wastes
GINI	GINI Coefficient
HHOWNED	Occupied Private Dwellings (Proportion Owned)
INC<10000	Proportion of Population with per capita Household Income < $10,000
INC>25000	Proportion of Population with per capita Household Income > $25,000
INVINC	Mean Investment Income
LABFOR	Total Labour Force
LBR	Live Birth Rate
LFAGR	Agriculture Labour Force
LFFIS	Fishery Labour Force
LFFOR	Forestry Labour Force
LFMIN	Mines Labour Force
LIVEBRATE	Live Birth Rate
MEANINC	Mean Personal Income
MFG	Manufacturing Labour Force

continued ...

Variable	Definition
MIGIN	Net In Migration Rate
MIGINRATE	In Migration Rate
MIGNET	Net In Migration Rate
MIGOUT RATE	Out Migration Rate
MINES	Mines Labour Force
NDLFSEC	Not Defined Labour Force
OWNHOUSE	Proportion of Hown Ownership
POPRUR	Rural Population
POPULATION	Total Population
POPURB	Urban Population
PUBADM	Public Administration Labour Force
PUBSHARE	Proportional Employment in Public Utilities and Administration
PUBUTL	Public Utilities Labour Force
RDI	Respiratory Disease Incidence
RDIMF	RDI - Male to Female Case Ratio
RDIRATE	Respiratory Disease Incidence Rate
RELDIV	Religious Diversity Index
RELIG	Religious Diversity Index
RESEMPLSH	Proportion of Labour Employed in Resource Industries
RESSHARE	Proportional Employment in Resource Industry
RURPOP	Rural Population
SACRPLND	Cropland on Farms Rèporting Salinity Control
SALES	Value of Products Sold
SALIN	Number of Farms Reporting Salinity Control
SATFAREA	Farmland Area on Farms Reporting Other Salinity Control
SCI	Skin Cancer Incidence
SCIMF	SCI - Male to Female Case Ratio
SERVI	Services Labour Force
TCI	Total Cancer Incidence
TCIMF	TCI - Male to Female Case Ratio
TOTFER	Total Area Fertilized
TOTLFSEC	Total Labour Force from All Sectors
TOTTONE	Total Estimated Fertilizer
TRANS	Transportation Labour Force
TRANSF	Proportion Reliant on Tranfer Payments
UNEMPLOY	Unemployed Labour Force
UNEMPLRATE	Unemployment Rate
UNEMPRATE	Unemployment Rate
UNIV	Proportion of +15 Population with Some University Education
URBPART	Urban Partition
URBPOP	Urban Population
VALADD	Value Added from Manufacturing Enterprises
VALADDPC	Per Capita Value Added from Manufacturing Enterprises
WATMUN	Proportion Connected to Municipal Water Supplies
WATPC	Per Capita Consumption of Water
WATPY	Consumption of Water per Dollar of Output

Table D.2 - Partial Correlation Coefficients for Unscreened Data	AREA	POPULATION	INC<10000	INC>25000	VAL ADD	RDI	RDMF	TCI	TCIMF	SCI	SCIMF	LBR	ASMR	HHOWNED	MIGIN	MIGINRATE
AREA	1.00															
POPULATION	0.39	1.00														
INC<10000	(0.54)	(0.76)	1.00													
INC>25000	0.08	0.87	(0.83)	1.00												
VAL ADD	0.40	1.00	(0.80)	0.89	1.00											
RDI	(0.89)	(0.65)	0.48	(0.24)	(0.63)	1.00										
RDIMF	0.66	0.04	0.22	(0.45)	(0.01)	(0.73)	1.00									
TCI	(0.28)	0.32	0.38	0.06	0.24	(0.16)	0.31	1.00								
TCIMF	(0.65)	(0.32)	0.85	(0.42)	(0.39)	0.37	0.13	0.78	1.00							
SCI	0.72	(0.16)	0.20	(0.59)	(0.19)	(0.64)	0.95	(0.00)	(0.05)	1.00						
SCIMF	(0.89)	0.07	0.26	0.31	0.04	0.63	(0.64)	0.52	0.61	(0.82)	1.00					
LBR	(0.47)	(0.36)	(0.15)	0.14	(0.30)	0.75	(0.88)	(0.68)	(0.33)	(0.68)	0.27	1.00				
ASMR	(0.60)	(0.94)	0.65	(0.67)	(0.93)	0.85	(0.36)	(0.36)	0.29	(0.17)	0.18	0.61	1.00			
HHOWNED	(0.54)	(0.99)	0.78	(0.80)	(0.98)	0.76	(0.16)	(0.25)	0.40	0.01	0.10	0.43	0.98	1.00		
MIGIN	0.43	1.00	(0.73)	0.83	0.99	(0.70)	0.12	0.35	(0.30)	(0.09)	0.02	(0.43)	(0.97)	(0.99)	1.00	
MIGINRATE	(0.07)	(0.29)	0.78	(0.65)	(0.36)	(0.15)	0.70	0.70	0.79	0.57	0.01	(0.74)	0.06	0.26	(0.22)	1.00
BANKRUPT	0.98	0.31	(0.36)	(0.07)	0.31	(0.91)	0.81	(0.13)	(0.47)	0.84	(0.89)	(0.62)	(0.58)	(0.47)	0.37	0.15
CRIMERATE	0.93	0.67	(0.77)	0.43	0.69	(0.90)	0.45	(0.21)	(0.73)	0.45	(0.69)	(0.40)	(0.79)	(0.78)	0.70	(0.28)
MIGNET	(0.06)	0.48	0.21	0.15	0.41	(0.39)	0.43	0.97	0.63	0.12	0.36	(0.80)	(0.56)	(0.44)	0.52	0.65
MIGOUT RATE	(0.03)	(0.88)	0.77	(0.99)	(0.90)	0.23	0.43	(0.17)	0.33	0.60	(0.38)	(0.08)	0.68	0.81	(0.84)	0.57
EMPLOY	0.39	1.00	(0.76)	0.87	1.00	(0.64)	0.03	0.31	(0.33)	(0.17)	0.06	(0.35)	(0.94)	(0.99)	1.00	(0.29)
UNEMPLOY	0.39	1.00	(0.75)	0.87	1.00	(0.65)	0.05	0.32	(0.32)	(0.16)	0.06	(0.37)	(0.95)	(0.99)	1.00	(0.28)
LABFOR	0.39	1.00	(0.76)	0.87	1.00	(0.64)	0.03	0.31	(0.33)	(0.17)	0.06	(0.35)	(0.94)	(0.99)	1.00	(0.29)
RURPOP	0.45	0.97	(0.61)	0.73	0.95	(0.75)	0.26	0.47	(0.18)	0.03	0.00	(0.58)	(0.98)	(0.97)	0.99	(0.05)
URBPOP	0.38	1.00	(0.76)	0.88	1.00	(0.63)	0.02	0.30	(0.33)	(0.18)	0.07	(0.34)	(0.94)	(0.98)	0.99	(0.30)
AGRIC	0.40	1.00	(0.71)	0.83	0.99	(0.68)	0.11	0.38	(0.27)	(0.11)	0.06	(0.43)	(0.96)	(0.99)	1.00	(0.21)
FOREST	0.33	0.98	(0.61)	0.79	0.96	(0.65)	0.13	0.49	(0.14)	(0.11)	0.13	(0.49)	(0.95)	(0.96)	0.99	(0.10)
FISH	0.40	1.00	(0.77)	0.88	1.00	(0.64)	0.03	0.30	(0.34)	(0.17)	0.06	(0.34)	(0.94)	(0.99)	1.00	(0.30)
MINES	0.17	0.74	(0.12)	0.41	0.68	(0.60)	0.41	0.85	0.34	0.11	0.23	(0.79)	(0.80)	(0.71)	0.77	0.42
MFG	0.40	1.00	(0.78)	0.88	1.00	(0.64)	0.02	0.29	(0.35)	(0.18)	0.06	(0.33)	(0.94)	(0.99)	0.99	(0.32)
CONST	0.39	1.00	(0.76)	0.87	1.00	(0.65)	0.04	0.31	(0.33)	(0.16)	0.06	(0.35)	(0.94)	(0.99)	1.00	(0.29)
TRANS	0.39	1.00	(0.76)	0.87	1.00	(0.64)	0.03	0.31	(0.33)	(0.17)	0.06	(0.35)	(0.94)	(0.99)	1.00	(0.29)
COMMU	0.39	1.00	(0.77)	0.88	1.00	(0.63)	0.02	0.29	(0.34)	(0.18)	0.07	(0.33)	(0.94)	(0.98)	0.99	(0.31)
PUBUTL	0.40	1.00	(0.77)	0.87	1.00	(0.65)	0.03	0.30	(0.34)	(0.16)	0.06	(0.35)	(0.94)	(0.99)	1.00	(0.30)
COMME	0.39	1.00	(0.76)	0.87	1.00	(0.65)	0.04	0.31	(0.33)	(0.17)	0.06	(0.35)	(0.94)	(0.99)	1.00	(0.29)
FINAN	0.39	1.00	(0.77)	0.88	1.00	(0.64)	0.02	0.29	(0.34)	(0.17)	0.06	(0.34)	(0.94)	(0.99)	0.99	(0.31)
SERVI	0.39	1.00	(0.76)	0.87	1.00	(0.64)	0.03	0.31	(0.33)	(0.17)	0.07	(0.35)	(0.94)	(0.99)	1.00	(0.29)
PUBADM	0.38	1.00	(0.76)	0.88	1.00	(0.63)	0.02	0.31	(0.32)	(0.18)	0.08	(0.35)	(0.94)	(0.98)	1.00	(0.29)
NDLFSEC	0.39	1.00	(0.77)	0.88	1.00	(0.64)	0.03	0.30	(0.34)	(0.17)	0.06	(0.34)	(0.94)	(0.99)	1.00	(0.30)
TOTLFSEC	0.39	1.00	(0.76)	0.87	1.00	(0.64)	0.03	0.31	(0.33)	(0.17)	0.06	(0.35)	(0.94)	(0.99)	1.00	(0.29)
COUNT	0.42	0.98	(0.64)	0.77	0.97	(0.72)	0.19	0.45	(0.20)	(0.04)	0.04	(0.52)	(0.97)	(0.98)	0.99	(0.11)
AOWNED	0.02	0.30	0.37	(0.09)	0.22	(0.41)	0.61	0.94	0.68	0.34	0.20	(0.89)	(0.45)	(0.29)	0.35	0.82
ARNTED	0.03	0.20	0.45	(0.21)	0.12	(0.40)	0.67	0.91	0.70	0.42	0.14	(0.90)	(0.38)	(0.20)	0.26	0.88
CRPLND	0.11	0.93	(0.48)	0.79	0.90	(0.48)	0.02	0.63	0.05	(0.27)	0.36	(0.45)	(0.86)	(0.87)	0.93	(0.04)
TOTFER	0.16	0.94	(0.81)	0.99	0.95	(0.36)	(0.32)	0.17	(0.38)	(0.48)	0.26	(0.02)	(0.77)	(0.88)	0.90	(0.54)
SALES	0.40	1.00	(0.73)	0.85	0.99	(0.67)	0.08	0.35	(0.30)	(0.13)	0.06	(0.40)	(0.96)	(0.99)	1.00	(0.24)
TOTTONE	0.40	1.00	(0.76)	0.87	1.00	(0.65)	0.04	0.31	(0.33)	(0.16)	0.06	(0.36)	(0.95)	(0.99)	1.00	(0.29)
SALIN	0.41	1.00	(0.71)	0.83	0.99	(0.68)	0.11	0.38	(0.27)	(0.11)	0.05	(0.43)	(0.96)	(0.99)	1.00	(0.21)
SARPLND	0.52	0.98	(0.73)	0.78	0.98	(0.77)	0.21	0.33	(0.33)	0.01	(0.07)	(0.49)	(0.99)	(1.00)	0.99	(0.18)
SATFAREA	0.35	0.61	(0.03)	0.18	0.55	(0.73)	0.67	0.80	0.32	0.40	(0.02)	(0.94)	(0.77)	(0.64)	0.67	0.58
RELIG	0.18	0.98	(0.66)	0.90	0.97	(0.49)	(0.09)	0.43	(0.16)	(0.33)	0.28	(0.30)	(0.87)	(0.93)	0.96	(0.25)
ETHNIC	(0.95)	(0.10)	0.26	0.24	(0.11)	0.79	(0.78)	0.30	0.51	(0.88)	0.97	0.50	0.37	0.27	(0.16)	(0.13)
EDUCATION	(0.17)	0.81	(0.32)	0.75	0.78	(0.23)	(0.16)	0.70	0.23	(0.46)	0.60	(0.31)	(0.68)	(0.71)	0.80	(0.02)
MEANINC	0.55	0.80	(1.00)	0.84	0.84	(0.53)	(0.18)	(0.32)	(0.82)	(0.18)	(0.25)	0.09	(0.71)	(0.82)	0.77	(0.74)
INVINC	0.38	0.94	(0.50)	0.67	0.91	(0.73)	0.30	0.59	(0.05)	0.04	0.07	(0.64)	(0.96)	(0.93)	0.96	0.07
URBPART	(0.25)	0.79	(0.48)	0.89	0.78	(0.06)	(0.45)	0.45	0.04	(0.68)	0.65	0.00	(0.57)	(0.68)	0.75	(0.32)
UNEMPRATE	(0.05)	(0.94)	0.60	(0.90)	(0.93)	0.37	0.19	(0.47)	0.09	0.44	(0.41)	0.23	0.80	0.87	(0.92)	0.26
PUBSHARE	(0.78)	0.26	0.12	0.46	0.23	0.47	(0.59)	0.58	0.54	(0.81)	0.98	0.17	(0.02)	(0.09)	0.22	(0.02)
RESSHARE	(0.24)	(0.95)	0.85	(0.98)	(0.97)	0.42	0.27	(0.12)	0.44	0.42	(0.18)	0.04	0.80	0.91	(0.92)	0.55
FINSHARE	0.29	0.99	(0.71)	0.88	0.99	(0.57)	(0.02)	0.39	(0.24)	(0.24)	0.18	(0.34)	(0.92)	(0.96)	0.99	(0.26)
FARMSIZE	(0.70)	(0.93)	0.80	(0.70)	(0.93)	0.86	(0.29)	(0.13)	0.51	(0.16)	0.31	0.46	0.97	0.98	(0.94)	0.25
FERTINTENS	0.12	0.37	(0.83)	0.70	0.44	0.07	(0.66)	(0.66)	(0.81)	(0.54)	(0.03)	0.68	(0.15)	(0.34)	0.30	(1.00)
	AREA	POPULATION	INC<10000	INC>25000	VAL ADD	RDI	RDMF	TCI	TCIMF	SCI	SCIMF	LBR	ASMR	HHOWNED	MIGIN	MIGINRATE

Table D.2 - Partial Correlation Coefficients for Unscreened Data	BANKRUPT	CRIMERATE	MIGNET	MIGOUT RATE	EMPLOY	UNEMPLOY	LABFOR	RURPOP	URBPOP	AGRIC	FOREST	FISH	MINES	MFG	CONST	TRANS
AREA																
POPULATION																
INC<10000																
INC>25000																
VAL ADD																
RDI																
RDIMF																
TCI																
TCIMF																
SCI																
SCIMF																
LBR																
ASMR																
HHOWNED																
MIGIN																
MIGINRATE																
BANKRUPT	1.00															
CRIMERATE	0.86	1.00														
MIGNET	0.08	0.02	1.00													
MIGOUT RATE	0.11	(0.38)	(0.25)	1.00												
EMPLOY	0.31	0.67	0.47	(0.89)	1.00											
UNEMPLOY	0.32	0.67	0.48	(0.88)	1.00	1.00										
LABFOR	0.31	0.67	0.47	(0.89)	1.00	1.00	1.00									
RURPOP	0.43	0.68	0.63	(0.76)	0.97	0.97	0.97	1.00								
URBPOP	0.30	0.67	0.46	(0.89)	1.00	1.00	1.00	0.96	1.00							
AGRIC	0.34	0.67	0.54	(0.85)	1.00	1.00	1.00	0.99	0.99	1.00						
FOREST	0.30	0.60	0.64	(0.83)	0.98	0.98	0.98	0.99	0.98	0.99	1.00					
FISH	0.32	0.68	0.46	(0.89)	1.00	1.00	1.00	0.97	1.00	0.99	0.98	1.00				
MINES	0.25	0.32	0.94	(0.49)	0.73	0.74	0.73	0.86	0.72	0.79	0.85	0.72	1.00			
MFG	0.31	0.68	0.45	(0.89)	1.00	1.00	1.00	0.96	1.00	0.99	0.97	1.00	0.71	1.00		
CONST	0.32	0.68	0.47	(0.88)	1.00	1.00	1.00	0.97	1.00	1.00	0.98	1.00	0.73	1.00	1.00	
TRANS	0.31	0.68	0.47	(0.89)	1.00	1.00	1.00	0.97	1.00	1.00	0.98	1.00	0.73	1.00	1.00	1.00
COMMU	0.30	0.67	0.45	(0.89)	1.00	1.00	1.00	0.96	1.00	0.99	0.98	1.00	0.72	1.00	1.00	1.00
PUBUTL	0.32	0.68	0.46	(0.89)	1.00	1.00	1.00	0.97	1.00	1.00	0.98	1.00	0.73	1.00	1.00	1.00
COMME	0.31	0.67	0.47	(0.89)	1.00	1.00	1.00	0.97	1.00	1.00	0.98	1.00	0.73	1.00	1.00	1.00
FINAN	0.31	0.68	0.45	(0.89)	1.00	1.00	1.00	0.96	1.00	0.99	0.98	1.00	0.72	1.00	1.00	1.00
SERVI	0.31	0.67	0.47	(0.89)	1.00	1.00	1.00	0.97	1.00	1.00	0.98	1.00	0.73	1.00	1.00	1.00
PUBADM	0.30	0.66	0.47	(0.89)	1.00	1.00	1.00	0.97	1.00	1.00	0.98	1.00	0.73	1.00	1.00	1.00
NDLFSEC	0.31	0.68	0.46	(0.89)	1.00	1.00	1.00	0.97	1.00	0.99	0.98	1.00	0.72	1.00	1.00	1.00
TOTLFSEC	0.31	0.67	0.47	(0.89)	1.00	1.00	1.00	0.97	1.00	1.00	0.98	1.00	0.73	1.00	1.00	1.00
COUNT	0.38	0.66	0.61	(0.80)	0.98	0.98	0.98	1.00	0.98	0.99	1.00	0.98	0.84	0.98	0.98	0.98
AOWNED	0.19	0.00	0.97	(0.00)	0.29	0.31	0.29	0.50	0.28	0.37	0.48	0.28	0.86	0.27	0.29	0.29
ARNTED	0.22	(0.03)	0.93	0.12	0.19	0.21	0.19	0.41	0.18	0.28	0.38	0.18	0.80	0.16	0.19	0.19
CRPLND	0.08	0.39	0.72	(0.84)	0.93	0.93	0.93	0.93	0.92	0.94	0.97	0.92	0.88	0.92	0.93	0.92
TOTFER	0.03	0.50	0.28	(0.99)	0.94	0.93	0.94	0.83	0.94	0.91	0.88	0.94	0.54	0.94	0.94	0.94
SALES	0.33	0.68	0.51	(0.87)	1.00	1.00	1.00	0.98	1.00	1.00	0.99	1.00	0.76	1.00	1.00	1.00
TOTTONE	0.32	0.68	0.47	(0.88)	1.00	1.00	1.00	0.97	1.00	1.00	0.98	1.00	0.73	1.00	1.00	1.00
SALIN	0.35	0.67	0.54	(0.85)	1.00	1.00	1.00	0.99	0.99	1.00	0.99	1.00	0.78	0.99	1.00	1.00
SARPLND	0.46	0.76	0.51	(0.79)	0.98	0.99	0.98	0.99	0.98	0.99	0.98	0.98	0.77	0.98	0.98	0.98
SATFAREA	0.47	0.40	0.91	(0.25)	0.61	0.62	0.61	0.78	0.60	0.68	0.74	0.60	0.95	0.59	0.61	0.61
RELIG	0.11	0.49	0.55	(0.93)	0.98	0.98	0.98	0.94	0.98	0.97	0.98	0.97	0.77	0.97	0.97	0.97
ETHNIC	(0.97)	(0.77)	0.11	(0.29)	(0.10)	(0.10)	(0.10)	(0.21)	(0.09)	(0.12)	(0.07)	(0.10)	(0.03)	(0.10)	(0.10)	(0.10)
EDUCATION	(0.19)	0.13	0.73	(0.82)	0.81	0.81	0.81	0.80	0.81	0.82	0.87	0.80	0.83	0.80	0.81	0.81
MEANINC	0.38	0.79	(0.15)	(0.79)	0.80	0.79	0.80	0.67	0.81	0.75	0.67	0.81	0.19	0.82	0.80	0.80
INVINC	0.38	0.60	0.74	(0.71)	0.93	0.94	0.93	0.99	0.93	0.96	0.98	0.93	0.92	0.92	0.93	0.93
URBPART	(0.33)	0.09	0.48	(0.93)	0.79	0.79	0.79	0.70	0.79	0.77	0.79	0.79	0.61	0.79	0.79	0.79
UNEMPRATE	0.02	(0.38)	(0.56)	0.94	(0.94)	(0.94)	(0.94)	(0.89)	(0.94)	(0.93)	(0.94)	(0.94)	(0.75)	(0.94)	(0.94)	(0.94)
PUBSHARE	(0.79)	(0.54)	0.46	(0.53)	0.26	0.26	0.26	0.19	0.26	0.25	0.32	0.25	0.37	0.25	0.25	0.25
RESSHARE	(0.11)	(0.57)	(0.25)	0.98	(0.95)	(0.95)	(0.95)	(0.84)	(0.95)	(0.92)	(0.88)	(0.95)	(0.53)	(0.96)	(0.95)	(0.95)
FINSHARE	0.22	0.58	0.53	(0.91)	0.99	0.99	0.99	0.96	0.99	0.99	0.99	0.99	0.76	0.99	0.99	0.99
FARMSIZE	(0.63)	(0.89)	(0.34)	0.70	(0.93)	(0.93)	(0.93)	(0.93)	(0.93)	(0.93)	(0.89)	(0.93)	(0.64)	(0.93)	(0.93)	(0.93)
FERTINTENS	(0.10)	0.35	(0.60)	(0.62)	0.37	0.36	0.37	0.14	0.38	0.29	0.19	0.38	(0.35)	0.40	0.37	0.37
	BANKRUPT	CRIMERATE	MIGNET	MIGOUT RATE	EMPLOY	UNEMPLOY	LABFOR	RURPOP	URBPOP	AGRIC	FOREST	FISH	MINES	MFG	CONST	TRANS

Table D.2 - Partial Correlation Coefficients for Unscreened Data	COMMU	PUBUTL	COMME	FINAN	SERVI	PUBADM	NDLFSEC	TOTLFSEC	COUNT	AOWNED	ARNTED	CRPLND	TOTFER	SALES	TOTTONE	SALIN
AREA																
POPULATION																
INC<10000																
INC>25000																
VAL ADD																
RDI																
RDIMF																
TCI																
TCIMF																
SCI																
SCIMF																
LBR																
ASMR																
HHOWNED																
MIGIN																
MIGINRATE																
BANKRUPT																
CRIMERATE																
MIGNET																
MIGOUT RATE																
EMPLOY																
UNEMPLOY																
LABFOR																
RURPOP																
URBPOP																
AGRIC																
FOREST																
FISH																
MINES																
MFG																
CONST																
TRANS																
COMMU	1.00															
PUBUTL	1.00	1.00														
COMME	1.00	1.00	1.00													
FINAN	1.00	1.00	1.00	1.00												
SERVI	1.00	1.00	1.00	1.00	1.00											
PUBADM	1.00	1.00	1.00	1.00	1.00	1.00										
NDLFSEC	1.00	1.00	1.00	1.00	1.00	1.00	1.00									
TOTLFSEC	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00								
COUNT	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	1.00							
AOWNED	0.27	0.28	0.29	0.27	0.29	0.29	0.28	0.29	0.46	1.00						
ARNTED	0.17	0.18	0.19	0.17	0.19	0.19	0.18	0.19	0.37	0.99	1.00					
CRPLND	0.92	0.92	0.93	0.92	0.93	0.93	0.92	0.93	0.95	0.54	0.44	1.00				
TOTFER	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.86	0.04	(0.07)	0.86	1.00			
SALES	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.34	0.24	0.93	0.92	1.00		
TOTTONE	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.30	0.19	0.93	0.93	1.00	1.00	
SALIN	0.99	1.00	1.00	0.99	1.00	1.00	1.00	1.00	0.99	0.37	0.27	0.94	0.91	1.00	1.00	1.00
SARPLND	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.99	0.37	0.28	0.90	0.86	0.99	0.99	0.99
SATFAREA	0.59	0.60	0.61	0.59	0.60	0.60	0.60	0.61	0.75	0.91	0.88	0.73	0.33	0.65	0.61	0.67
RELIG	0.98	0.97	0.98	0.97	0.98	0.98	0.97	0.98	0.96	0.35	0.24	0.97	0.95	0.97	0.97	0.97
ETHNIC	(0.09)	(0.11)	(0.10)	(0.10)	(0.10)	(0.09)	(0.10)	(0.10)	(0.16)	(0.04)	(0.09)	0.15	0.16	(0.12)	(0.11)	(0.13)
EDUCATION	0.80	0.80	0.81	0.80	0.81	0.81	0.80	0.81	0.82	0.53	0.43	0.96	0.81	0.81	0.81	0.82
MEANINC	0.81	0.81	0.80	0.81	0.80	0.80	0.81	0.80	0.70	(0.31)	(0.39)	0.53	0.83	0.78	0.80	0.76
INVINC	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.98	0.61	0.53	0.95	0.78	0.95	0.94	0.96
URBPART	0.79	0.78	0.79	0.79	0.79	0.80	0.79	0.79	0.74	0.23	0.11	0.88	0.90	0.78	0.79	0.77
UNEMPRATE	(0.94)	(0.93)	(0.94)	(0.94)	(0.94)	(0.94)	(0.94)	(0.94)	(0.91)	(0.34)	(0.23)	(0.97)	(0.95)	(0.93)	(0.94)	(0.93)
PUBSHARE	0.26	0.25	0.25	0.25	0.26	0.27	0.25	0.26	0.24	0.27	0.20	0.53	0.43	0.25	0.25	0.25
RESSHARE	(0.96)	(0.95)	(0.95)	(0.95)	(0.95)	(0.95)	(0.95)	(0.95)	(0.88)	(0.03)	0.08	(0.85)	(1.00)	(0.93)	(0.95)	(0.92)
FINSHARE	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.98	0.33	0.23	0.96	0.95	0.99	0.99	0.99
FARMSIZE	(0.93)	(0.93)	(0.93)	(0.93)	(0.93)	(0.93)	(0.93)	(0.93)	(0.93)	(0.24)	(0.16)	(0.76)	(0.79)	(0.93)	(0.93)	(0.93)
FERTINTENS	0.39	0.38	0.37	0.39	0.37	0.37	0.38	0.37	0.19	(0.77)	(0.84)	0.11	0.60	0.32	0.37	0.29
	COMMU	PUBUTL	COMME	FINAN	SERVI	PUBADM	NDLFSEC	TOTLFSEC	COUNT	AOWNED	ARNTED	CRPLND	TOTFER	SALES	TOTTONE	SALIN

Table D.2 - Partial Correlation Coefficients for Unscreened Data	SACRPLND	SATFAREA	RELIG	ETHNIC	EDUCATION	MEANINC	INVINC	URBPART	UNEMPRATE	PUBSHARE	RESSHARE	FINSHARE	FARMSIZE	FERTINTENS
AREA														
POPULATION														
INC<10000														
INC>25000														
VAL ADD														
RDI														
RDIMF														
TCI														
TCIMF														
SCI														
SCIMF														
LBR														
ASMR														
HHOWNED														
MIGIN														
MIGINRATE														
BANKRUPT														
CRIMERATE														
MIGNET														
MIGOUT RATE														
EMPLOY														
UNEMPLOY														
LABFOR														
RURPOP														
URBPOP														
AGRIC														
FOREST														
FISH														
MINES														
MFG														
CONST														
TRANS														
COMMU														
PUBUTL														
COMME														
FINAN														
SERVI														
PUBADM														
NDLFSEC														
TOTLFSEC														
COUNT														
AOWNED														
ARNTED														
CRPLND														
TOTFER														
SALES														
TOTTONE														
SALIN														
SARPLND	1.00													
SATFAREA	0.69	1.00												
RELIG	0.93	0.60	1.00											
ETHNIC	(0.26)	(0.28)	0.11	1.00										
EDUCATION	0.74	0.62	0.91	0.41	1.00									
MEANINC	0.77	0.09	0.70	(0.27)	0.37	1.00								
INVINC	0.96	0.85	0.92	(0.15)	0.84	0.56	1.00							
URBPART	0.68	0.35	0.90	0.53	0.94	0.51	0.70	1.00						
UNEMPRATE	(0.88)	(0.55)	(0.99)	(0.24)	(0.95)	(0.64)	(0.88)	(0.95)	1.00					
PUBSHARE	0.12	0.11	0.46	0.91	0.74	(0.10)	0.26	0.78	(0.57)	1.00				
RESSHARE	(0.89)	(0.34)	(0.95)	(0.08)	(0.77)	(0.87)	(0.78)	(0.86)	0.93	(0.35)	1.00			
FINSHARE	0.96	0.62	0.99	0.00	0.87	0.75	0.94	0.85	(0.97)	0.36	(0.95)	1.00		
FARMSIZE	(0.97)	(0.61)	(0.83)	0.46	(0.56)	(0.84)	(0.88)	(0.51)	0.74	0.12	0.83	(0.88)	1.00	
FERTINTENS	0.27	(0.51)	0.33	0.10	0.08	0.79	0.01	0.37	(0.33)	0.02	(0.61)	0.34	(0.33)	1.00
	SACRPLND	SATFAREA	RELIG	ETHNIC	EDUCATION	MEANINC	INVINC	URBPART	UNEMPRATE	PUBSHARE	RESSHARE	FINSHARE	FARMSIZE	FERTINTENS

Table D.3 Partial Correlation Coefficients on Screened Data Set	POPRUR	POPTOT	EMPL	LABFOR	LFAGR	LFFOR	LFFIS	LFMIN	FARMS	AOWNED	ARNTED	CRPLND	TOTFER	SALES	TOTTONE
POPRUR	1.000	0.902	0.883	0.881	0.951	0.907	0.854	0.872	0.984	0.599	0.400	0.859	0.813	0.786	0.872
POPTOT	POPTOT=>	1.000	0.997	0.996	0.980	0.849	0.992	0.805	0.921	0.371	0.197	0.715	0.763	0.908	0.946
EMPL		EMPL=>	1.000	1.000	0.975	0.844	0.992	0.800	0.902	0.357	0.187	0.704	0.765	0.931	0.954
LABFOR	POPRUR-^-		LABFOR=>	1.000	0.978	0.844	0.992	0.797	0.899	0.357	0.188	0.704	0.766	0.938	0.954
LFAGR		POPTOT-^-		LFAGR=>	1.000	0.860	0.959	0.825	0.969	0.433	0.351	0.742	0.794	0.988	0.939
LFFOR			EMPL-^-		LFFOR=>	1.000	0.820	0.815	0.878	0.694	0.649	0.951	0.968	0.843	0.827
LFFIS				LABFOR-^-		LFFIS=>	1.000	0.776	0.894	0.326	0.234	0.655	0.737	0.973	0.910
LFMIN					LFAGR-^-		LFMIN=>	1.000	0.856	0.740	0.619	0.792	0.750	0.793	0.761
FARMS						LFFOR-^-		FARMS=>	1.000	0.499	0.298	0.810	0.790	0.786	0.869
AOWNED							LFFIS-^-		AOWNED=	1.000	0.880	0.802	0.613	0.343	0.407
ARNTED								LFMIN-^-		ARNTED=>	1.000	0.614	0.463	0.188	0.274
CRPLND									FARMS-^-		CRPLND=>	1.000	0.945	0.657	0.716
TOTFER										AOWNED-^-		TOTFER=>	1.000	0.765	0.759
SALES											ARNTED-^-		SALES=>	1.000	0.944
TOTTONE												CRPLND-^-		TOTTONE=	1.000
GINI													TOTFER-^-		GINI=>
VALADD														SALES-^-	
CRIME															TOTTONE-
MIGIN															
BANKRUPT															
GARBRATE															
WATPC															
WATPY															
WATMUN															
FORPLANHAR															
FORBILLAREA															
RDIRATE															
CANCRATE															
SKINRATE															
LIVEBRATE															
ASMR															
OWNHOUSE															
RELDIV															
ETHDIV															
UNIV															
TRANSF															
URBPART															
UNEMPLRATE															
VALADDPC															
RESEMPLSH															
AOWNEDSH															
FERTINT															

BASIN8J	1	71	1
BASIN8K	1	76	1
BASIN8L	1	81	1
BASIN8M	1	86	1
SSUB8MH	1	91	1
SSUB8JC	1		
SSUB8KB	1		
SSUB8KC	1		
SSUB8KD	1		
SSUB8KE	1		
SSUB8LA	1		
SSUB8LB	1		
SSUB8LC	1		
SSUB8LE	1		
SSUB8LF	1		
SSUB8LG	1		
SSUB8NL	1		
SSUB8NM	1		
SSUB8NN	1		

SELECTION CRITERIA: 1=ON; 0=OFF

Table D.3 Partial Correlation Coefficients on Screened Data Set	GINI	VALADD	CRIME	MIGIN	BANKRUPT	GARBRATE	WATPC	WATPY	WATMUN	FORPLANHAR	FORBILLAREA	RDIRATE	CANCRATE	SKINRATE	LIVEBRATE
POPRUR	0.094	0.886	0.541	-0.251	0.173	-0.403	0.012	-0.249	0.815	-0.267	0.627	-0.610	-0.192	-0.084	-0.059
POPTOT	0.099	0.997	0.615	-0.416	0.074	-0.476	-0.205	-0.441	0.804	-0.288	0.815	-0.577	-0.139	-0.091	0.008
EMPL	0.098	0.998	0.622	-0.415	0.068	-0.478	-0.212	-0.447	0.798	-0.274	0.817	-0.571	-0.140	-0.092	0.011
LABFOR	0.093	0.998	0.620	-0.415	0.081	-0.479	-0.210	-0.446	0.800	-0.280	0.817	-0.572	-0.141	-0.093	0.012
LFAGR	0.091	0.978	0.573	-0.345	0.155	-0.423	-0.144	-0.388	0.808	-0.299	0.775	-0.616	-0.103	-0.057	-0.062
LFFOR	0.081	0.834	0.676	-0.439	0.161	-0.708	-0.066	-0.264	0.901	-0.326	0.418	-0.352	-0.510	-0.340	0.347
LFFIS	0.102	0.996	0.596	-0.460	0.040	-0.483	-0.217	-0.453	0.787	-0.331	0.824	-0.574	-0.119	-0.089	0.015
LFMIN	0.286	0.825	0.471	-0.239	-0.001	-0.491	0.421	0.176	0.768	-0.076	0.601	-0.497	-0.102	-0.122	-0.137
FARMS	0.121	0.923	0.532	-0.301	0.092	-0.395	-0.051	-0.307	0.813	-0.299	0.738	-0.630	-0.118	-0.046	-0.089
AOWNED	0.198	0.348	0.262	-0.041	0.109	-0.491	0.787	0.756	0.462	0.220	-0.405	-0.010	-0.368	-0.334	0.177
ARNTED	0.123	0.303	0.251	0.001	0.293	-0.477	0.799	0.779	0.407	0.315	-0.532	0.136	-0.478	-0.363	0.287
CRPLND	0.123	0.681	0.582	-0.340	0.121	-0.768	0.166	0.076	0.836	-0.097	0.112	-0.195	-0.565	-0.421	0.424
TOTFER	0.092	0.754	0.671	-0.439	0.060	-0.767	-0.384	-0.473	0.912	-0.355	0.380	-0.230	-0.554	-0.378	0.463
SALES	0.069	0.991	0.610	-0.358	0.164	-0.455	-0.167	-0.408	0.795	-0.264	0.771	-0.587	-0.123	-0.074	-0.028
TOTTONE	0.064	0.994	0.646	-0.287	0.170	-0.467	-0.205	-0.440	0.737	-0.120	0.680	-0.505	-0.182	-0.108	0.015
GINI	1.000	0.020	-0.201	-0.210	-0.545	0.079	0.383	0.506	-0.052	0.653	0.311	0.549	0.305	-0.478	-0.115
VALADD	VALADD=>	1.000	0.711	-0.514	0.540	-0.495	-0.267	-0.497	0.836	-0.666	0.799	-0.564	-0.275	-0.393	0.165
CRIME	^-	CRIME=>	1.000	-0.073	0.343	-0.540	-0.609	-0.832	0.761	-0.003	0.425	-0.154	-0.493	-0.099	0.341
MIGIN	GINI-^-		MIGIN=>	1.000	-0.064	0.684	0.957	0.931	-0.335	0.799	-0.211	0.135	0.141	0.474	-0.533
BANKRUPT		VALADD-^-		BANKRUP	1.000	-0.258	0.000	-0.299	0.287	0.050	-0.269	-0.324	-0.194	-0.169	-0.027
GARBRATE			CRIME-^-		GARBRATI	1.000	0.202	0.052	-0.614	-0.374	-0.492	0.048	0.643	0.376	-0.748
WATPC				MIGIN-^-		WATPC=>	1.000	0.944	-0.158	0.514	-0.122	-0.045	0.772	0.428	-0.679
WATPY					BANKRUPT-^-		WATPY=>	1.000	-0.402	0.752	-0.271	0.287	0.658	0.250	-0.399
WATMUN						GARBRATE-^-		WATMUN=	1.000	-0.407	0.824	-0.283	-0.496	-0.345	0.363
FORPLANHAR							WATPC-^-		FORPLANH	1.000	0.013	0.477	0.177	0.280	-0.054
FORBILLAREA								WATPY-^-		FORBILLA	1.000	-0.488	0.609	0.441	-0.423
RDIRATE									WATMUN-^-		RDIRATE=>	1.000	-0.116	-0.220	0.380
CANCRATE										FORPLANHAR-^-		CANCRATI	1.000	0.568	-0.768
SKINRATE											FORBILLAREA-^-		SKINRATE	1.000	-0.616
LIVEBRATE												RDIRATE-^-		LIVEBRAT	1.000
ASMR													CANCRATE-^-		ASMR=>
OWNHOUSE														SKINRATE-^-	
RELDIV															LIVEBRAT
ETHDIV															
UNIV															
TRANSF															
URBPART															
UNEMPLRATE															
VALADDPC															
RESEMPLSH															
AOWNEDSH															
FERTINT															

Table D.3 Partial Correlation Coefficients on Screened Data Set	ASMR	OWNHOUSE	RELDIV	ETHDIV	UNIV	TRANSF	URBPART	UNEMPLRATE	VALADDPC	RESEMPLSH	AOWNEDSH	FERTINT
POPRUR	-0.486	-0.873	0.755	-0.042	0.802	-0.376	0.574	-0.257	-0.222	-0.573	0.092	0.223
POPTOT	-0.448	-0.936	0.893	-0.092	0.959	-0.441	0.561	-0.229	-0.137	-0.523	0.093	0.256
EMPL	-0.444	-0.932	0.895	-0.098	0.960	-0.443	0.551	-0.221	-0.133	-0.519	0.091	0.265
LABFOR	-0.445	-0.933	0.898	-0.094	0.962	-0.444	0.551	-0.214	-0.134	-0.520	0.089	0.267
LFAGR	-0.475	-0.929	0.859	-0.082	0.931	-0.377	0.564	-0.379	-0.171	-0.525	0.069	0.233
LFFOR	-0.294	-0.832	0.806	0.055	0.748	-0.703	0.642	-0.362	-0.206	-0.593	0.036	0.277
LFFIS	-0.431	-0.933	0.891	-0.114	0.957	-0.446	0.523	-0.356	-0.118	-0.488	0.079	0.241
LFMIN	-0.376	-0.799	0.651	-0.019	0.680	-0.295	0.615	-0.434	-0.275	-0.409	0.084	0.049
FARMS	-0.493	-0.905	0.752	-0.056	0.843	-0.347	0.577	-0.273	-0.210	-0.557	0.110	0.226
AOWNED	0.001	-0.260	0.213	0.146	0.089	-0.346	0.458	-0.213	-0.274	-0.248	-0.042	-0.048
ARNTED	0.071	-0.140	0.218	0.151	0.026	-0.367	0.388	-0.201	-0.262	-0.277	-0.310	-0.146
CRPLND	-0.186	-0.688	0.625	0.230	0.521	-0.697	0.638	-0.212	-0.233	-0.563	0.039	0.261
TOTFER	-0.225	-0.795	0.715	0.251	0.652	-0.746	0.625	-0.125	-0.191	-0.604	0.062	0.436
SALES	-0.455	-0.913	0.890	-0.098	0.954	-0.410	0.478	-0.126	-0.152	-0.501	0.072	0.284
TOTTONE	-0.407	-0.841	0.887	-0.070	0.903	-0.411	0.525	-0.210	-0.145	-0.498	0.078	0.263
GINI	0.601	-0.112	0.109	0.437	0.047	0.349	0.177	-0.063	-0.214	0.157	-0.142	-0.504
VALADD	-0.315	-0.958	0.952	0.101	0.980	-0.537	0.543	-0.457	-0.112	-0.554	0.136	0.184
CRIME	-0.101	-0.716	0.555	0.265	0.610	-0.592	0.556	-0.423	0.187	-0.337	0.076	0.599
MIGIN	0.014	0.355	-0.539	0.068	-0.431	0.615	-0.310	-0.149	-0.691	0.245	-0.068	-0.452
BANKRUPT	0.001	-0.129	0.360	-0.347	0.188	-0.140	0.031	0.619	-0.109	-0.013	-0.491	0.054
GARBRATE	0.220	0.402	-0.539	-0.368	-0.379	0.845	-0.766	0.452	-0.100	0.722	0.182	-0.365
WATPC	0.061	0.209	-0.085	0.046	-0.228	0.998	-0.177	0.147	-0.755	0.235	-0.133	-0.894
WATPY	0.352	0.471	-0.271	0.303	-0.463	0.942	-0.273	0.324	-0.613	0.427	-0.262	-0.920
WATMUN	-0.225	-0.862	0.799	0.425	0.747	-0.700	0.831	-0.465	0.011	-0.660	0.046	0.741
FORPLANHAR	0.431	0.404	-0.397	0.081	-0.223	0.434	-0.104	-0.172	-0.213	0.162	-0.077	-0.491
FORBILLARE/	-0.742	-0.797	0.868	-0.031	0.859	-0.007	0.842	-0.839	-0.448	-0.866	0.424	0.544
RDIRATE	0.623	0.542	-0.427	0.500	-0.521	0.072	-0.310	0.450	0.294	0.429	-0.302	-0.086
CANCRATE	-0.119	0.191	-0.108	-0.267	-0.037	0.793	-0.411	0.015	-0.234	0.503	0.470	-0.356
SKINRATE	-0.582	0.115	-0.352	-0.357	0.009	0.522	-0.251	-0.250	0.156	0.162	0.145	-0.200
LIVEBRATE	0.208	-0.022	0.150	0.483	-0.058	-0.846	0.311	0.253	0.566	-0.319	-0.372	0.400
ASMR	1.000	0.350	-0.342	0.272	-0.441	0.130	-0.381	0.504	-0.061	0.555	-0.098	-0.086
OWNHOUSE	OWNHOUS	1.000	-0.819	0.040	-0.872	0.430	-0.798	0.476	0.192	0.544	-0.141	-0.660
RELDIV	E-^-	RELDIV=>	1.000	-0.056	0.928	-0.472	0.760	-0.259	-0.143	-0.619	-0.062	0.651
ETHDIV	ASMR-^-		ETHDIV=>	1.000	-0.182	-0.272	0.250	-0.057	-0.164	-0.183	0.079	0.319
UNIV		OWNHOUSE-^-		UNIV=>	1.000	-0.364	0.727	-0.334	-0.063	-0.527	0.082	0.596
TRANSF			RELDIV-^-		TRANSF=>	1.000	-0.595	0.108	-0.478	0.627	0.185	-0.542
URBPART				ETHDIV-^-		URBPART=	1.000	-0.241	-0.614	-0.571	-0.096	0.154
UNEMPLRATE					UNIV-^-		UNEMPLR/	1.000	0.644	0.418	-0.186	0.235
VALADDPC						TRANSF-^-		VALADDP(	1.000	0.321	-0.488	-0.172
RESEMPLSH							URBPART-^-		RESEMPLS	1.000	-0.062	-0.431
AOWNEDSH								UNEMPLRATE-^-		AOWNEDS	1.000	0.391
FERTINT									VALADDPC-^-		FERTINT=>	1.000
										RESEMPLSH-^-		
											AOWNEDSH-^-	
												FERTINT-^

Table D.4 Partial Correlation Coefficients on Screened Data Set	POPRUR	POPTOT	EMPL	LABFOR	LFAGR	LFFOR	LFFIS	LFMIN	FARMS	AOWNED	ARNTED	CRPLND	TOTFER	SALES	TOTTONE
POPRUR	1.000	0.876	0.854	0.853	0.950	0.872	0.795	0.825	0.988	0.316	0.102	0.879	0.818	0.776	0.848
POPTOT	POPTOT=>	1.000	0.997	0.996	0.966	0.905	0.990	0.872	0.880	0.178	0.033	0.770	0.793	0.910	0.941
EMPL		EMPL=>	1.000	1.000	0.959	0.901	0.990	0.869	0.859	0.168	0.029	0.757	0.792	0.932	0.947
LABFOR	POPRUR-^-		LABFOR=>	1.000	0.962	0.900	0.991	0.866	0.857	0.168	0.030	0.757	0.792	0.938	0.947
LFAGR		POPTOT-^-		LFAGR=>	1.000	0.900	0.930	0.873	0.962	0.235	0.203	0.819	0.832	0.981	0.931
LFFOR			EMPL-^-		LFFOR=>	1.000	0.871	0.790	0.881	0.324	0.353	0.933	0.957	0.886	0.854
LFFIS				LABFOR-^-		LFFIS=>	1.000	0.850	0.831	0.131	0.085	0.703	0.751	0.967	0.898
LFMIN					LFAGR-^-		LFMIN=>	1.000	0.853	0.442	0.351	0.719	0.706	0.852	0.792
FARMS						LFFOR-^-		FARMS=>	1.000	0.311	0.088	0.884	0.823	0.768	0.847
AOWNED							LFFIS-^-		AOWNED=	1.000	0.726	0.507	0.353	0.162	0.206
ARNTED								LFMIN-^-		ARNTED=>	1.000	0.238	0.188	0.039	0.077
CRPLND									FARMS-^-		CRPLND=>	1.000	0.947	0.701	0.760
TOTFER										AOWNED-^-		TOTFER=>	1.000	0.783	0.775
SALES											ARNTED-^-		SALES=>	1.000	0.941
TOTTONE												CRPLND-^-		TOTTONE=	1.000
GINI													TOTFER-^-		GINI=>
VALADD														SALES-^-	
CRIME															TOTTONE-
MIGIN															
BANKRUPT															
GARBRATE															
WATPC															
WATPY															
WATMUN															
FORPLANHAR															
FORBILLAREA															
RDIRATE															
CANCRATE															
SKINRATE															
LIVEBRATE															
ASMR															
OWNHOUSE															
RELDIV															
ETHDIV															
UNIV															
TRANSF															
URBPART															
UNEMPLRATE															
VALADDPC															
RESEMPLSH															
AOWNEDSH															
FERTINT															

BASIN8J	0	71	1
BASIN8K	0	76	1
BASIN8L	0	81	1
BASIN8M	0	86	1
SSUB8MH	1	91	1
SSUB8JC	1		
SSUB8KB	1		
SSUB8KC	1		
SSUB8KD	1		
SSUB8KE	1		
SSUB8LA	1		
SSUB8LB	1		
SSUB8LC	1		
SSUB8LE	1		
SSUB8LF	1		
SSUB8LG	1		
SSUB8NL	1		
SSUB8NM	1		
SSUB8NN	1		

SELECTION CRITERIA: 1=ON; 0=OFF

Table D.4 Partial Correlation Coefficients on Screened Data Set	GINI	VALADD	CRIME	MIGIN	BANKRUPT	GARBRATE	WATPC	WATPY	WATMUN	FORPLANHAR	FORBILLAREA	RDIRATE	CANCRATE	SKINRATE	LIVEBRATE
POPRUR	0.030	0.831	0.647	-0.167	0.286	-0.579			0.899	1.000	1.000	-0.720	-0.662	-0.188	0.408
POPTOT	0.062	0.998	0.802	-0.422	0.147	-0.744			0.932	1.000	1.000	-0.637	-0.614	-0.290	0.589
EMPL	0.063	0.999	0.807	-0.424	0.138	-0.746			0.923	1.000	1.000	-0.627	-0.612	-0.291	0.590
LABFOR	0.059	0.999	0.805	-0.422	0.151	-0.746			0.925	1.000	1.000	-0.630	-0.612	-0.291	0.591
LFAGR	0.053	0.965	0.784	-0.327	0.272	-0.685			0.972	1.000	1.000	-0.680	-0.633	-0.264	0.523
LFFOR	-0.001	0.878	0.713	-0.369	0.166	-0.781			0.925	1.000	1.000	-0.765	-0.706	-0.261	0.588
LFFIS	0.070	0.996	0.781	-0.474	0.089	-0.756			0.903	1.000	1.000	-0.607	-0.576	-0.297	0.610
LFMIN	0.246	0.895	0.818	-0.340	0.100	-0.738			0.941	1.000	1.000	-0.690	-0.647	-0.236	0.498
FARMS	0.066	0.882	0.699	-0.246	0.211	-0.607			0.946	1.000	1.000	-0.709	-0.638	-0.216	0.442
AOWNED	0.210	0.151	-0.026	0.253	0.032	-0.523			0.122	1.000	1.000	-0.697	-0.601	-0.142	0.335
ARNTED	0.143	0.086	-0.141	0.309	0.424	-0.440			0.049	1.000	1.000	-0.651	-0.551	0.073	0.052
CRPLND	0.043	0.758	0.581	-0.279	0.187	-0.717			0.849	1.000	1.000	-0.828	-0.706	-0.293	0.613
TOTFER	0.006	0.794	0.684	-0.345	0.157	-0.701			0.950	-1.000	-1.000	-0.754	-0.639	-0.253	0.540
SALES	0.040	0.991	0.813	-0.363	0.248	-0.728			0.941	1.000	1.000	-0.642	-0.629	-0.282	0.566
TOTTONE	0.031	0.993	0.805	-0.280	0.263	-0.723			0.846	1.000	1.000	-0.560	-0.609	-0.269	0.504
GINI	1.000	-0.003	0.114	-0.305	-0.442	0.523			-0.107			0.718	0.117	-0.636	-0.391
VALADD	VALADD=>	1.000	0.961	-0.640	0.715	-0.743			0.937			-0.605	-0.716	-0.518	0.872
CRIME	^-	CRIME=>	1.000	0.044	0.399	-0.580			0.799	1.000	1.000	-0.262	-0.313	0.007	0.126
MIGIN	GINI-^-		MIGIN=>	1.000	0.031	0.652			-0.242	1.000	1.000	0.338	-0.182	0.404	-0.787
BANKRUPT		VALADD-^-		BANKRUP	1.000	-0.367			0.401	1.000	1.000	-0.269	-0.016	-0.159	0.033
GARBRATE			CRIME-^-		GARBRATI	1.000			-0.545			0.923	0.722	-0.028	-0.882
WATPC				MIGIN-^-		WATPC=>									
WATPY					BANKRUPT-^-		WATPY=>								
WATMUN						GARBRATE-^-		WATMUN=	1.000	-1.000	-1.000	-0.549	-0.488	-0.223	0.419
FORPLANHAF							WATPC-^-		FORPLANH	1.000	1.000	1.000	-1.000	-1.000	1.000
FORBILLARE/								WATPY-^-		FORBILLA	1.000	1.000	-1.000	-1.000	1.000
RDIRATE									WATMUN-^-		RDIRATE=>	1.000	0.626	0.165	-0.689
CANCRATE										FORPLANHAR-^-		CANCRATI	1.000	0.298	-0.316
SKINRATE											FORBILLAREA-^-		SKINRATE	1.000	-0.476
LIVEBRATE												RDIRATE-^-		LIVEBRAT	1.000
ASMR													CANCRATE-^-		ASMR=>
OWNHOUSE														SKINRATE-^-	
RELDIV															LIVEBRAT
ETHDIV															
UNIV															
TRANSF															
URBPART															
UNEMPLRATE															
VALADDPC															
RESEMPLSH															
AOWNEDSH															
FERTINT															

Table D.4 Partial Correlation Coefficients on Screened Data Set	ASMR	OWNHOUSE	RELDIV	ETHDIV	UNIV	TRANSF	URBPART	UNEMPLRATE	VALADDPC	RESEMPLSH	AOWNEDSH	FERTINT
POPRUR	-0.416	-0.831	0.698	0.300	0.733	-0.674	0.529	-0.227	-0.219	-0.533	0.084	0.242
POPTOT	-0.311	-0.933	0.908	0.082	0.950	-0.844	0.503	-0.193	-0.115	-0.456	0.065	0.245
EMPL	-0.306	-0.928	0.910	0.067	0.951	-0.843	0.493	-0.187	-0.111	-0.451	0.062	0.251
LABFOR	-0.307	-0.929	0.913	0.073	0.953	-0.844	0.493	-0.181	-0.112	-0.452	0.061	0.252
LFAGR	-0.338	-0.933	0.857	0.215	0.900	-0.792	0.511	-0.333	-0.156	-0.463	0.032	0.235
LFFOR	-0.413	-0.908	0.864	0.090	0.885	-0.850	0.666	-0.364	-0.235	-0.607	0.023	0.335
LFFIS	-0.279	-0.922	0.909	0.036	0.948	-0.850	0.453	-0.293	-0.090	-0.411	0.037	0.226
LFMIN	-0.335	-0.951	0.788	0.123	0.856	-0.772	0.656	-0.386	-0.261	-0.323	0.030	0.066
FARMS	-0.377	-0.875	0.699	0.300	0.765	-0.710	0.521	-0.238	-0.198	-0.495	0.092	0.228
AOWNED	-0.364	-0.180	-0.028	0.105	-0.071	-0.301	0.639	-0.260	-0.422	-0.043	-0.039	-0.158
ARNTED	-0.392	-0.102	0.065	-0.157	-0.068	-0.129	0.527	-0.255	-0.470	-0.195	-0.491	-0.293
CRPLND	-0.422	-0.831	0.682	0.199	0.715	-0.794	0.695	-0.242	-0.296	-0.580	0.073	0.295
TOTFER	-0.380	-0.896	0.739	0.233	0.799	-0.787	0.627	-0.136	-0.231	-0.589	0.064	0.464
SALES	-0.319	-0.920	0.907	0.120	0.946	-0.828	0.435	-0.109	-0.133	-0.437	0.045	0.270
TOTTONE	-0.293	-0.835	0.891	0.091	0.895	-0.748	0.474	-0.182	-0.128	-0.434	0.058	0.255
GINI	0.926	-0.087	0.028	0.541	0.067	0.466	0.128	0.012	-0.194	0.223	-0.189	-0.540
VALADD	-0.176	-0.950	0.984	0.249	0.975	-0.872	0.475	-0.379	-0.089	-0.471	0.144	0.167
CRIME	-0.183	-0.895	0.913	0.476	0.819	-0.420	0.651	-0.630	-0.185	-0.217	0.344	0.651
MIGIN	0.022	0.270	-0.546	0.083	-0.459	0.625	-0.258	-0.142	-0.677	0.186	-0.152	-0.355
BANKRUPT	0.002	-0.191	0.510	0.022	0.249	-0.055	0.206	0.548	-0.425	-0.096	-0.552	0.261
GARBRATE	0.631	0.544	-0.727	0.289	-0.640	0.920	-0.777	0.845	0.018	0.800	0.168	-0.338
WATPC												
WATPY												
WATMUN	-0.269	-0.932	0.921	0.562	0.910	-0.706	0.864	-0.649	-0.028	-0.591	0.059	0.892
FORPLANHAF	-1.000	1.000		-1.000	1.000	-1.000	1.000	-1.000		-1.000	1.000	-1.000
FORBILLARE/	-1.000	1.000		-1.000	1.000	-1.000	1.000	-1.000		-1.000	1.000	-1.000
RDIRATE	0.586	0.500	-0.553	-0.027	-0.458	0.811	-0.832	0.557	0.249	0.868	0.329	-0.327
CANCRATE	0.243	0.487	-0.588	0.124	-0.498	0.538	-0.748	0.874	0.638	0.779	0.348	-0.264
SKINRATE	-0.628	0.217	-0.416	-0.110	-0.217	0.290	-0.235	0.009	0.509	0.114	-0.173	-0.131
LIVEBRATE	-0.281	-0.392	0.917	-0.199	0.513	-0.883	0.553	-0.249	0.325	-0.591	0.208	0.155
ASMR	1.000	0.199	-0.245	0.176	-0.281	0.495	-0.448	0.466	-0.377	0.640	0.232	-0.113
OWNHOUSE	OWNHOUS	1.000	-0.795	-0.197	-0.860	0.635	-0.873	0.485	0.191	0.485	0.014	-0.795
RELDIV	E-^-	RELDIV=>	1.000	-0.156	0.982	-0.900	0.749	-0.134	0.174	-0.573	-0.103	0.758
ETHDIV	ASMR-^-		ETHDIV=>	1.000	0.037	0.072	0.139	-0.023	-0.419	-0.105	0.489	0.324
UNIV		OWNHOUSE-^-		UNIV=>	1.000	-0.785	0.780	-0.256	0.178	-0.516	-0.015	0.768
TRANSF			RELDIV-^-		TRANSF=>	1.000	-0.795	0.581	-0.227	0.772	-0.044	-0.465
URBPART				ETHDIV-^-		URBPART=	1.000	-0.221	-0.642	-0.497	-0.105	0.115
UNEMPLRATI					UNIV-^-		UNEMPLR/	1.000	0.656	0.377	-0.190	0.213
VALADDPC						TRANSF-^-		VALADDP(	1.000	0.315	-0.489	-0.192
RESEMPLSH							URBPART-^-		RESEMPLS	1.000	-0.059	-0.418
AOWNEDSH								UNEMPLRATE-^-		AOWNEDS	1.000	0.414
FERTINT									VALADDPC-^-		FERTINT=>	1.000
										RESEMPLSH-^-		
											AOWNEDSH-^-	
												FERTINT-^

Table D.5 Partial Correlation Coefficients on Screened Data Set	POPRUR	POPTOT	EMPL	LABFOR	LFAGR	LFFOR	LFFIS	LFMIN	FARMS	AOWNED	ARNTED	CRPLND	TOTFER	SALES	TOTTONE
POPRUR	1.000	0.906	0.899	0.901	0.957	0.900	0.866	0.904	0.993	0.569	0.544	0.811	0.818	0.930	0.925
POPTOT	POPTOT=>	1.000	1.000	1.000	0.988	0.834	0.996	0.851	0.940	0.367	0.324	0.681	0.745	0.997	0.998
EMPL		EMPL=>	1.000	1.000	0.985	0.830	0.997	0.846	0.935	0.360	0.317	0.675	0.741	0.996	0.997
LABFOR	POPRUR-^-		LABFOR=>	1.000	0.986	0.832	0.997	0.847	0.936	0.362	0.320	0.677	0.742	0.996	0.997
LFAGR		POPTOT-^-		LFAGR=>	1.000	0.856	0.970	0.883	0.981	0.423	0.383	0.718	0.765	0.994	0.993
LFFOR			EMPL-^-		LFFOR=>	1.000	0.803	0.844	0.879	0.718	0.694	0.966	0.973	0.849	0.856
LFFIS				LABFOR-^-		LFFIS=>	1.000	0.827	0.906	0.333	0.289	0.640	0.709	0.988	0.989
LFMIN					LFAGR-^-		LFMIN=>	1.000	0.900	0.716	0.700	0.775	0.728	0.870	0.857
FARMS						LFFOR-^-		FARMS=>	1.000	0.499	0.468	0.774	0.797	0.957	0.953
AOWNED							LFFIS-^-		AOWNED=	1.000	0.985	0.802	0.675	0.409	0.400
ARNTED								LFMIN-^-		ARNTED=>	1.000	0.785	0.646	0.366	0.356
CRPLND									FARMS-^-		CRPLND=>	1.000	0.977	0.701	0.709
TOTFER										AOWNED-^-		TOTFER=>	1.000	0.755	0.769
SALES											ARNTED-^-		SALES=>	1.000	0.999
TOTTONE												CRPLND-^-		TOTTONE=	1.000
GINI													TOTFER-^-		GINI=>
VALADD														SALES-^-	
CRIME															TOTTONE-
MIGIN															
BANKRUPT															
GARBRATE															
WATPC															
WATPY															
WATMUN															
FORPLANHAR															
FORBILLAREA															
RDIRATE															
CANCRATE															
SKINRATE															
LIVEBRATE															
ASMR															
OWNHOUSE															
RELDIV															
ETHDIV															
UNIV															
TRANSF															
URBPART															
UNEMPLRATE															
VALADDPC															
RESEMPLSH															
AOWNEDSH															
FERTINT															

BASIN8J	1	71	0
BASIN8K	1	76	0
BASIN8L	1	81	0
BASIN8M	1	86	0
SSUB8MH	1	91	1
SSUB8JC	1		
SSUB8KB	1		
SSUB8KC	1		
SSUB8KD	1		
SSUB8KE	1		
SSUB8LA	1		
SSUB8LB	1		
SSUB8LC	1		
SSUB8LE	1		
SSUB8LF	1		
SSUB8LG	1		
SSUB8NL	1		
SSUB8NM	1		
SSUB8NN	1		

SELECTION CRITERIA: 1=ON; 0=OFF

Table D.5 Partial Correlation Coefficients on Screened Data Set	GINI	VALADD	CRIME	MIGIN	BANKRUPT	GARBRATE	WATPC	WATPY	WATMUN	FORPLANHAR	FORBILLAREA	RDIRATE	CANCRATE	SKINRATE	LIVEBRATE
POPRUR	-0.024	0.886	0.627	-0.223	0.714	-0.403	0.012	-0.249	0.836	-0.635	0.607	-0.636	-0.217	-0.315	0.026
POPTOT	0.030	0.997	0.682	-0.461	0.546	-0.476	-0.205	-0.441	0.830	-0.643	0.795	-0.588	-0.236	-0.375	0.114
EMPL	0.030	0.998	0.684	-0.469	0.539	-0.478	-0.212	-0.447	0.827	-0.644	0.798	-0.585	-0.238	-0.376	0.118
LABFOR	0.030	0.998	0.684	-0.468	0.541	-0.479	-0.210	-0.446	0.828	-0.644	0.797	-0.585	-0.239	-0.377	0.119
LFAGR	0.023	0.978	0.653	-0.359	0.601	-0.423	-0.144	-0.388	0.835	-0.640	0.758	-0.616	-0.197	-0.357	0.051
LFFOR	-0.020	0.834	0.804	-0.523	0.683	-0.708	-0.066	-0.264	0.913	-0.590	0.431	-0.391	-0.543	-0.521	0.425
LFFIS	0.040	0.996	0.682	-0.497	0.506	-0.483	-0.217	-0.453	0.809	-0.644	0.806	-0.577	-0.238	-0.375	0.122
LFMIN	0.128	0.825	0.561	-0.196	0.598	-0.491	0.421	0.176	0.796	-0.286	0.604	-0.547	-0.167	-0.390	-0.026
FARMS	-0.003	0.923	0.625	-0.250	0.678	-0.395	-0.051	-0.307	0.840	-0.622	0.719	-0.632	-0.187	-0.332	0.015
AOWNED	0.089	0.348	0.378	-0.114	0.435	-0.491	0.787	0.756	0.484	0.277	-0.432	-0.067	-0.339	-0.348	0.225
ARNTED	0.100	0.303	0.341	-0.083	0.412	-0.477	0.799	0.779	0.419	0.307	-0.501	-0.065	-0.351	-0.303	0.218
CRPLND	-0.004	0.681	0.765	-0.486	0.675	-0.768	0.166	0.076	0.871	-0.240	0.093	-0.182	-0.638	-0.579	0.565
TOTFER	-0.033	0.754	0.836	-0.599	0.665	-0.767	-0.384	-0.473	0.918	-0.529	0.373	-0.195	-0.667	-0.616	0.627
SALES	0.031	0.991	0.672	-0.423	0.563	-0.455	-0.167	-0.408	0.829	-0.650	0.752	-0.601	-0.219	-0.367	0.085
TOTTONE	0.026	0.994	0.687	-0.449	0.562	-0.467	-0.205	-0.440	0.837	-0.659	0.755	-0.582	-0.240	-0.382	0.116
GINI	1.000	0.020	-0.201	0.161	-0.409	0.079	0.383	0.506	-0.052	0.653	0.311	0.549	0.305	-0.478	-0.115
VALADD	VALADD=>	1.000	0.711	-0.514	0.540	-0.495	-0.267	-0.497	0.836	-0.666	0.799	-0.564	-0.275	-0.393	0.165
CRIME	^-	CRIME=>	1.000	-0.600	0.811	-0.540	-0.609	-0.832	0.870	-0.968	0.325	-0.297	-0.789	-0.667	0.546
MIGIN	GINI-^-		MIGIN=>	1.000	-0.138	0.684	0.957	0.931	-0.537	0.501	-0.388	0.002	0.503	0.209	-0.748
BANKRUPT		VALADD-^-		BANKRUP	1.000	-0.258	0.000	-0.299	0.778	-0.786	0.128	-0.494	-0.580	-0.458	0.184
GARBRATE			CRIME-^-		GARBRATI	1.000	0.202	0.052	-0.614	-0.374	-0.492	0.048	0.643	0.376	-0.748
WATPC				MIGIN-^-		WATPC=>	1.000	0.944	-0.158	0.514	-0.122	-0.045	0.772	0.428	-0.679
WATPY					BANKRUPT-^-		WATPY=>	1.000	-0.402	0.752	-0.271	0.287	0.658	0.250	-0.399
WATMUN						GARBRATE-^-		WATMUN=	1.000	-0.616	0.828	-0.300	-0.529	-0.623	0.445
FORPLANHAF							WATPC-^-		FORPLANH	1.000	-0.219	0.792	0.304	-0.271	0.246
FORBILLARE/								WATPY-^-		FORBILLA	1.000	-0.441	0.430	-0.407	-0.267
RDIRATE									WATMUN-^-		RDIRATE=	1.000	0.007	-0.292	0.395
CANCRATE										FORPLANHAR-^-		CANCRATI	1.000	0.599	-0.778
SKINRATE											FORBILLAREA-^-		SKINRATE	1.000	-0.474
LIVEBRATE												RDIRATE-^-		LIVEBRAT	1.000
ASMR													CANCRATE-^-		ASMR=>
OWNHOUSE														SKINRATE-^-	
RELDIV															LIVEBRAT
ETHDIV															
UNIV															
TRANSF															
URBPART															
UNEMPLRATI															
VALADDPC															
RESEMPLSH															
AOWNEDSH															
FERTINT															

Table D.5 Partial Correlation Coefficients on Screened Data Set	ASMR	OWNHOUSE	RELDIV	ETHDIV	UNIV	TRANSF	URBPART	UNEMPLRATE	VALADDPC	RESEMPLSH	AOWNEDSH	FERTINT
POPRUR	-0.377	-0.889	0.826	0.217	0.838	-0.414	0.571	-0.534	-0.222	-0.611	0.147	0.139
POPTOT	-0.333	-0.959	0.956	0.106	0.978	-0.496	0.549	-0.465	-0.137	-0.561	0.133	0.170
EMPL	-0.330	-0.958	0.957	0.101	0.979	-0.499	0.546	-0.461	-0.133	-0.557	0.132	0.171
LABFOR	-0.330	-0.958	0.957	0.102	0.979	-0.499	0.547	-0.463	-0.134	-0.558	0.132	0.171
LFAGR	-0.351	-0.957	0.934	0.149	0.957	-0.439	0.561	-0.494	-0.171	-0.571	0.140	0.154
LFFOR	-0.188	-0.829	0.785	0.342	0.744	-0.721	0.659	-0.557	-0.206	-0.637	0.182	0.187
LFFIS	-0.317	-0.950	0.958	0.068	0.980	-0.501	0.518	-0.435	-0.118	-0.527	0.125	0.166
LFMIN	-0.243	-0.832	0.836	0.221	0.775	-0.347	0.618	-0.494	-0.275	-0.502	0.105	-0.006
FARMS	-0.373	-0.926	0.877	0.207	0.895	-0.404	0.578	-0.532	-0.210	-0.600	0.147	0.141
AOWNED	0.076	-0.253	0.237	0.337	0.108	-0.347	0.501	-0.352	-0.274	-0.270	0.146	-0.100
ARNTED	0.076	-0.182	0.157	0.291	0.029	-0.328	0.462	-0.343	-0.262	-0.294	0.057	-0.129
CRPLND	-0.058	-0.663	0.612	0.503	0.528	-0.757	0.664	-0.554	-0.233	-0.590	0.185	0.146
TOTFER	-0.078	-0.760	0.704	0.493	0.654	-0.821	0.670	-0.556	-0.191	-0.623	0.211	0.233
SALES	-0.336	-0.957	0.948	0.116	0.969	-0.472	0.547	-0.469	-0.152	-0.552	0.137	0.158
TOTTONE	-0.325	-0.959	0.949	0.128	0.972	-0.495	0.552	-0.474	-0.145	-0.558	0.141	0.170
GINI	0.601	-0.022	0.163	0.461	0.039	0.349	0.052	0.136	-0.214	0.272	-0.465	-0.565
VALADD	-0.315	-0.958	0.952	0.101	0.980	-0.537	0.543	-0.457	-0.112	-0.554	0.136	0.184
CRIME	0.115	-0.797	0.555	0.203	0.630	-0.789	0.625	-0.384	0.187	-0.486	0.189	0.730
MIGIN	0.210	0.386	-0.509	-0.020	-0.497	0.862	-0.404	0.223	-0.691	0.441	-0.135	-0.621
BANKRUPT	-0.012	-0.705	0.372	0.178	0.470	-0.489	0.547	-0.328	-0.109	-0.535	0.095	0.469
GARBRATE	0.220	0.402	-0.539	-0.368	-0.379	0.845	-0.766	0.452	-0.100	0.722	0.182	-0.365
WATPC	0.061	0.209	-0.085	0.046	-0.228	0.998	-0.177	0.147	-0.755	0.235	-0.133	-0.894
WATPY	0.352	0.471	-0.271	0.303	-0.463	0.942	-0.273	0.324	-0.613	0.427	-0.262	-0.920
WATMUN	-0.076	-0.892	0.799	0.430	0.793	-0.720	0.840	-0.621	0.011	-0.684	0.403	0.719
FORPLANHAF	0.691	0.705	-0.397	0.720	-0.637	0.495	-0.217	0.419	-0.213	0.517	-0.182	-0.552
FORBILLARE/	-0.746	-0.791	0.868	0.019	0.833	-0.165	0.854	-0.865	-0.448	-0.864	0.995	0.553
RDIRATE	0.656	0.527	-0.427	0.563	-0.539	0.099	-0.330	0.571	0.294	0.522	0.116	-0.019
CANCRATE	-0.241	0.348	-0.108	-0.260	-0.120	0.804	-0.453	0.056	-0.234	0.383	0.305	-0.491
SKINRATE	-0.684	0.550	-0.352	-0.690	-0.318	0.393	-0.496	0.231	0.156	0.034	-0.369	-0.565
LIVEBRATE	0.152	-0.135	0.150	0.473	0.073	-0.861	0.413	0.028	0.566	-0.375	-0.118	0.567
ASMR	1.000	0.121	-0.342	0.427	-0.335	0.172	-0.277	0.448	-0.061	0.670	0.198	0.058
OWNHOUSE	OWNHOUS	1.000	-0.880	-0.196	-0.932	0.489	-0.787	0.803	0.192	0.563	-0.502	-0.694
RELDIV	E-^-	RELDIV=>	1.000	0.213	0.959	-0.472	0.820	-0.891	-0.143	-0.634	0.536	0.587
ETHDIV	ASMR-^-		ETHDIV=>	1.000	0.061	-0.233	0.496	-0.158	-0.164	-0.185	0.307	0.377
UNIV		OWNHOUSE-^-		UNIV=>	1.000	-0.444	0.726	-0.852	-0.063	-0.571	0.582	0.667
TRANSF			RELDIV-^-		TRANSF=>	1.000	-0.640	0.289	-0.478	0.681	0.078	-0.647
URBPART				ETHDIV-^-		URBPART=	1.000	-0.698	-0.614	-0.648	0.376	0.136
UNEMPLRATI					UNIV-^-		UNEMPLR/	1.000	0.644	0.580	-0.555	-0.318
VALADDPC						TRANSF-^-		VALADDP(	1.000	0.321	-0.488	-0.172
RESEMPLSH							URBPART-^-		RESEMPLS	1.000	-0.219	-0.394
AOWNEDSH								UNEMPLRATE-^-		AOWNEDS	1.000	0.756
FERTINT									VALADDPC-^-		FERTINT=>	1.000
										RESEMPLSH-^-		
											AOWNEDSH-^-	
												FERTINT-^

Table D.6 Partial Correlation Coefficients on Screened Data Set	POPRUR	POPTOT	EMPL	LABFOR	LFAGR	LFFOR	LFFIS	LFMIN	FARMS	AOWNED	ARNTED	CRPLND	TOTFER	SALES	TOTTONE
POPRUR	1.000	0.996	0.994	0.993	0.981	0.931	0.875	0.888	0.960	0.552	0.318	0.923	0.961	0.915	0.974
POPTOT	POPTOT=>	1.000	0.998	0.997	0.984	0.919	0.854	0.890	0.963	0.498	0.277	0.905	0.951	0.924	0.981
EMPL		EMPL=>	1.000	0.999	0.976	0.919	0.848	0.892	0.948	0.490	0.268	0.893	0.951	0.939	0.983
LABFOR	POPRUR-^-		LABFOR=>	1.000	0.980	0.925	0.855	0.890	0.941	0.478	0.269	0.886	0.952	0.949	0.979
LFAGR		POPTOT-^-		LFAGR=>	1.000	0.873	0.850	0.900	0.984	0.534	0.542	0.872	0.966	0.985	0.950
LFFOR			EMPL-^-		LFFOR=>	1.000	0.934	0.788	0.862	0.727	0.776	0.910	0.881	0.912	0.862
LFFIS				LABFOR-^-		LFFIS=>	1.000	0.843	0.844	0.757	0.843	0.908	0.892	0.844	0.754
LFMIN					LFAGR-^-		LFMIN=>	1.000	0.909	0.602	0.577	0.830	0.879	0.889	0.855
FARMS						LFFOR-^-		FARMS=>	1.000	0.532	0.279	0.932	0.922	0.804	0.950
AOWNED							LFFIS-^-		AOWNED=	1.000	0.654	0.725	0.475	0.320	0.445
ARNTED								LFMIN-^-		ARNTED=>	1.000	0.384	0.233	0.193	0.196
CRPLND									FARMS-^-		CRPLND=>	1.000	0.885	0.741	0.860
TOTFER										AOWNED-^-		TOTFER=>	1.000	0.932	0.915
SALES											ARNTED-^-		SALES=>	1.000	0.930
TOTTONE												CRPLND-^-		TOTTONE=	1.000
GINI													TOTFER-^-		GINI=>
VALADD														SALES-^-	
CRIME															TOTTONE-
MIGIN															
BANKRUPT															
GARBRATE															
WATPC															
WATPY															
WATMUN															
FORPLANHAR															
FORBILLAREA															
RDIRATE															
CANCRATE															
SKINRATE															
LIVEBRATE															
ASMR															
OWNHOUSE															
RELDIV															
ETHDIV															
UNIV															
TRANSF															
URBPART															
UNEMPLRATE															
VALADDPC															
RESEMPLSH															
AOWNEDSH															
FERTINT															

BASIN8J	0	71	1
BASIN8K	0	76	1
BASIN8L	0	81	1
BASIN8M	0	86	1
SSUB8MH	0	91	1
SSUB8JC	0		
SSUB8KB	0		
SSUB8KC	0		
SSUB8KD	0		
SSUB8KE	0		
SSUB8LA	0		
SSUB8LB	0		
SSUB8LC	0		
SSUB8LE	1		
SSUB8LF	0		
SSUB8LG	0		
SSUB8NL	1		
SSUB8NM	1		
SSUB8NN	1		

SELECTION CRITERIA: 1=ON; 0=OFF

Table D.6 Partial Correlation Coefficients on Screened Data Set	GINI	VALADD	CRIME	MIGIN	BANKRUPT	GARBRATE	WATPC	WATPY	WATMUN	FORPLANHAR	FORBILLAREA	RDIRATE	CANCRATE	SKINRATE	LIVEBRATE
POPRUR	-0.211	0.975	0.111	0.349	0.405	-0.023			0.780			-0.520	-0.424	0.064	-0.097
POPTOT	-0.216	0.979	0.136	0.347	0.416	0.009			0.798			-0.486	-0.403	0.071	-0.128
EMPL	-0.220	0.976	0.138	0.366	0.398	-0.003			0.781			-0.484	-0.418	0.079	-0.137
LABFOR	-0.231	0.977	0.136	0.361	0.420	-0.002			0.785			-0.488	-0.415	0.076	-0.131
LFAGR	-0.186	0.978	0.201	0.313	0.466	0.113			0.862			-0.438	-0.330	0.049	-0.158
LFFOR	-0.376	0.869	-0.098	0.323	0.456	-0.343			0.551			-0.726	-0.595	0.053	0.069
LFFIS	-0.314	0.602	-0.045	0.287	0.455	-0.568			0.463			-0.798	-0.606	0.050	0.081
LFMIN	-0.235	0.745	0.418	0.476	0.393	-0.131			0.640			-0.482	-0.416	0.146	-0.298
FARMS	-0.117	0.979	0.161	0.299	0.356	0.050			0.834			-0.480	-0.366	0.054	-0.127
AOWNED	-0.126	0.557	-0.207	0.356	0.070	-0.572			0.061			-0.796	-0.663	-0.115	0.342
ARNTED	-0.628	0.308	-0.164	0.362	0.468	-0.748			0.240			-0.859	-0.722	0.057	0.113
CRPLND	-0.152	0.911	-0.131	0.219	0.312	-0.245			0.489			-0.729	-0.516	-0.094	0.263
TOTFER	-0.108	0.968	0.043	0.219	0.371	-0.089			0.772			-0.597	-0.381	0.012	0.022
SALES	-0.253	0.977	0.202	0.383	0.499	0.077			0.820			-0.431	-0.382	0.077	-0.183
TOTTONE	-0.158	0.986	0.187	0.392	0.339	0.139			0.815			-0.345	-0.349	0.056	-0.209
GINI	1.000	-0.552	0.507	-0.237	-0.396	0.750			-0.177			0.861	0.130	-0.768	-0.737
VALADD	VALADD=>	1.000	0.338	0.457	0.883	0.089			0.906			-0.293	-0.026	0.031	0.018
CRIME	^-	CRIME=>	1.000	0.582	0.401	0.709			0.388			0.425	0.341	0.452	-0.765
MIGIN	GINI-^-		MIGIN=>	1.000	-0.005	0.304			0.266			0.143	-0.513	0.342	-0.770
BANKRUPT		VALADD-^-		BANKRUP	1.000	0.265			0.778			-0.296	0.151	-0.125	-0.058
GARBRATE			CRIME-^-		GARBRATI	1.000			0.499			0.902	0.399	-0.743	-0.702
WATPC				MIGIN-^-		WATPC=>									
WATPY					BANKRUPT-^-		WATPY=>								
WATMUN						GARBRATE-^-		WATMUN=	1.000			-0.037	0.058	0.106	-0.368
FORPLANHAF							WATPC-^-		FORPLANHAR=>						
FORBILLARE/								WATPY-^-		FORBILLAREA=>					
RDIRATE									WATMUN-^-		RDIRATE=>	1.000	0.446	-0.016	-0.513
CANCRATE										FORPLANHAR-^-		CANCRATI	1.000	0.159	0.047
SKINRATE											FORBILLAREA-^-		SKINRATE	1.000	-0.389
LIVEBRATE												RDIRATE-^-		LIVEBRAT	1.000
ASMR													CANCRATE-^-		ASMR=>
OWNHOUSE														SKINRATE-^-	
RELDIV															LIVEBRAT
ETHDIV															
UNIV															
TRANSF															
URBPART															
UNEMPLRATI															
VALADDPC															
RESEMPLSH															
AOWNEDSH															
FERTINT															

Table D.6 Partial Correlation Coefficients on Screened Data Set	ASMR	OWNHOUSE	RELDIV	ETHDIV	UNIV	TRANSF	URBPART	UNEMPLRATE	VALADDPC	RESEMPLSH	AOWNEDSH	FERTINT
POPRUR	-0.332	-0.520	0.000	0.457	0.044	-0.099	0.917	0.040	-0.377	-0.703	0.013	0.478
POPTOT	-0.322	-0.532	0.021	0.463	0.086	-0.070	0.908	0.055	-0.368	-0.670	0.017	0.480
EMPL	-0.332	-0.525	0.018	0.453	0.077	-0.067	0.901	0.060	-0.378	-0.677	0.021	0.491
LABFOR	-0.329	-0.527	0.037	0.451	0.089	-0.070	0.897	0.082	-0.377	-0.675	0.010	0.501
LFAGR	-0.240	-0.612	-0.028	0.506	0.095	-0.003	0.863	-0.151	-0.384	-0.581	-0.188	0.665
LFFOR	-0.456	-0.315	0.171	0.234	0.001	-0.310	0.958	-0.138	-0.436	-0.831	-0.295	0.369
LFFIS	-0.396	-0.403	-0.026	0.216	-0.156	-0.274	0.956	-0.143	-0.634	-0.757	-0.330	0.373
LFMIN	-0.246	-0.733	-0.239	0.387	-0.121	0.167	0.880	-0.296	-0.774	-0.450	-0.171	0.488
FARMS	-0.277	-0.566	-0.116	0.506	0.025	-0.048	0.906	-0.034	-0.381	-0.632	0.037	0.397
AOWNED	-0.349	-0.239	-0.341	0.122	-0.545	-0.397	0.692	-0.358	-0.675	-0.778	-0.019	-0.173
ARNTED	-0.426	-0.235	0.039	-0.161	-0.288	-0.342	0.370	-0.323	-0.636	-0.613	-0.722	-0.246
CRPLND	-0.353	-0.411	-0.174	0.317	-0.189	-0.362	0.954	-0.032	-0.431	-0.801	0.068	0.252
TOTFER	-0.307	-0.505	-0.147	0.465	-0.040	-0.187	0.860	0.124	-0.366	-0.699	0.030	0.606
SALES	-0.285	-0.584	0.094	0.452	0.145	0.002	0.777	0.241	-0.388	-0.615	-0.023	0.613
TOTTONE	-0.258	-0.526	0.003	0.509	0.109	0.023	0.846	0.005	-0.337	-0.626	0.050	0.488
GINI	0.932	0.103	-0.063	0.606	0.045	0.877	-0.308	0.197	-0.077	0.114	0.769	0.102
VALADD	-0.294	-0.560	0.311	0.722	0.337	-0.158	0.763	-0.530	-0.185	-0.651	0.105	0.576
CRIME	0.062	-0.799	-0.473	0.620	0.258	0.807	-0.038	-0.060	-0.661	0.499	0.293	0.323
MIGIN	-0.091	-0.531	0.066	0.124	-0.123	0.629	0.360	-0.546	-0.903	-0.129	-0.154	0.049
BANKRUPT	0.049	-0.403	0.601	-0.002	0.461	0.116	0.360	0.644	-0.576	-0.094	-0.582	0.489
GARBRATE	0.792	-0.696	0.082	0.668	0.578	0.817	-0.415	0.588	0.038	0.686	0.943	0.836
WATPC												
WATPY												
WATMUN	-0.057	-0.627	0.360	0.876	0.442	0.238	0.438	-0.023	-0.088	-0.199	-0.315	0.860
FORPLANHAF												
FORBILLARE/												
RDIRATE	0.549	-0.128	0.162	0.133	0.633	0.720	-0.768	0.252	0.315	0.800	0.582	0.155
CANCRATE	0.110	-0.070	0.882	0.284	0.371	0.123	-0.621	0.813	0.925	0.679	0.600	0.197
SKINRATE	-0.774	-0.132	0.596	-0.058	0.360	0.071	0.035	-0.336	0.602	-0.076	-0.115	0.104
LIVEBRATE	-0.150	0.490	0.638	-0.427	-0.427	-0.871	0.088	0.359	0.652	-0.370	0.099	-0.468
ASMR	1.000	-0.120	-0.510	0.249	-0.069	0.516	-0.426	0.415	-0.380	0.614	0.310	0.108
OWNHOUSE	OWNHOUS	1.000	0.384	-0.438	0.052	-0.609	-0.415	0.194	0.574	-0.125	0.102	-0.410
RELDIV	E-^-	RELDIV=>	1.000	-0.240	0.882	-0.504	-0.081	0.905	0.876	-0.218	-0.261	0.228
ETHDIV	ASMR-^-		ETHDIV=>	1.000	0.040	0.483	0.237	-0.085	-0.429	-0.115	0.518	0.483
UNIV		OWNHOUSE-^-		UNIV=>	1.000	0.308	-0.186	0.665	0.718	0.089	-0.107	0.460
TRANSF			RELDIV-^-		TRANSF=>	1.000	-0.274	-0.092	-0.443	0.652	0.270	0.313
URBPART				ETHDIV-^-		URBPART=	1.000	-0.015	-0.587	-0.790	0.040	0.250
UNEMPLRATE					UNIV-^-		UNEMPLR/	1.000	0.681	0.210	0.093	0.658
VALADDPC						TRANSF-^-		VALADDP(	1.000	0.033	0.359	0.151
RESEMPLSH							URBPART-^-		RESEMPLS	1.000	0.030	-0.121
AOWNEDSH								UNEMPLRATE-^-		AOWNEDS	1.000	0.051
FERTINT									VALADDPC-^-		FERTINT=>	1.000
										RESEMPLSH-^-		
											AOWNEDSH-^-	
												FERTINT-^

Table D.7. Selected Summary of Multivariate Correlation Studies

Indicator Set*	Linkages Detected and Modeling Implications
EMPL; LABFOR	Perfectly correlated (R^2=0.9992): Not independently estimated. May use one or the other interchangeably in Complex System Model.
RESEMPLSH; UNEMPLRATE; URBPART	Correlated at 95% significance level (t=2.04 and t=4.15) ; use estimated elasticities in Complex System Model.
UNEMPLRATE; URBPART	Correlated at 95% significance level (t=2.39) ; use Resource Employment Share (RESEMPLSH) as Complex System Proxy.
GINI; [OTHER]	Uncorrelated; GINI exhibits statistically independent bahaviour.
ETHDIV; [OTHER]	Uncorrelated; Ethnic Diversity exhibits statistically independent bahaviour.
CRIME; URBPART; MIGIN; VALADDPC; BANKRUPT; GINI; UNEMPLRATE	Significant correlation between CRIME and URBPART (t=2.22) , independent of other explanatory variables: MIGIN (t=0.40); BANKRUPT (t=1.44); VALADDPC (t=1.02); GINI (t=0.20); UNEMPL (t=0.74); Focus on urban partition as explanatory proxy indicator for CRIME and others within Complex System Model.
Health indicator set: RDIRATE; CANCRATE; LIVEBRATE; ASMR; TIME	High levels of correlation among all variables. Focus on any one health indicator in Complex System Model as proxy and exclude others. Lowest levels of autocorrelation detected in ASMR.
UNEMPLRATE; ASMR	Moderate potential linkage between health and unemployment (R^2=0.34); Use a variable linkage in Complex System Model permitting sensitivity tests.
WATPC; VALADDPC	Significant negative correlation (t=-2.00). Use computed income elasticity at means within Complex System Model.
WATPC; WATMUN; URBPART	Uncorrelated.
UNIV; UNEMPLRATE; MIGIN; VALADDPC	Education positively correlated to income (t=2.1) and independent of others; use explicit link between education and income within Complex System Model.
FORPLANHAR; FORBILLAREA; TIME	Uncorrelated; insufficient degrees of freedom to obtain statistically significant results.

* See Table D.1 for variable definitions. "OTHER" signifies a representative cross-section of other key indicators. "TIME" signifies tests for autocorrelation on annual data that were gathered for some variables.

Annex E
Deterministic Modeling

INTRODUCTION

The deterministic modeling component of the Fraser study is based on the set of 1990 input-output economic accounts for British Columbia. These accounts describe the structure of production in an economy and are widely used around the world to track flows of goods and services between industries in a given region, between industries and their customers, and between different regions. Since its initial development by Leontief, input-output analysis - which involves the mathematical manipulation of the accounts - has become an invaluable tool for economists and others to estimate the impacts of exogenous changes in the economy. The basic structure of an input-output table is simply an accounting framework of inter-industry dollar flows, with additional columns added to represent final demand sectors (these represent the goods purchased by consumers - or 'households' - or the government, or which are privately invested or exported) and additional rows to represent payments to government and labour. There are two types of input-output tables: industry-by-industry tables, which track the sales/purchases of each industry to/from each other industry (and, hence, the tables are square matrices); and commodity-by-industry tables, which track the sales and purchases of various commodities by aggregate industrial sectors (where there are more commodities than industries; hence, the table is a rectangular matrix). The Canadian tables - which are regionalized by province - are of the commodity-by-industry type and are available in three different levels of aggregation. For the purposes of the Fraser study, we used the small (or S) level of data, which includes 43 commodities and 16 industries. The accounts are comprised of three separate tables: a 'make' matrix, which records the commodities which each of the 16 industries produce; a 'use' matrix, which records commodity inputs to all industries (this records the 'intermediate demand' for commodities); and a 'final demand' matrix, which provides a record of the final demand for each commodity (ie., from households, the government or exports). Basically, these tables provide an economic 'snapshot' of a regional economy for a given year. They also allow for an indication of the level of technological development of a given economy. By simple mathematical manipulation, we can transform the tables into ones which represent the dollars worth of input of any given commodity needed to produce $1 worth of output from a particular industry. These so-called 'technical coefficients' are 'fixed' and give a simple 'cookbook' approach to economic activity. That is, if output is to be doubled for a given industry, all commodity inputs must be doubled as well. In order to use the accounts for analytical purposes, they must be converted to a square table, and the resulting framework looks similar to Figure E.1. For a more detailed discussion of input-output tables and their manipulation, see the section at the end of this Annex.

Table E.1. The Structure of a Simplified Input-Output Table

Outputs → / ↓ Inputs	Industry				Final Demand	Total Gross Output
Industry 1						
Industry 2						
Industry 3						
Industry 4						
Value Added						
Total						

In addition to producing a given level of output (recorded in dollars), industries also produce other external factors of production, some of which are measurable, such as various types of pollution and employment, and others which are difficult to measure, including various social activities. If a relationship can be measured - or even estimated - between industrial activity and these other activities, then one can develop sets of augmented or satellite accounts to link with the basic input-output structure. These satellite accounts are simply rows added to the input-output matrix and are expressed in terms of tonnes of pollutant or number of employees per dollar worth of output of each industry. In this way, we can link economic, environmental and social variables. The technical coefficients matrix (A_p) of the augmented table is squared off by adding columns of zeros to the augmented matrix (which have no effect on the manipulation of the matrix). Table E.2 illustrates the expanded table of technical coefficients (or inter-industry coefficients).

A detailed discussion of the use of input-output analysis for environmental management can be found in Lonergan and Cocklin (1985).

For the tables to be used for analytical purposes - and to use the tables to improve our understanding of how indicators relate to one another - we had to go through a number of steps, as follows:

Table E.2. The Augmented Technical Coefficients Matrix (with Pollution and Employment Added; This is a "Hybrid Table," so Units are Mixed and are Expressed in Dollars or Tonnes or Employees per Dollar of Output)

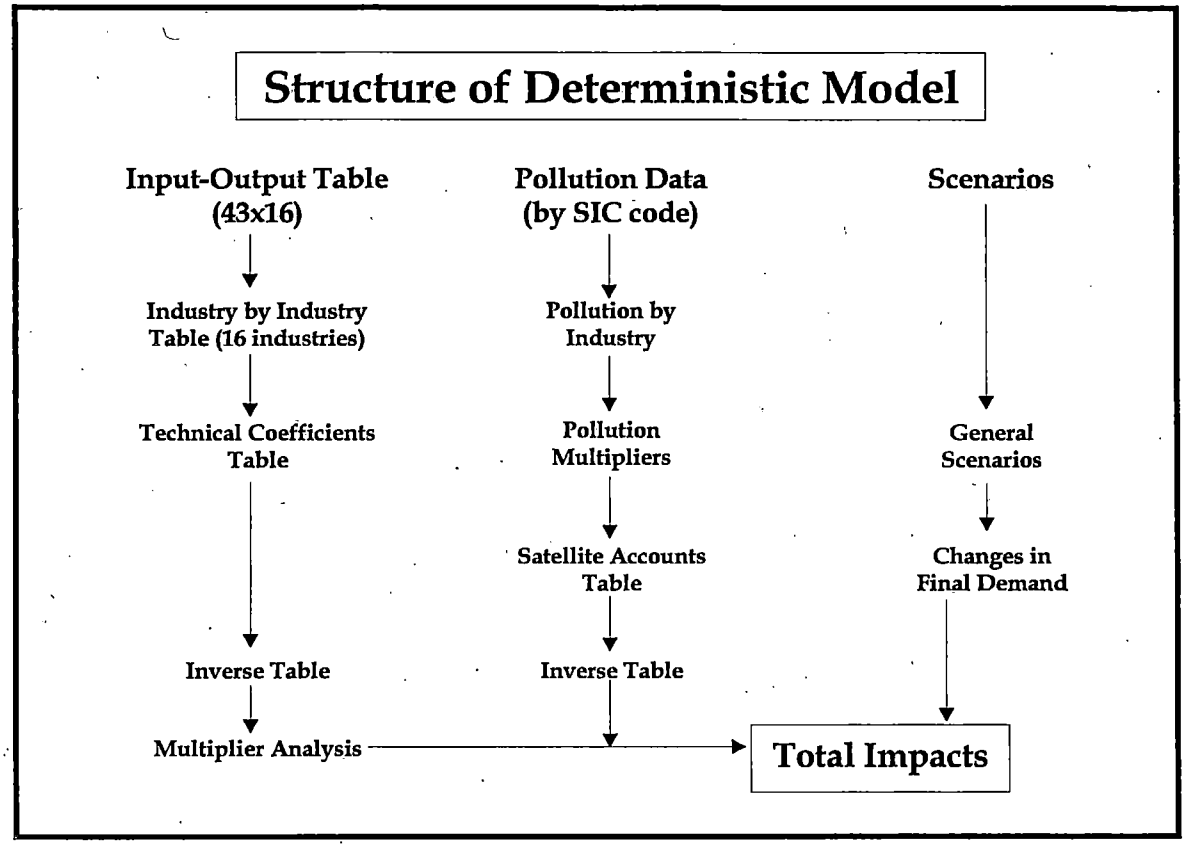
Outputs → / ↓ Inputs	Industry 1	Industry 2	Industry 3	Industry 4	Pollutant A	Pollutant B	Employ-ment
Industry 1	a_{11}	a_{12}	a_{13}	a_{14}	0	0	0
Industry 2	a_{21}	a_{22}	a_{23}	a_{24}	0	0	0
Industry 3	a_{31}	a_{32}	a_{33}	a_{34}	0	0	0
Industry 4	a_{41}	a_{42}	a_{43}	a_{44}	0	0	0
Pollutant A	a_{a1}	a_{a2}	a_{a3}	a_{a4}	0	0	0
Pollutant B	a_{b1}	a_{b2}	a_{b3}	a_{b4}	0	0	0
Employment	a_{e1}	a_{e2}	a_{e3}	a_{e4}	0	0	0

- We restructured the commodity-by-industry table to an industry-by-industry table, as noted above. (The mathematics of this are presented in the mathematical appendix to this annex. Figure E.1 also presents a schematic diagram of the various steps we progressed through in going from the basic commodity-by-industry input output structure to the final set of impacs.) The table is now square, and reflects the intermediate outputs - or the structure of the provincial economy - in a 16 x 16 matrix.

- Next, we calculated the technical coefficients matrix, which presents the data in terms of dollars' worth of input from industry i needed to produce one dollar worth of output of industry j.

- Using environmental, economic and social indicators data (which can be attached to specific industries), we developed a set of indicator satellite accounts, which present the data in terms of tonnes of pollutant or number of employees per dollar of output of industry j. In some cases - such as with the data in the British Columbia Emissions Inventory - data are specified in terms of standard industrial classification index, and need to be converted to the input-output categories. These data are then linked to the economic accounts to come up with a matrix such as indicated in Table E.2.

Figure E.1. Diagram of the Steps Used in Reaching the Assessment of Total Impacts



- This matrix (which was now of the dimension 25 x 25, once all of the satellite accounts were attached) was manipulated to calculate the total value of each indicator associated with a dollar's worth of demand for each industry. As the output of each industry changes, so will the total impacts associated with this output. It is important to note that these impacts include the ***direct*** impacts associated with a change in output of any given sector, the ***indirect*** impacts associated with changes in output of all other sectors (whose output must change in response to changes in the original sector), and the ***induced*** impacts associated with changes in consumer spending.

- We next developed a set of scenarios based on the futuring exercise; while there is not a direct, one-to-one correspondence between the exercise itself and the scenarios used in the deterministic modeling, the exercise was used to generate the types of changes in final demand - and, hence, economic and pollutant output - that might be expected. From this, we were able to calculate the changes in the set of indicator accounts based on these scenarios.

Each of these steps is presented in more detail below, corresponding to the specific indicator data used in the study.

THE ECONOMY OF B.C. AND THE FRASER RIVER BASIN

A detailed description of the Fraser River Basin economy was presented previously in this report. In this section on deterministic modeling, the regional economy is divided into 16 industrial sectors, as noted in Table E.3. This table also presents the total output of each sector, which is the sum of intermediate demands and final demands, for 1990, the base year used in this study.

Changes in the final demand for all sectors, expressed as gross domestic product, between 1984 and 1994 is presented in Figure E.2, and the average annual growth in employment by sector between 1971 and 1989 (which is used later for employment scenarios) is presented in Figure E.3. The complete 43 x 16 input-output transactions tables (the 'make' matrix, which corresponds to the amount of commodity each industry produces; the 'use' matrix, which corresponds to the inputs of each commodity to every industry; and the final demand matrix, which depicts the final demand for each of the 43 commodities) for the B.C. economy is presented in Tables E.4, E.5, and E.6. Although this table could be regionalized to the Fraser River Basin, the actual technical coefficients table - which is a snapshot of the level of technology used by each sector and which is the appropriate table for the scenario analysis - is virtually the same for both the province and the region; hence, the provincial table was used in this analysis.

Figure E.2. Gross Domestic Product (GDP) for British Columbia, 1984 - 1994

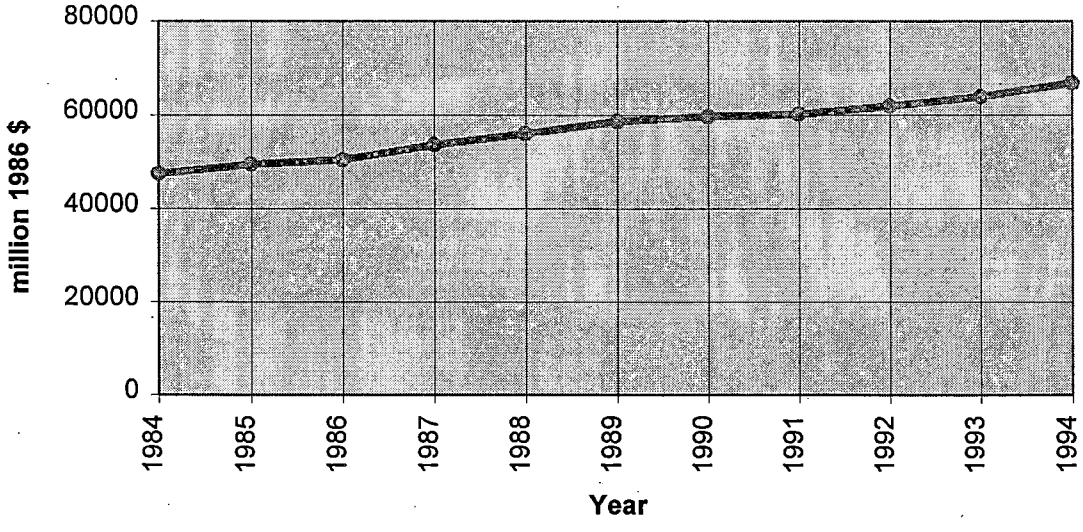


Table E.3. Total Output for Each of the 16 Industries in the FRB

Industry	Total Output (million $)
AGRICULTURE	1675
FISHING & TRAPPING	568
LOGGING & FORESTRY	4293
MINING QUARRYING & OIL WELLS	26319
MANUFACTURING	13280
CONSTRUCTION	8638
TRANSPORTATION & STORAGE	2771
COMMUNICATION	2460
OTHER UTILITY	5736
WHOLESALE TRADE	7190
RETAIL TRADE	20959
FINANCE,INSURANCE & REAL ESTATE	14937
COMMUNITY,BUSINESS, PERSONAL SERVICE	3862
OPERATING, OFFICE, CAFÉ. & LAB.	2803
TRAVEL,ADVERTISING & PROMOTION	3645
TRANSPORTATION MARGINS	80

Figure E.3. B.C. Employment by Sector: Annual Average Growth Rate, 1971 - 1989

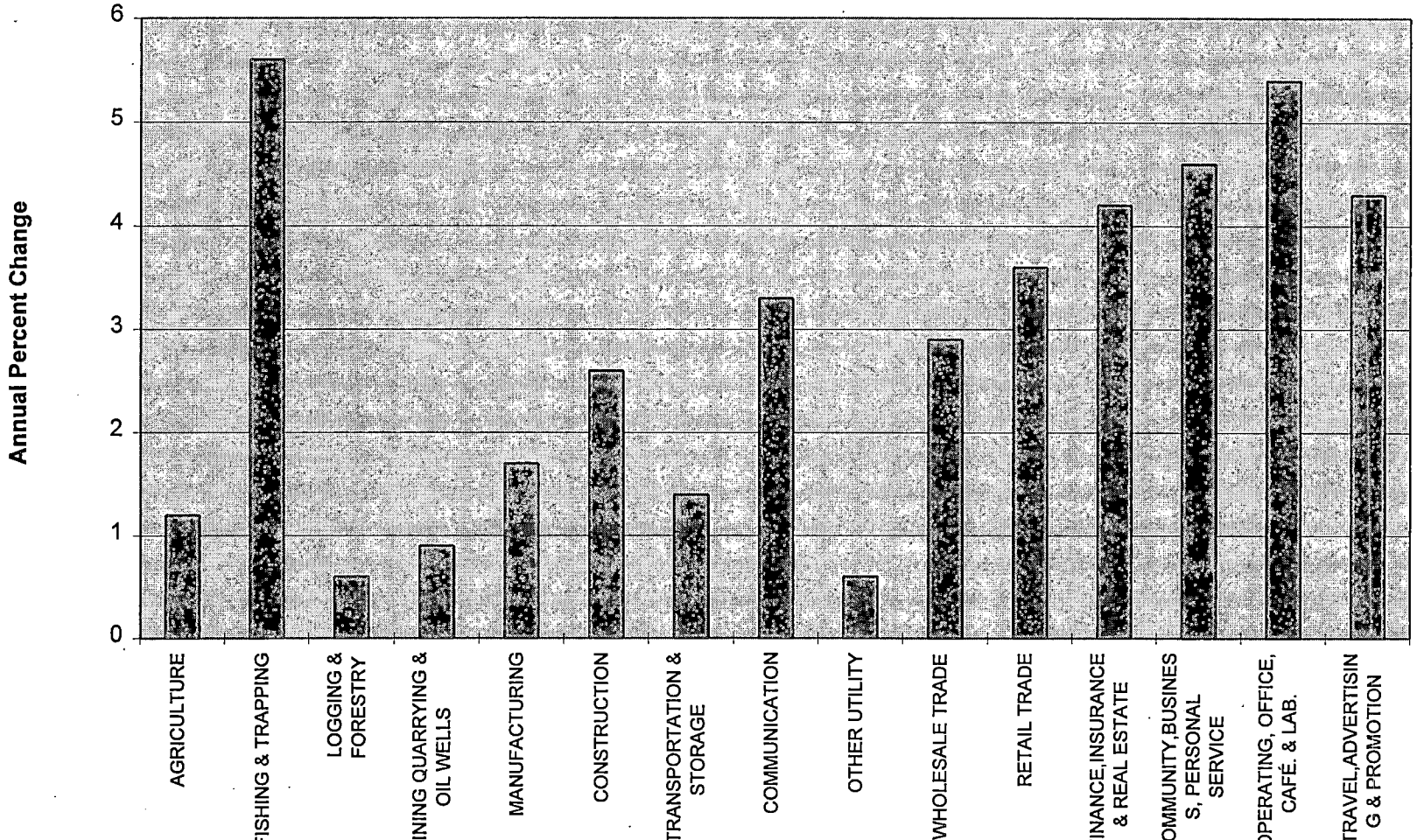


Table E.4. Commodity Outputs (Intermediate Only) by Industry, British Columbia 1990 (in Thousand Dollars)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
1	GRAINS	AGRICULTURE	FISHING & TRAPPING	LOGGING & FORESTRY	MINING QUARR & OIL WELLS	MANUFACTURIN	CONSTRUCTION	TRANSPORTATI & STORAGE	COMMUNICATIO	OTHER UTILITY	WHOLESALE TRADE	RETAIL TRADE	FINANCE,INSU & REAL ESTAT	COMMUNITY,BU PERSONAL SER	OPERATING, O CAFE. & LAB.	TRAVEL,ADVER & PROMOTION	TRANSPORTATI MARGINS	TOTAL
2	OTHER AGRICULTURAL PRODUCTS																	
3	FORESTRY PRODUCTS	133537	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	133538
4	FISHING & TRAPPING PRODUCTS	1491905	0	159335	0	19	0	4998	0	0	0	0	0	0	0	0	0	1656029
5	METALLIC ORES & CONCENTRATES	18606	0	3853201	0	26072	0	0	0	3448	1699	0	0	0	0	0	0	3903026
6	MINERALS FUELS	0	558448	0	0	0	0	0	0	0	0	0	0	0	0	0	0	558448
7	NON-METALLIC MINERALS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1220953
8	SERVICES INCIDENTAL TO MINING	0	0	0	1813268	0	0	0	0	0	0	0	0	0	0	0	0	1813268
9	MEAT,FISH & DAIRY PRODUCTS	0	0	0	0	0	5039	0	0	0	2616	0	0	0	0	0	0	207624
10	FRUIT,VEG.,FEED,MISC.FOOD PROD	0	0	0	405884	0	0	0	0	0	0	0	0	0	0	0	0	405884
11	BEVERAGES	16509	8304	0	0	2095933	0	0	0	0	952	2443	0	0	0	0	0	2124141
12	TOBACCO & TOBACCO PRODUCTS	168	0	0	0	1086986	0	0	0	0	23948	47427	0	0	0	0	0	1158529
13	RUBBER,LEATHER,PLASTIC FAB.PRO	0	0	0	0	469990	0	0	0	0	12	0	0	0	0	0	0	470002
14	TEXTILE PRODUCTS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	KNITTED PRODUCTS & CLOTHING	0	0	0	0	299093	0	0	0	0	10743	0	0	0	0	0	0	309836
16	LUMBER,SAWMILL,OTHER WOOD PROD	0	0	0	0	125649	0	0	0	0	745	844	0	0	0	0	0	127238
17	FURNITURE & FIXTURES	0	0	0	0	283190	0	0	0	0	1715	154	0	0	0	0	0	285059
18	PAPER & PAPER PRODUCTS	0	0	12959	0	6797155	0	0	0	0	23117	26445	0	0	0	0	0	6859676
19	PRINTING & PUBLISHING	0	0	0	0	256949	0	0	0	0	463	0	0	0	0	0	0	257412
20	PRIMARY METAL PRODUCTS	0	0	0	0	5080685	0	0	0	0	10315	0	0	0	0	0	0	5091000
21	METAL FABRICATED PRODUCTS	0	0	0	0	958206	0	0	0	0	1997	0	0	0	0	0	0	960203
22	MACHINERY & EQUIPMENT	0	0	0	0	0	0	0	0	0	3502	0	0	0	0	0	0	1311152
23	AUTOS,TRUCKS,OTHER TRANSP. EQP	0	0	0	0	1230892	0	0	0	0	7089	0	0	0	0	0	0	1237981
24	ELEC. & COMMUNICATIONS PROD.	0	0	134	20750	902075	0	0	0	0	11196	0	0	0	0	0	0	934155
25	NON-METALLIC MINERAL PRODUCTS	0	0	0	0	931029	0	168050	0	0	5177	0	0	0	0	0	0	1107256
26	PETROLEUM & COAL PRODUCTS	0	0	0	0	416191	0	0	44383	0	8984	0	0	0	0	0	0	469558
27	CHEMICALS,CHEMICAL PROD	0	0	0	0	775249	0	0	0	0	1832	0	0	0	0	0	0	777081
28	MISC. MANUFACTURED PRODUCTS	0	0	0	23521	0	0	0	0	0	0	0	0	0	0	0	0	1775638
29	RESIDENTIAL CONSTRUCTION	12101	0	0	0	741122	0	0	0	0	17335	0	0	0	0	0	0	770558
30	NON-RESIDENTIAL CONSTRUCTION	0	0	0	0	298095	0	0	0	0	8278	0	0	870	0	0	0	307243
31	REPAIR CONSTRUCTION	0	0	0	0	0	5524956	0	0	0	0	0	0	0	0	0	0	5524956
32	TRANSPORTATION & STORAGE	0	0	0	0	0	5646122	0	0	0	0	0	0	0	0	0	0	5646122
33	COMMUNICATION SERVICES	0	0	0	0	0	2036549	0	0	0	0	0	0	0	0	0	0	2036549
34	OTHER UTILITIES	0	0	119578	0	0	0	6289161	0	10610	0	3203	0	22	0	0	0	9421574
35	WHOLESALE MARGINS	0	0	0	0	0	0	0	2597173	0	0	0	0	0	0	0	0	2597173
36	RETAIL MARGINS	0	0	0	0	0	0	0	0	2340352	0	0	0	0	0	0	0	2354448
37	IMPUTED RENT OWNER OCPD. DWEL.	0	0	448	0	0	0	3692	0	0	5244999	0	0	41088	0	0	0	5591038
38	OTHER FINANCE,INS.,REAL ESTATE	0	0	0	0	0	0	19014	40	41909	0	6104023	0	95067	0	0	0	6260053
39	BUSINESS SERVICES	0	0	0	0	0	0	0	0	0	0	0	8372798	0	0	0	0	8372798
40	PERSONAL & OTHER MISC. SERVICE	2175	0	12276	14406	25956	36674	32109	2247	5196	19258	20601	12323300	68114	0	0	0	12562314
41	TRANSPORTATION MARGINS	0	0	0	0	10809	0	10283	114657	0	47822	0	14016	4765302	0	0	0	4966442
42	OPERATING,OFFICE,LAB & FOOD	0	1525	134866	7262	124201	31140	113333	12574	55227	279512	985233	249301	9966810	0	0	0	11960984
43	TRAVEL, ADVERTISING, PROMOTION	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3644613	3644613
44	NON-COMPETING IMPORTS	0	0	0	0	0	0	0	0	0	0	0	0	0	3862192	0	0	3862192
45	UNALLOCATED IMPORTS & EXPORTS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2802775	0	2802775
46	NET INDIRECT TAXES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	LABOUR INCOME	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	NET INCOME UNINC. BUSINESS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	OTHER OPERATING SURPLUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		1675001	568277	4293359	3696945	26318958	13280480	8638732	2771074	2460505	5736507	7190373	20959415	14937173	3862192	2802775	3644613	122836379

Table E.5. Commodity Inputs (Intermediate Only) by Industry, British Columbia 1990 (in Thousand Dollars)

		1 AGRICULTURE	2 FISHING & TRAPPING	3 LOGGING & FORESTRY	4 MINING QUARR & OIL WELLS	5 MANUFACTURIN	6 CONSTRUCTION	7 TRANSPORTATI & STORAGE	8 COMMUNICATIO	9 OTHER UTILITY	10 WHOLESALE TRADE	11 RETAIL TRADE	12 FINANCE,INSU & REAL ESTAT	13 COMMUNITY,BU PERSONAL SER	14 OPERATING, O CAFE. & LAB.	15 TRAVEL,ADVER & PROMOTION	16 TRANSPORTATI MARGINS	TOTAL
1	GRAINS	110402	0	0	0	62114	0	0	0	0	5392	0	0	0	0	0	0	177908
2	OTHER AGRICULTURAL PRODUCTS	324158	290	0	0	669272	39713	1134	0	0	724	2414	0	53817	17615	0	0	1109137
3	FORESTRY PRODUCTS	210	0	975185	0	2933245	3711	0	0	0	6639	0	0	0	0	0	0	3918990
4	FISHING & TRAPPING PRODUCTS	0	9508	0	0	366096	0	0	0	0	0	0	0	1992	937	0	0	378433
5	METALLIC ORES & CONCENTRATES	0	0	0	0	0	0	0	0	0	246	0	0	1415	0	0	0	518190
6	MINERALS FUELS	1337	388	127	0	0	1228	15452	902	22450	0	11438	19156	13938	0	83	0	1437083
7	NON-METALLIC MINERALS	2619	862	0	15567	123942	83656	515	0	0	177	41	0	844	158	0	0	228411
8	SERVICES INCIDENTAL TO MINING	0	0	0	110360	0	251332	0	0	0	0	0	0	0	0	0	0	361692
9	MEAT,FISH & DAIRY PRODUCTS	821	0	0	0	270798	0	0	0	0	496	2855	0	420971	124591	0	0	820532
10	FRUIT,VEG.,FEED,MISC.FOOD PROD	182262	25734	0	0	206645	0	1572	0	0	4696	10788	0	198325	51400	0	0	681422
11	BEVERAGES	0	0	0	0	0	0	0	0	0	12	0	0	14607	0	12888	0	60252
12	TOBACCO & TOBACCO PRODUCTS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	RUBBER,LEATHER,PLASTIC FAB.PRO	2011	0	0	0	219563	42608	27	0	0	18867	20564	0	16664	0	334	0	725066
14	TEXTILE PRODUCTS	4805	11689	5954	425	179655	108069	9331	174	0	2086	5286	0	33074	20350	0	0	380898
15	KNITTED PRODUCTS & CLOTHING	0	0	0	0	5960	0	0	0	0	0	13065	0	3408	33618	0	0	56051
16	LUMBER,SAWMILL,OTHER WOOD PROD	1322	4401	0	102	1344724	904057	0	0	0	10009	3007	0	6538	5299	0	0	2279459
17	FURNITURE & FIXTURES	0	0	0	0	18580	6721	0	77	0	0	431	1166	1726	0	0	0	28701
18	PAPER & PAPER PRODUCTS	1547	0	0	1389	717472	94523	8231	0	0	37186	78446	0	59329	170162	960	0	1169245
19	PRINTING & PUBLISHING	0	0	0	0	0	0	5747	45915	1264	0	6149	35874	23601	487962	507679	0	1193894
20	PRIMARY METAL PRODUCTS	0	0	0	66427	742483	263978	10572	0	0	3440	0	0	2172	22863	0	0	1111935
21	METAL FABRICATED PRODUCTS	7184	1565	32121	2832	469051	1030056	8091	19	0	18099	20591	0	3338	199846	0	0	1792793
22	MACHINERY & EQUIPMENT	7937	6267	19509	139449	155247	106161	4197	36	0	2000	0	4427	253	320715	0	0	766198
23	AUTOS,TRUCKS,OTHER TRANSP. EQP	548	30052	9742	26053	295845	7806	414962	11	0	405	0	0	0	93774	5465	0	874663
24	ELEC. & COMMUNICATIONS PROD.	0	12751	0	4997	163207	348349	26383	91315	7240	2478	0	0	255	246502	823	0	904300
25	NON-METALLIC MINERAL PRODUCTS	1707	447	272	10593	174598	696953	6623	0	0	2059	594	0	9018	17934	0	0	920798
26	PETROLEUM & COAL PRODUCTS	42929	28866	79345	83662	304072	171949	550838	12507	26771	65371	57317	61495	85585	5743	45853	0	1621293
27	CHEMICALS,CHEMICAL PROD	57301	1096	4975	102680	764892	136837	9115	309	0	9751	3686	0	44963	210418	178	0	1346201
28	MISC. MANUFACTURED PRODUCTS	0	4627	0	0	119763	87940	6149	2032	0	2551	4380	0	79853	118742	51174	0	477211
29	RESIDENTIAL CONSTRUCTION	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	NON-RESIDENTIAL CONSTRUCTION	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	REPAIR CONSTRUCTION	22095	5700	49500	81000	104000	9100	257441	48500	53200	13900	32370	688983	41157	0	0	0	1406906
32	TRANSPORTATION & STORAGE	5612	7096	415824	39921	152276	40868	1051945	18716	4182	98210	50951	16145	39181	0	476249	3644614	6061989
33	COMMUNICATION SERVICES	7683	452	3528	10351	112794	23738	148404	100205	12789	157699	142473	199153	279309	0	247577	0	1646154
34	OTHER UTILITIES	27424	1013	3768	122467	542379	11883	82732	19189	38307	53603	166505	276031	155161	0	59	0	1506521
35	WHOLESALE MARGINS	33208	16074	40302	153266	576719	552767	201839	13445	6205	70113	27491	16997	152577	570427	26679	0	2458109
36	RETAIL MARGINS	8751	2319	1274	2684	3558	86109	7930	3227	1464	4946	4637	3117	78039	205277	29943	0	443275
37	IMPUTED RENT OWNER OCPD. DWEL.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	OTHER FINANCE,INS.,REAL ESTATE	57269	7171	471365	379761	549755	230437	342389	71967	269289	460535	653533	1781052	971300	0	0	0	6245823
39	BUSINESS SERVICES	10765	2451	9675	100019	255498	937274	155076	84309	36189	229286	293036	1104382	679636	0	378344	0	4175940
40	PERSONAL & OTHER MISC. SERVICE	14573	5442	138079	110996	486392	252162	535157	95250	42599	64645	64222	135185	471478	127373	838582	0	3382135
41	TRANSPORTATION MARGINS	24174	3065	5585	28014	738046	264314	30469	3470	1177	10173	8428	3765	43491	96832	10561	0	1271564
42	OPERATING,OFFICE,LAB & FOOD	78716	4303	458540	167434	1024056	109240	207305	40944	48371	99615	105714	312018	388595	0	0	0	3044851
43	TRAVEL, ADVERTISING, PROMOTION	172	0	10569	27973	312325	64630	183750	39700	18972	354250	352412	578746	502518	0	0	0	2445917
44	NON-COMPETING IMPORTS	0	0	0	0	0	0	0	0	0	0	1728	0	13242	0	0	0	118155
45	UNALLOCATED IMPORTS & EXPORTS	0	0	0	0	0	0	0	0	0	0	0	0	0	80879	0	0	80879
46	NET INDIRECT TAXES	-19064	16371	87554	195768	305355	913538	210257	11727	139966	126271	204944	1873415	167155	405227	169144	0	4807628
47	LABOUR INCOME	314308	67458	1168061	821710	6477390	3914101	2623326	1069198	295780	2831199	3949562	3822928	6211788	0	0	0	33266909
48	NET INCOME UNINC. BUSINESS	97638	115665	106383	15484	15848	564790	112595	327	5767	37400	249400	1861551	1854470	0	0	0	5037319
49	OTHER OPERATING SURPLUS	242586	175159	197132	863130	2345609	941093	1366749	997592	1428658	923543	641935	8264940	1812493	0	0	0	20100619
	TOTAL	1675010	568282	4293369	3696995	26318994	13280666	9638884	2771090	2460540	5736523	7190393	20959436	14937476	3862262	2802774	3644614	122837308

Table E.6. British Columbia 1990 Final Demand, by Commodity (in Thousand Dollars)

		1 PE DURABLE	2 PE SEMI-DURABLE	3 PE NON-DURABLE	4 PE SERVICES	5 CON BUSINESS	6 CON GOVERNMENT	7 M&E BUSINESS	8 M&E GOVERNMENT	9 GCE GROSS CURREN EXPENDITURES	10 GCE SALE OF GOODS, SERVI	11 DOMESTIC FINAL DEMAND
1	GRAINS	0	0	0	0	0	0	0	0	0	0	0
2	OTHER AGRICULTURAL PRODUCTS	0	4188	415475	65395	0	0	0	0	164497	-17	649538
3	FORESTRY PRODUCTS	0	0	31280	0	0	0	0	0	0	-16783	14497
4	FISHING & TRAPPING PRODUCTS	0	0	7719	0	0	0	0	0	0	-518	7201
5	METALLIC ORES & CONCENTRATES	0	0	0	0	0	0	0	0	0	0	0
6	MINERALS FUELS	0	0	92134	4209	0	0	0	0	18532	-355	114520
7	NON-METALLIC MINERALS	0	932	6152	0	0	0	0	0	3550	-1496	9138
8	SERVICES INCIDENTAL TO MINING	0	0	0	0	0	0	0	0	0	0	0
9	MEAT,FISH & DAIRY PRODUCTS	0	0	1415167	7741	0	0	0	0	466	0	1423374
10	FRUIT,VEG.,FEED,MISC.FOOD PROD	0	0	1367081	6641	0	0	0	0	0	0	1373722
11	BEVERAGES	0	0	483202	3618	0	0	0	0	0	-124	486696
12	TOBACCO & TOBACCO PRODUCTS	0	0	140972	2247	0	0	0	0	0	0	143219
13	RUBBER,LEATHER,PLASTIC FAB.PRO	35470	208888	19538	4285	0	0	4671	2138	10	0	275000
14	TEXTILE PRODUCTS	48613	111381	4351	1516	0	0	2522	1803	21741	0	191927
15	KNITTED PRODUCTS & CLOTHING	0	865952	0	17319	0	0	0	0	14041	-479	896833
16	LUMBER,SAWMILL,OTHER WOOD PROD	13335	13780	241	0	0	0	282	93	0	0	27731
17	FURNITURE & FIXTURES	289008	20231	0	25203	0	0	211014	34087	2355	0	581898
18	PAPER & PAPER PRODUCTS	0	22130	199448	0	0	0	0	0	1175	0	222753
19	PRINTING & PUBLISHING	0	360418	0	26635	0	0	0	0	129621	-17256	499418
20	PRIMARY METAL PRODUCTS	0	0	0	0	0	0	-59000	0	0	-10	0
21	METAL FABRICATED PRODUCTS	3426	82209	6944	179	0	0	108875	8985	9417	0	220035
22	MACHINERY & EQUIPMENT	87788	25717	0	5939	0	0	2060789	68169	15221	-229	2263394
23	AUTOS,TRUCKS,OTHER TRANSP. EQP	1817084	0	0	27515	30963	0	962856	82330	297590	0	3218338
24	ELEC. & COMMUNICATIONS PROD.	614610	52530	0	27508	0	0	485063	61905	143608	0	1385224
25	NON-METALLIC MINERAL PRODUCTS	0	98159	0	0	0	0	1325	43	0	0	99527
26	PETROLEUM & COAL PRODUCTS	0	0	590399	37789	0	0	0	0	58303	-2542	683949
27	CHEMICALS,CHEMICAL PROD	6229	16413	545856	8794	0	0	0	0	229908	-13813	793387
28	MISC. MANUFACTURED PRODUCTS	302725	248123	78960	43990	0	0	78322	52028	73354	-9830	867672
29	RESIDENTIAL CONSTRUCTION	0	0	0	0	5524956	0	0	0	0	0	5524956
30	NON-RESIDENTIAL CONSTRUCTION	0	0	0	0	3971189	1620000	0	0	54933	0	5646122
31	REPAIR CONSTRUCTION	0	0	0	27582	0	0	0	0	602103	0	629685
32	TRANSPORTATION & STORAGE	0	0	61019	1351832	0	0	0	0	110379	-158763	1364467
33	COMMUNICATION SERVICES	0	0	0	1149144	0	0	0	0	164770	-338	1313576
34	OTHER UTILITIES	0	0	776235	174050	0	0	0	0	197292	-315457	832120
35	WHOLESALE MARGINS	545573	260444	916002	14378	1633	0	823874	37923	103046	-6324	2696549
36	RETAIL MARGINS	1577095	1557973	2509984	16355	2546	0	54867	5167	88513	0	5812500
37	IMPUTED RENT OWNER OCPD. DWEL.	0	0	0	8372798	0	0	0	0	0	0	8372798
38	OTHER FINANCE,INS.,REAL ESTATE	0	0	0	5670247	1737000	0	0	0	261547	-267868	7400926
39	BUSINESS SERVICES	0	0	0	272889	0	0	0	3939	689903	-71926	894805
40	PERSONAL & OTHER MISC. SERVICE	736433	26949	0	7773490	0	0	0	0	2086221	-1437216	9185877
41	TRANSPORTATION MARGINS	90953	100780	246930	2929	837	0	79232	7456	21597	0	550714
42	OPERATING,OFFICE,LAB & FOOD	0	0	0	175671	0	0	0	0	641671	0	817342
43	TRAVEL, ADVERTISING, PROMOTION	0	0	0	83450	0	0	0	0	273408	0	356858
44	NON-COMPETING IMPORTS	0	0	98182	0	0	0	0	0	0	0	98182
45	UNALLOCATED IMPORTS & EXPORTS	0	0	0	0	0	0	0	0	0	0	0
46	NET INDIRECT TAXES	788142	295823	2071576	258706	238391	0	484472	41934	130058	0	4309102
47	LABOUR INCOME	0	0	0	1588239	0	0	0	0	8830865	0	10419104
48	NET INCOME UNINC. BUSINESS	0	0	0	0	0	0	0	0	0	0	0
49	OTHER OPERATING SURPLUS	0	0	0	122067	0	0	0	0	1064563	0	1186630
	TOTAL	6956484	4373020	12084847	27370350	11507515	1620000	5299164	408000	16504258	-2321344	83802296

ECONOMIC AND ENVIRONMENTAL INDICATORS

In order to assess the linkages between indicators, the deterministic modeling utilized environmental and economic indicators. In particular, we were interested in the generation of waste products associated with economic activity. Because of the availability of data (which must be assigned to one of the 16 economic sectors), we focused on air contaminants, economic output, and employment. Eight airborne pollutants were selected for this study:

Total Particulate Matter (TPM)
Carbon Monoxide (CO)
Nitrous Oxide (NO_x)
Sulfur Dioxide (SO_2)
Volatile Organic Compounds (VOC)
Carbon Dioxide (CO_2)
Methane (CH_4)
Chlorofluorocarbons (CFCs)

Although it is not the purpose of this document to present a detailed discussion of the sources and impacts of these pollutants, it should be noted that all of the pollutants listed above have multiple effects on the environment, and many have both local and long-distance effects. In particular:

- CO, CO_2, CH_4, NO_x and CFCs are considered 'greenhouse gases', and contribute to atmospheric heat retention;
- TPM and SO_2 may cause atmospheric cooling, affect visibility and have respiratory impacts on humans;
- SO_2 and NO_x contribute to acid precipitation;
- The reaction of NO_x and VOCs with oxygen and sunlight causes photochemical smog; and
- CFCs are responsible for the depletion of the stratospheric ozone layer.

These pollutants result from industrial and combustion processes, and can readily be assigned to individual industries. The principal source of data used in this section was the 1990 British Columbia Emissions Inventory of Common Air Contaminants (B.C. Environment, Air Resources Branch, 1994). Carbon dioxide emissions were taken from federal estimates (Jaques, 1992) and provincial studies (B.H. Levelton and Associates, 1990), and CFCs were taken from Archibald (1992). The complete table of pollutants by industry is presented in Table E.7.

Table E7. Annual B.C. Pollution, by sector, 1990, in tonnes per million dollars of output

	TPM $t/10^6$ $	CO $t/10^6$ $	NOx $t/10^6$ $	SOx $t/10^6$ $	VOC $t/10^6$ $	CO_2 $t/10^6$ $	CH_4 $t/10^6$ $	CFCs $t/10^6$ $
AGRICULTURE	6.0	0.1	0.7	0.0	6.3	93.7	56.7	0.0
FISHING & TRAPPING	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LOGGING & FORESTRY	40.3	145.8	8.6	0.9	8.3	1668.0	4.1	0.0
MINING QUARRYING & OIL WELLS	1.4	0.3	1.9	5.3	0.3	0.0	27.0	0.0
MANUFACTURING	3.9	19.8	1.5	2.0	2.2	1089.4	3.0	0.0
CONSTRUCTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRANSPORTATION & STORAGE	0.6	5.0	2.2	0.1	2.1	2111.8	1.3	0.0
COMMUNICATION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OTHER UTILITY	1.1	0.2	1.0	0.1	0.0	173.1	0.6	0.0
WHOLESALE TRADE	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
RETAIL TRADE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FINANCE,INSURANCE & REAL ESTATE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COMMUNITY,BUSINESS, PERSONAL SERVICE	0.5	3.3	1.0	0.2	3.7	0.0	0.0	0.0
OPERATING, OFFICE, CAFÉ. & LAB.	0.0	0.0	0.0	0.0	0.0	40.4	0.0	0.0
TRAVEL,ADVERTISING & PROMOTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRANSPORTATION MARGINS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Including Non-Point Sources

Source: B.C. Environment, 1990

THE FINAL MODEL

Once the satellite accounts - for pollution and employment in this case - are added to the technical coefficients matrix, the new matrix can be manipulated to provide a matrix of the total amount of income or pollution or employment resulting from a dollar change in the final demand for any given industry. With the 'hybrid' table (see Table E.8), the units are in dollars or tonnes of pollutant (of a certain type) or employees per dollar of final demand). Given that the final demand sector contains the demand by households, government or exports, the table can then be used to assess the impacts of changes in any of these sectors on any given indicator. In the case of the Fraser Basin, four scenarios are developed (an infinite number are possible, of course). These scenarios were informed by the futuring exercise which we undertook during the study. In all cases, a fifteen year time horizon was used, starting with a base year of 1990 (the year of the input-output table and the pollution accounts). The purpose of that exercise was simply to have a general sense of what types of changes are occurring in the Fraser Basin which should be considered in our analysis. For example, in one scenario the final demand for Community, Business and Personal Services sector is projected to decline by 15% by year 2005 due to government cutbacks in social assistance. While the exact amount of the decline did not result from the futuring exercise, it was apparent in the exercise that this was a likely scenario for the future, and should be included as one of our test runs.

Model Results

Four scenarios were run to demonstrate the utility of the deterministic model. Since the focus was on the environmental implications of economic activity, Tables E.9 and E.10 depict the impact on pollution only. The scenarios were, as follows:

Scenario #1: **Retail Trade increases at 3.6% per year.** The assumption was that the increase in retail trade over the past decade would continue at the same rate it did in the 1980s, in response to continued population growth in the Fraser River Basin.

Scenario #2: **A decline in the final demand for Community, Business and Personal Services by 15% by year 2005.** In this scenario, there will be a decline in the government demand for certain services based on expected cutbacks in social services. While it is possible that this demand will be made up from other final demand categories (ie, households), the objective was to isolate the impacts of government cutbacks to one sector .

Scenario #3: **Increase in the demand for Forest Products by 1.5% per year.** This is an 'export driven' scenario, resulting from the implications of NAFTA and

Table E.8. Income (in $) and pollution (in tonnes), per dollar of final demand, B.C.,1990.

	Base year 1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
AGRICULTURE	1.2797325	0.0051673	0.0075131	0.0044416	0.0480978	0.0209076	0.0040553	0.0024051	0.0017116	0.0046559	0.0043636	0.0021798	0.0088705	0.0254004	0.0101136	0.0046512
FISHING & TRAPPING	0.004619	1.0276878	0.0029614	0.0022695	0.0315574	0.0111928	0.0020406	0.0012673	0.0008385	0.0020076	0.0022997	0.0010516	0.0029893	0.0131152	0.0054364	0.0023273
LOGGING & FORESTRY	0.063352	0.0213469	1.3114264	0.0176798	0.2243618	0.0824165	0.0190711	0.0099342	0.0065914	0.0171733	0.0173536	0.0080583	0.020668	0.0930072	0.0470903	0.0424171
MINING QUARRYING & OIL WELLS	0.0032017	0.0022204	0.0024059	1.0370754	0.0022263	0.0237133	0.0049669	0.0014134	0.0124423	0.0011552	0.0031989	0.0026007	0.0021895	0.0022032	0.0027554	0.0056011
MANUFACTURING	0.2204622	0.1371338	0.1380562	0.1067639	1.5220251	0.5378311	0.0954814	0.0592785	0.0390289	0.0946743	0.1089467	0.048873	0.1269677	0.6098239	0.2532436	0.1088864
CONSTRUCTION	0.0253994	0.0144151	0.0290397	0.0317476	0.0197457	1.0124529	0.0406219	0.0215838	0.0278321	0.0099102	0.0120411	0.0386038	0.0094384	0.012626	0.0174533	0.0458479
TRANSPORTATION & STORAGE	0.0943522	0.0541054	0.2037328	0.0622407	0.1758805	0.1279437	1.1993207	0.0288996	0.0169819	0.0602425	0.0431935	0.0214188	0.0419721	0.1495369	0.2832573	1.3418038
COMMUNICATION	0.0135302	0.005894	0.0134807	0.0129787	0.0179809	0.0165053	0.027962	1.0396779	0.0106961	0.0380046	0.0295836	0.0261781	0.0277919	0.0181088	0.1038765	0.0314517
OTHER UTILITY	0.0300638	0.0070401	0.0114456	0.0420142	0.0387437	0.0187749	0.0178403	0.011001	1.0200133	0.0156693	0.0297796	0.0176875	0.017409	0.0210732	0.0184973	0.0215648
WHOLESALE TRADE	0.0527273	0.0408162	0.0507906	0.0635431	0.0644186	0.0756672	0.0447222	0.015054	0.0121089	1.0259209	0.016634	0.0111826	0.0261285	0.1862407	0.0466381	0.0507537
RETAIL TRADE	0.0179466	0.0087097	0.0162116	0.0095723	0.0136227	0.0163796	0.0124846	0.0073329	0.0052361	0.0079056	1.0068175	0.0048793	0.0137118	0.0628361	0.0441577	0.014636
FINANCE,INSURANCE & REAL ESTAT	0.071999	0.027879	0.1668421	0.1290722	0.0825768	0.0648071	0.0687028	0.0397917	0.1188065	0.0979188	0.1080324	1.0971069	0.0849871	0.0601841	0.0712026	0.0795775
COMMUNITY,BUSINESS, PERSONAL S	0.0521829	0.0309823	0.0878523	0.089991	0.0882754	0.1303955	0.1168551	0.0812139	0.0513925	0.0983363	0.0911968	0.0888519	1.1092475	0.0922279	0.4506328	0.1319447
OPERATING, OFFICE, CAFÉ. & LAB.	0.0825376	0.0194411	0.1573609	0.0615165	0.0960387	0.0497933	0.0410842	0.0230776	0.0271126	0.0301483	0.0276899	0.0234663	0.0403019	1.0468814	0.038606	0.0484358
TRAVEL,ADVERTISING & PROMOTION	0.0133621	0.0078162	0.0211349	0.0221293	0.0329235	0.0264477	0.0366652	0.021558	0.015061	0.0729231	0.0594139	0.0359868	0.0449952	0.0304935	1.0330537	0.0413072
TRANSPORTATION MARGINS	0.0561049	0.0213818	0.0229178	0.0277491	0.0956868	0.0765112	0.0190129	0.0090099	0.0065537	0.0127841	0.0120667	0.0070565	0.0172292	0.0910669	0.0303288	1.0216026
TPM	0.011269	0.0014834	0.0536228	0.0027523	0.0154199	0.0057296	0.0020249	0.0007206	0.0016503	0.0012	0.0012591	0.0006091	0.001982	0.0064296	0.0033719	0.0031262
CO	0.0143169	0.0062005	0.1952763	0.0055758	0.0640284	0.0237408	0.0110069	0.0030351	0.0022294	0.0050038	0.0052086	0.0025448	0.0093712	0.0266881	0.0147667	0.0154338
NOx	0.0020384	0.0005526	0.0119908	0.0025406	0.0047459	0.0019978	0.003115	0.0003346	0.0012199	0.0005394	0.0005343	0.0002999	0.0015687	0.0021715	0.0018815	0.0036715
SOx	0.000558	0.0003174	0.0014741	0.0057841	0.003293	0.0013142	0.0004017	0.000154	0.0002545	0.0002365	0.0002739	0.0001382	0.0004812	0.0013491	0.0006762	0.0004725
VOC	0.0094481	0.000743	0.0120454	0.0011823	0.0061866	0.0027583	0.0033345	0.0006	0.0004286	0.0009993	0.0008444	0.0005671	0.0047452	0.002941	0.00329	0.0039164
CO2	0.6735438	0.3017516	2.7771198	0.2874177	2.4188921	1.0008106	2.6736479	0.1452425	0.2672235	0.2633725	0.2455348	0.1161321	0.2669073	1.1836561	0.9583226	3.0290815
CH4	0.0736716	0.0009221	0.0065903	0.0287902	0.0084735	0.0039378	0.0023046	0.0004352	0.0011735	0.0007341	0.0008015	0.0004099	0.0010882	0.0038973	0.0019734	0.0026802
CFCs	4.643E-06	1.154E-05	8.471E-06	3.544E-06	1.138E-05	7.494E-06	4.237E-05	2.098E-06	1.298E-06	4.784E-06	1.478E-05	1.86E-06	1.351E-05	8.736E-06	1.559E-05	4.743E-05
Employment	-0.0296048	-0.014866	-0.0234315	-0.0070961	-0.0029367	-0.0076484	-0.008686	-0.0134201	-0.0040886	-0.0129152	-0.0286722	-0.0044744	-0.0207979	-0.0311108	-0.0692164	0
Total Output Multipliers (column sums)	2.0815734	1.4320369	2.2431718	1.7207849	2.5541617	2.2917399	1.7508873	1.3724989	1.3724074	1.58943	1.5726116	1.4351819	1.5948977	2.5148256	2.4563434	2.9928089

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increased demand from abroad. The amount is consistent with annual increases in the demand for that sector's output from 1984 to 1994.

Scenario #4: **Construction increases by 2.6% per year.** Again, this is a population growth-driven scenario, and reflects the historical growth in the demand for construction and the expected population growth for the Fraser River Basin over the next decade.

When these changes in final demand were incorporated into the model, the results were, as follows:

Table E.9. Change in Pollution Due to Changes in Final Demand, by Scenario

Scenario Analysis: 2005	Change in Pollution (tonnes)				Total 1990
	Scen. #1	Scen. #2	Scen. #3	Scen. #4	Levels
TPM	5672.0739	-2459.5067	2696.8225	31869.43	305999.7
CO	23463.67	-11629.077	9820.9154	132051.47	1240571.2
NOx	2407.1009	-1946.6391	603.04877	11112.28	120363.3
SOx	1233.7222	-597.09628	74.136921	7309.7583	79971.5
VOC	3803.7361	-5888.5309	605.79076	15342.462	179266.1
CO2	1106091.6	-331214.32	139668.07	5566717.7	54816095
CH4	3610.686	-1350.3253	331.44278	21902.792	303289
CFCs	66.589434	-16.768218	0.4260277	41.681955	615.6

Table E.10. Percent Change in Pollution Due to Changes in Final Demand

Scenario Analysis: 2005	Percent Change in Pollution			
	Scen. #1	Scen. #2	Scen. #3	Scen. #4
TPM	2.34%	-1.01%	1.11%	13.14%
CO	2.36%	-1.17%	0.99%	13.27%
NOx	2.51%	-2.03%	0.63%	11.60%
SOx	2.42%	-1.17%	0.15%	14.36%
VOC	2.48%	-3.83%	0.39%	9.99%
CO2	2.44%	-0.73%	0.31%	12.29%
CH4	1.93%	-0.72%	0.18%	11.72%
CFCs	11.80%	-2.97%	0.08%	7.39%

How reliable are these projections? They provide an estimate of the general increase or decrease in pollution which can be expected given specific changes in final demand. The analysis is a static one; that is, it is assumed the level of technology remains constant over time and that prices do not change (and no product substitution is allowed). While this restricts the applicability of the model, it does not negate its usefulness as a tool for demonstrating how different indicators or measures are linked to one another, and how changes in one affect changes in the other.

Scenario Analysis #2: Setting Target Levels for Pollution

What happens to the economy if pollution levels are constrained to specific amounts (for example, if CO_2 is limited to 90% of 1990 levels)? Table E.8 provides the answer directly. Each cell contains the amount of pollution attributable to a dollar's worth of final demand for a specific sector. If, for example, there was a 1000$ increase in the final demand for manufactured goods - by households let's say - then CO_2 emissions would increase by almost 2.5 tonnes. This also implies that restrictions on CO_2 emissions - if not applied across-the-board, but applied in a manner to minimize costs - would affect the manufacturing, transportation and transportation margin sectors the most. The values in the cells give the CO_2 which could be *saved* and its effect on total output.

Conclusion

The deterministic modeling, despite the constraints of linear functions and fixed technology, is a useful exercise in linking indicators of sustainability for three reasons.

1) It can provide useful input into other qualitative modeling exercises - such as the complex systems models used in this study;

2) It explicitly recognizes the links between and among indicators; and

3) It gives a general sense of the magnitude of the changes which can be expected given various policy and other scenarios.

It should be noted that this form of modeling is particularly useful at an aggregate spatial scale; that is, the provincial level or large watershed level. It can also be used to provide estimates of the structure of regional economies in watersheds which cross provincial (or international) borders, assuming the input-output tables are compatible. However, its utility is limited at the sub-basin or sub-sub-basin level, due to inadequate or suppressed data. Provided one has pollution (or other indicator) data by industry, the development of satellite accounts can be a major contribution to better understanding how changes in one indicator -or sets of indicators - affect other indicators. This is particular true for economic-ecological linkages, although some social indicators could potentially be included as well.

Most importantly, the conclusions derived from the deterministic modeling effort and results are consistent with those obtained via correlation modeling or the qualitative systems modeling; it is clear that time is better spent focusing on a small number of indicators which can be linked at fairly aggregate spatial levels. Once modeling moves to the more local level the benefits are far outweighed by the costs of data acquisition and the problems of data availability and reliability.

MATHEMATICS

Input-Output Analysis

Input-output models are economic models of the structure of production. They are widely used around the world to track flows of goods and services between different industries in a given region, between industries and their customers in the household sector, and between different regions. Since its initial development by Leontief (1936), input-output analysis has become an invaluable tool for economists and others to estimate the impacts of exogenous changes in the economy. The basic structure of an input-output table is simply an accounting framework of inter-industry dollar flows, with additional columns added to represent final demand sectors and additional rows to represent payments to government, labour and value added. The literature in input-output analysis is quite extensive and texts describing the basic method have been written by Miernyk (1965), Richardson (1972) and Miller and Blair (1985). The standard industry-by-industry input-output table is a framework for listing the activities in a regional economy. The table can then be mathematically manipulated to estimate all direct and indirect impacts of an exogenous change in the economy. The model can also incorporate various types of multipliers, including pollution, so that one can calculate the total pollution in a region resulting from a change in the economic structure of that region (e.g., a new firm moving to the region). Although input-output models are most commonly restricted to the analysis of economic production and in particular, the implications of changes in consumption (final demand), government expenditures, and the structure of production, it is possible to assess some of the ecological effects of economic output by means of extensions to the model. In the late 1960s, a few economists and regional scientists expanded the use of input-output models to include environmental variables. Models were developed by Cumberland (1966), Daly (1968), Isard (1969, 1972) and Victor (1972) and a complete review of economic-ecological input-output models can be found in Lonergan and Cocklin (1985).

Industry-by-industry input-output models are based upon a series of equations depicted by:

$$X_i = \sum_j z_{ij} + Y_i$$

where: X_i = total output from industry i;
Y_i = final demand for products from industry i;
with z_{ij} = the dollar value of goods and services purchased by industry j from industry i.

A set of technical coefficients (a_{ij}) are then calculated, where a_{ij} corresponds to the dollar's worth of input from industry i needed to produce one dollar's worth of output of industry j.

$$a_{ij} = \frac{z_{ij}}{X_j}$$

Then, by substitution:

$$X = a_{ij} X + Y$$

And:

$$X = (I - A)^{-1} Y$$

Which expresses the total output (X) of each industry in terms of final demand.

Here **X** and **Y** are nx1 matrices, **A** is the nxn technical coefficients matrix (with elements a_{ij}) and **I** is the nxn identity matrix. Use of this last expression allows one to calculate, among other things, the impact on total economic output resulting from an increase in final demand in one or more industries. The model is based upon a view of the economy as a series of interlinked industries which buy and sell to one another in the process of satisfying their requirements in the consumptive sectors. Thus, increases or decreases in final demand have both direct and indirect affects on total output, as industries make round by round adjustments to their output.

Extensions to input-output models in order to adapt them to ecological analysis can take essentially one of two basic forms. One extension is accomplished by developing additional matrices which include either the output of pollution per unit of economic activity in each sector, or the resource requirement per unit of sectoral activity. A second

extension entails the addition of so-called ecological sectors to the industry list. The resulting model is revised with additional 'pseudo' industries.

The first type of extension is a simple multiplier approach which does not necessitate the monetary valuation of either resource inputs or pollution outputs. An example of this approach is provided by Cumberland (1966) in an assessment of the environmental implications of a given level of output based on estimated pollution production. The problem is most easily expressed as follows:

$$\mathbf{EX} = \mathbf{P}$$

where: $\mathbf{E}$ = the kxn matrix of pollution output (CO_2 for example) per unit of sectoral economic activity. The coefficient e_{ij} is the production of the ith pollutant per unit of output in the jth sector; and

$\mathbf{P}$ = the kx1 matrix of total pollution output for k pollutants, with $\mathbf{P}_i$ the total output of the ith pollutant.

If the coefficients e_{ij} are stable, then it is reasonable to substitute for $\mathbf{X}$ in the previous equation in order to assess the influence of a change in final demand on the output of pollutants (see Miller and Blair (1985) for a full description). In similar fashion, a matrix $\mathbf{R}$ can take the place of $\mathbf{E}$, where $\mathbf{R}$ gives the total resource requirements per unit of sectoral output. The main limitation to this approach is that the stability of the coefficients of the matrices $\mathbf{E}$ and $\mathbf{R}$ is unclear. To the extent that the coefficients are as stable as the a_{ij} values (the structural coefficients of economic productions), it is neither more nor less reasonable to superimpose the structure of current production on the future economy. However, a recent empirical test of the predictive powers of pollution coefficients indicates that their stability is highly questionable (Breuil 1992).

The extension of I/O models by including additional 'eco-sectors', is a conceptually elegant way of building fully integrated ecological-economic models, but is inherently difficult due to the following two assumptions in the model: (1) single product industries; and (2) the need to assign market prices to all industry outputs. These difficulties are minimized by the use of a commodity-by-industry model, where there are more commodities than industries. Commodities are listed in rows and industries or activities are listed in columns. Such models are most easily built by examining the flow of ecological commodities from so-called sectors of the environment to all economic as well as other environmental sectors. A new technical coefficient matrix is compiled on this

basis, and the model is manipulated as in (3). Instead of characterizing only the economy, however, the new matrix has four sectors: an economic sector, an economic-ecological sector, an ecological-economic sector, and an ecological-ecological sector (Daly 1968). Thus, full implementation of the model requires that all flows, including the ecological-ecological (i.e. flows between different sectors of the environment, e.g. wetland habitat provision for wildfowl) would have to be expressed in dollars or some other unit metric. In addition, the relationships between all sectors are again assumed constant and linear. Over the short term, this assumption may be valid for economic processes; however, it is less likely to hold in ecological sectors. These two requirements make the integrated ecological-economic I/O models conceptually appealing but operationally limited. There is some potential, however, to use these I/O models as information systems. These may not afford the analytical capabilities of traditional I/O models, but there are clear applications for well organised ecological-economic information systems. The connection between full ecological-economic I/O transactions tables and physical resource accounts is clear.

Despite the limitations of I/O methodology as applied to ecological systems, there has been some considerable effort directed at adapting I/O for strictly ecological modeling. Much of the work can be traced to Hannon (1973) who draws an analogy between the interactions of ecological systems and those of an economy. Leontieff's vision of the economy is one in which there is a fixed structural production system which links individual sectors. It is possible to conceive of ecosystems functioning in like fashion, with exchanges of matter and energy across a food web (Ulanowicz and Kemp 1979). Analytical use of such models hinges on the extent to which exchanges between ecosystem 'compartments' can be expressed in terms of a single measure.

Annex F

Complex System Models

INTRODUCTION TO COMPLEX SYSTEM MODELING

The science of 'complexity' focuses on the analysis of systems that exhibit certain types of behaviour. In particular, a 'complex adaptive system' is characterized by four distinct attributes. First, there are agents in the system that act in parallel. Second, these agents are organized along many layers, and are capable of re-organizing and self-organizing. Third, they operate by sets of 'rules' which, in effect, are equivalent to the anticipation of future events and conditions. Finally, the complex system allows niches of certain types of activity to establish themselves. Many systems have been found which fit into such a description: including economic structures, living organisms, neurological networks, and ecosystems. Common features of such systems are that they generate 'surprises' and that certain types of phenomena 'emerge' as a result of system complexity. The only effective means found to date to investigate these phenomena is the use of simulation. Describing such systems has led to the development of complex system simulator models that augment simple deterministic cause-effect models.

The primary attributes of a complex system model are:

- System as Cause. An underlying attribute of self-organizing or adaptive systems is that the set of rules under which the system (and various indicators) behave, itself will generate much system behaviour. In simple deterministic models, behaviour is often attributed to exogenous shocks, whereas in a complex system model much of the behaviour is endogenously determined through various feedback mechanisms.
- Closed Loops. This component allows causal relationships to be reciprocal such that no absolute distinction is maintained between cause and effect. The importance of various traditional 'causal' factors may shift over time as the overall system itself changes and adapts.
- Operational Cause-Effect Linkages. This component is similar to the standard linkages that one finds in correlation models and deterministic models. The distinction is that, wherever possible, such linkages focus on physical cause-effect relationships as opposed to simple coincidence.
- Dynamic Perspective. Observing changes to system structure over time provide insights into system behaviour.

The major data requirements for complex system models involve the use of time series of high level indicators coupled with knowledge (or hypotheses) of linkages among indicators. These linkages can also be specified as policy variables, which in effect allow explicit modeling of the 'rules' by which the system behaves.

There are a number of major advantages to complex system modeling:

- Reflects Adaptive Systems. Large complex economies show constant adaptation, and complex models (through their feedback loops) readily replicate this type of adaptive behaviour. As such, they are often regarded as more realistic physical representations of conditions.

- Accommodates Qualitative Relationships. Many of the relationships between system components are, initially, difficulty to quantify. Complex models provide a framework for specifying qualitative relationships that still allows meaningful modeling of the system.
- Accommodates Non-Linearities. Most deterministic model structures do not adequately permit specification of non-linear or chaotic relationships. Complex system models allow such relationships to be specified and, indeed, such relationships typically are responsible for much of the adaptive behaviour of the system.
- Applicable to Hot Spots. Sub-systems are readily identified and modeled to demonstrate how these sub-systems can influence the overall system dynamics.
- Intuitive Policy Modeling. Policy variables or institutional arrangements can themselves become part of the dynamic 'rule set' of the system. They are explicitly modeled as linkages between components, and sensitivity of system dynamics can be analysed as a response to changes in this rule set.

The major disadvantage to complex system models is that they have a tendency to become overly complex. There is often a temptation to try to 'model the entire system' which can add complexity without necessarily adding to understanding. Careful modeling requires precise definition of the model purpose (e.g., in terms of the 'rule sets' that it seeks to investigate) and definition of the model that focuses on the minimum number of rules that adequately describe system behaviour ('Occam's Razor'.)

For this research, a prototype example of a complex system model was developed for the Fraser River Basin as a whole. The prototype model used a number of the key indicators to demonstrate model structure and hypothetical linkages in four sectors: economic activities; social conditions; environment; and, policies and institutions. The prototype model was subsequently simplified to remove 'unnecessary' or inefficient indicators. Complexity was also reduced to improve system stability. The resultant model structure was then further fine-tuned for the Fraser River Basin to develop a set of four base models as described below.

THE FRB MODELS

The STELLA II (Version 3) modeling environment is being used for developing experimental models of the Fraser River Basin that can be used for policy simulation. The primary rationale for using this environment is that it easily permits specification of non-linearities and circular relationships (which are not readily modeled in a deterministic environment). In addition, STELLA provides a simple user interface that can be readily customized as the complexity of the model increases or decreases. The attached flow structure sheets in this annex represent a representation of key model components for four different design cases:

- Backcast Model - Fraser Basin 1971-1991. This is the structural tuning model that was used to develop approximations for many of the control parameters within the model. The internal structure of this model is identical to that of the 1991 Forecast Model. The differences are in the start values and in the policy dependent variables and linkages. The model was tuned with a view to hitting 1991 targets that were consistent with the 1991 Forecast Model. The

data set from 1971 to 1991 was incomplete for many of the indicators hence it was not possible to use standard statistical methods for generating efficient estimators.

- Forecast Model - Fraser Basin 1991+. This is the base case simulation model that is designed to provide 30 year projections of the entire Fraser River Basin. Its design is based on a combination of qualitative policy variable controls, estimated coefficients from the correlation studies, and tuned approximations based on 1971-1991 simulations developed through the Backcast Model. Long-term (30 year) basin simulations provided in the main text are conducted using this model.
- Linked Forecast Model - Fraser Basin 1991-2006. This provides a structure of a 15 year simulation of the Base Forecast Model linked to a single sensitivity scenario of the deterministic input-output model. The primary linkage is through the pollutant coefficients, although the production forecasts and population forecasts in this simulation are also tuned to coincide to those in the deterministic model. Medium-term (15 year) simulations provided in the main text are based on this model structure.
- Hotspot Model - Shuswap Sub-Sub-Basin 1991+. This is the base case simulation model that is designed to provide 30 year projections of the Shuswap area. Its structure is identical to the Basin Forecast Model, although its estimated coefficients and initial values are based on data specific to the sub-sub-basin. Long-term (30 year) basin simulations provided in the main text are conducted using this model.

MODEL DISPLAY STRUCTURES

The display structure of the models have three layers as follows:

- High Level Map Layer. (3 pages) This highlights the inputs and output for the baseline runs of the model. One type of user input is shown in a 'slider' format to demonstrate the primary interface for policy simulations. The outputs shown here are of two types. First, graphical representations of the time series projections of the model are shown in a series of graphs. Second, numerical displays below the slider inputs show the predicted values at the end of the model run; these are used to tune the model in the development stage and facilitate interpreting model results in the simulation stage.
- Model Layer. (3 pages) The structure of the model is summarized in this layer, showing detailed linkages between principle model components. Model layer symbols are basically of the following types:
  - clouds - represent infinite sinks and sources that are external to the model.
  - rectangles - represent stocks. Some of these are 'ovens' or 'conveyors' that permit internal time delays to occur where responses are not instantaneous, or where constraints apply.
  - solitary circles - represent conversions or calculations. Those with a "~" in them are graphical non-linear relations.
  - circles as spigots - represent flows. These control the increase and decrease of stocks.
  - connector arrows - represent a dependency.

- aliases - a number of variables in the model layer occur in more than one place. This arises through aliasing and is done to minimize the number of arrows connecting far-removed parts of the model. On the user-oriented simulation displays these are shaded differently in distinct colours, but this shading is not obvious in black and white flowsheets. As a tip, however, note that: the alias will only have connector arrows flowing out of it whereas the original is fully dynamic.

- Equation and Documentation Layer. This shows all of the equations specified in the model, and documents the meaning and source of key indicators and functional specifications. The reader will note that relationships can be defined as constants, equations, or graphically. All equations are dynamic. Graphical representations are shown where non-linearities are modeled.

The attached model summaries provide details of the Documentation and the Model Layer only for the full Basin Forecast Model; structures and documentation of the other models are identical to this one.

Fraser Basin Dynamic Simulation Model
Version 1.00 (Basin 1971-1991)
Copyright: Ruitenbeek, H.J. 1996
Software: Stella II Version 3.0

Exogenous Growth = 0.024
-0.10 0.10

Cropland Sh = 0.5
0.0 1.0

Exogenous Health Policy = 100
0 100

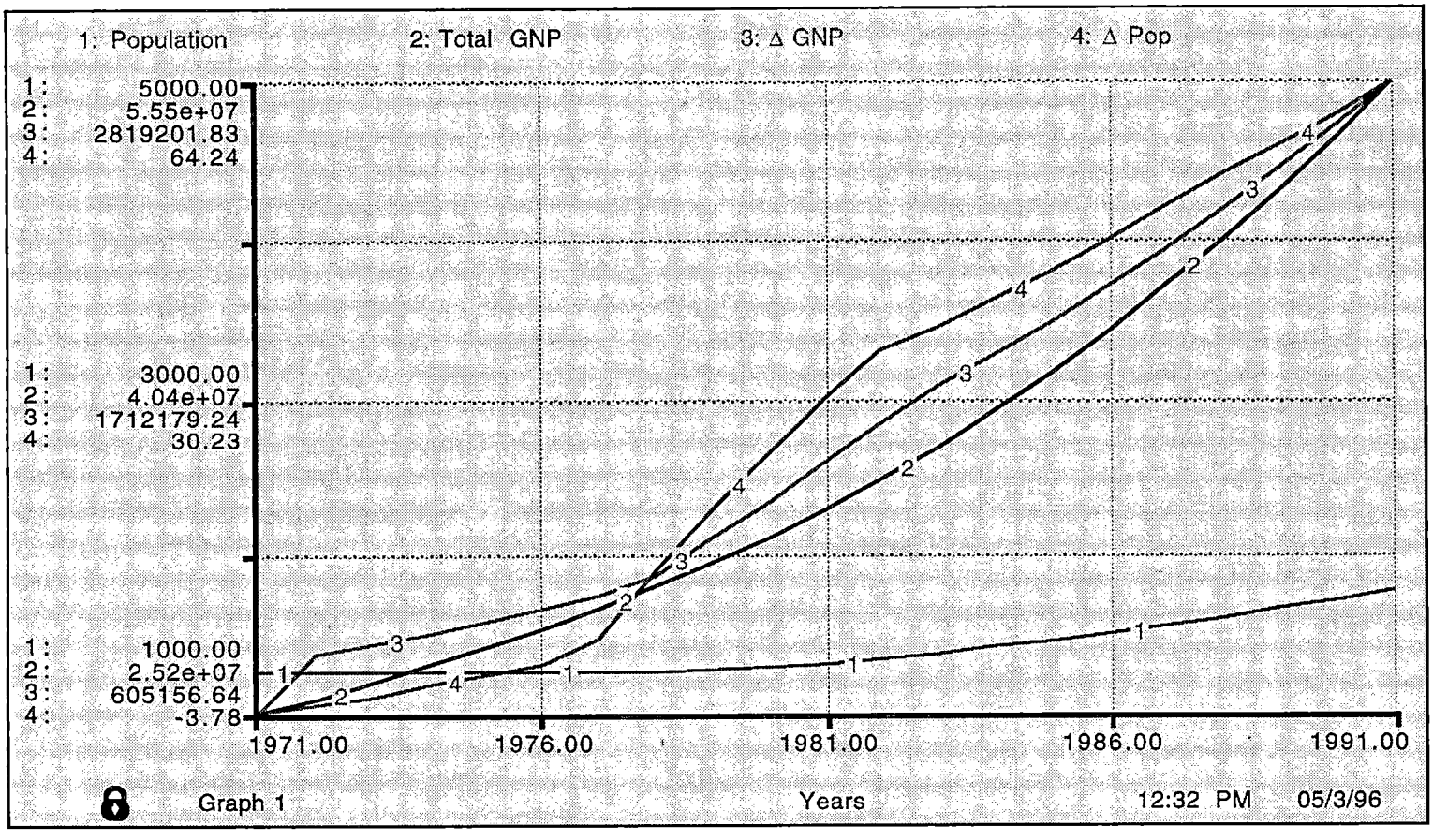
New Land Policy = 0.025
-0.10 0.10

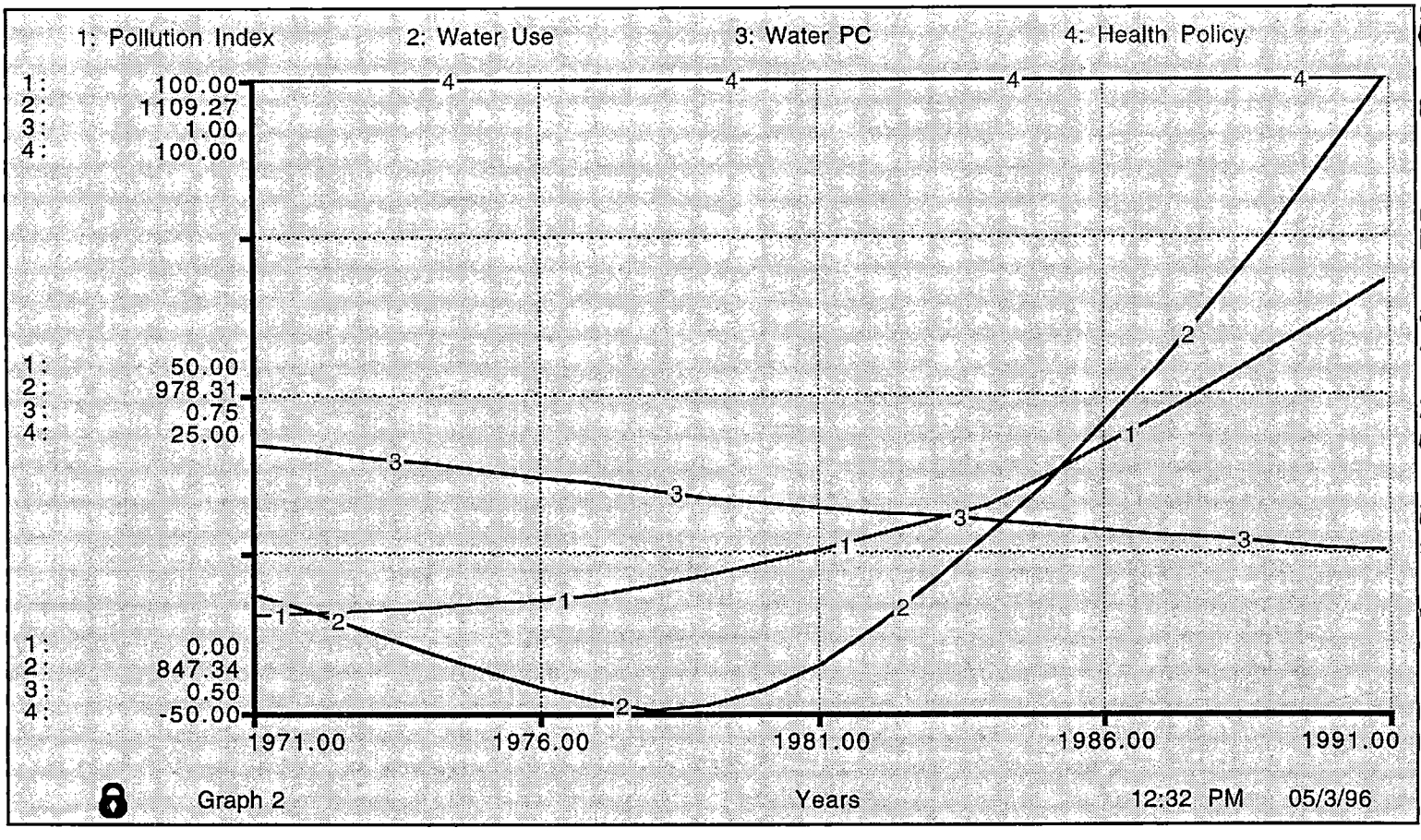
Health Weight = 0.5
0.0 1.0

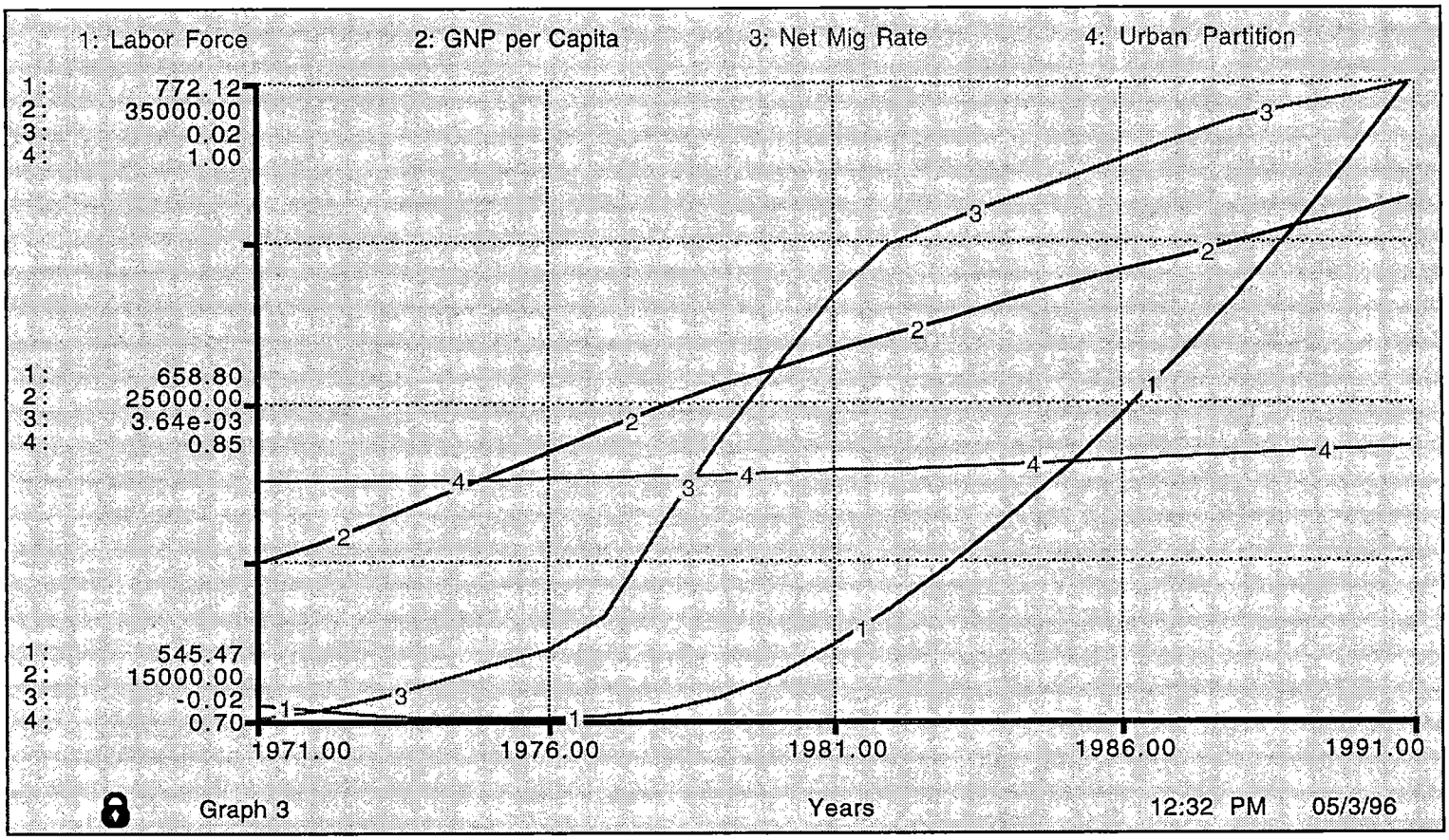
Net Depletion = -0.007
-0.05 0.05

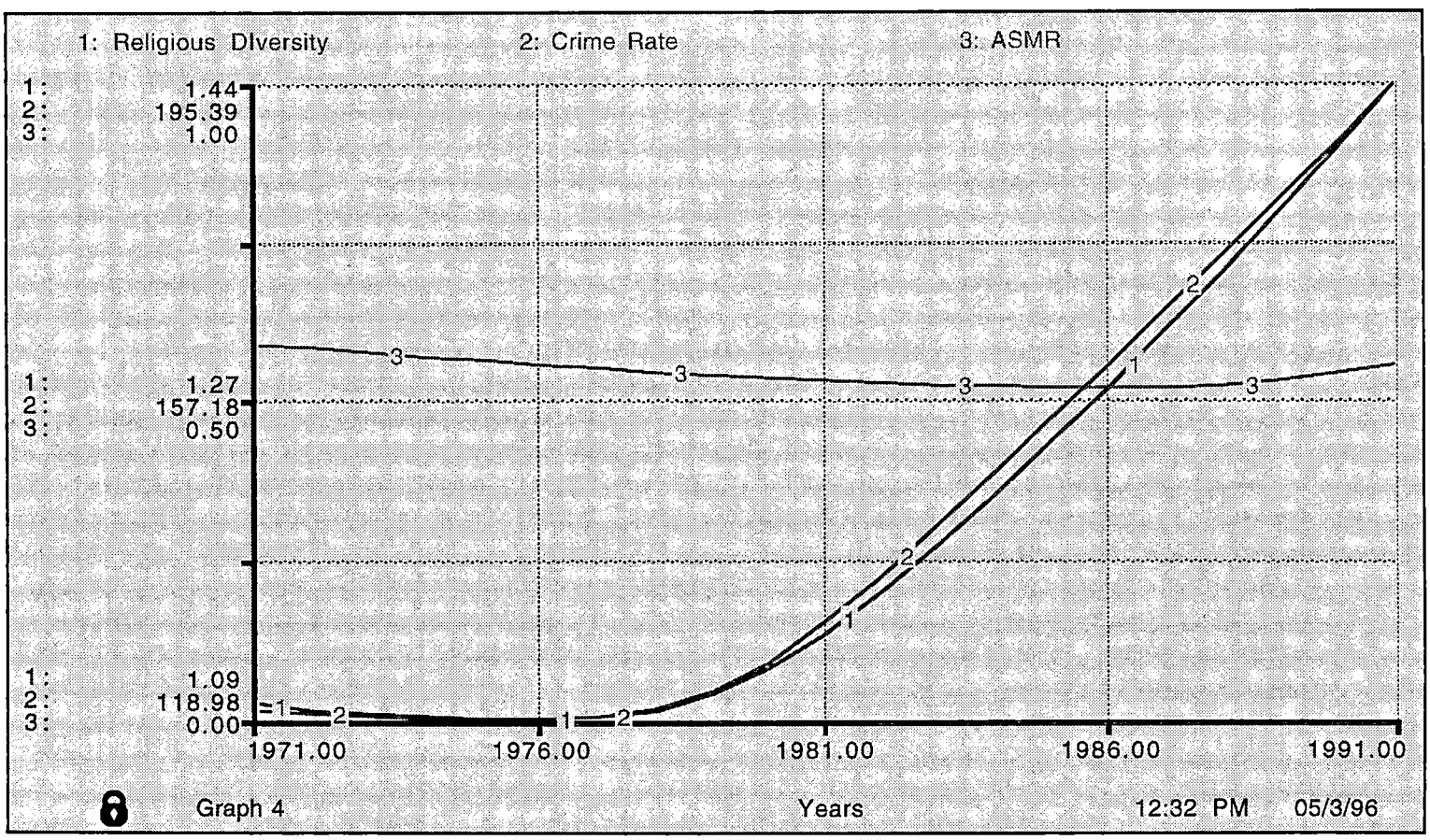
Total GNP	55,540,906
Water Use	1,109
Pollution Index	68
ASMR	0.55
Population	1,770.59
Pop Index	140.44
GNP Index	220.27
Cropland	202,142

Pollution Response = 0
0.0 1.0


1: Population
2: Total GNP
3: Δ GNP
4: Δ Pop
1: 5000.00
2: 5.55e+07
3: 2819201.83
4: 64.24
1: 3000.00
2: 4.04e+07
3: 1712179.24
4: 30.23
1: 1000.00
2: 2.52e+07
3: 605156.64
4: -3.78
1971.00
1976.00
1981.00
1986.00
1991.00
Graph 1
Years
12:32 PM 05/3/96


1: Pollution Index
2: Water Use
3: Water PC
4: Health Policy
1: 100.00
2: 1109.27
3: 1.00
4: 100.00
1: 50.00
2: 978.31
3: 0.75
4: 25.00
1: 0.00
2: 847.34
3: 0.50
4: -50.00
1971.00
1976.00
1981.00
1986.00
1991.00
Graph 2
Years
12:32 PM 05/3/96


1: Labor Force
2: GNP per Capita
3: Net Mig Rate
4: Urban Partition
1: 772.12
2: 35000.00
3: 0.02
4: 1.00
1: 658.80
2: 25000.00
3: 3.64e-03
4: 0.85
1: 545.47
2: 15000.00
3: -0.02
4: 0.70
1971.00
1976.00
1981.00
1986.00
1991.00
Graph 3
Years
12:32 PM
05/3/96


1: Religious DIversity
2: Crime Rate
3: ASMR
1: 1.44
2: 195.39
3: 1.00
1: 1.27
2: 157.18
3: 0.50
1: 1.09
2: 118.98
3: 0.00
1971.00
1976.00
1981.00
1986.00
1991.00
Graph 4
Years
12:32 PM
05/3/96

ASMR(t) = ASMR(t - dt) + (Δ_ASMR) * dt
INIT ASMR = Initial_ASMR
INFLOWS:
Δ_ASMR = GRAPH(Health_Policy-Pollution_Index)
(0.00, 0.027), (5.00, 0.0235), (10.0, 0.021), (15.0, 0.019), (20.0, 0.018), (25.0, 0.0165), (30.0, 0.0155), (35.0, 0.0135), (40.0, 0.0115), (45.0, 0.009), (50.0, 0.0065), (55.0, 0.0035), (60.0, -0.0005), (65.0, -0.0015), (70.0, -0.0025), (75.0, -0.0035), (80.0, -0.005), (85.0, -0.007), (90.0, -0.008), (95.0, -0.008), (100, -0.0095)

Crime_Rate(t) = Crime_Rate(t - dt) + (Δ_Crime_Rate) * dt
INIT Crime_Rate = Initial_Crime_Rate
INFLOWS:
Δ_Crime_Rate = GRAPH(Pop_Growth_Rate*Urban_Partition)
(-0.1, -9.20), (-0.08, -8.40), (-0.06, -7.10), (-0.04, -5.00), (-0.02, -3.20), (6.94e-18, 0.00), (0.02, 6.00), (0.04, 8.00), (0.06, 9.10), (0.08, 9.50), (0.1, 9.90)

Cropland(t) = Cropland(t - dt) + (Δ_Cropland + Encroach) * dt
INIT Cropland = Initial_Cropland
INFLOWS:
Δ_Cropland = Cropland*(New_Land_Policy+Net_Depletion)
Encroach = -Cropland*Urban_Rural_Mix*(Urban_Partition-delay(Urban_Partition,1))

Ethnic_Diversity(t) = Ethnic_Diversity(t - dt) + (Δ_Ethnic_Diversity) * dt
INIT Ethnic_Diversity = Initial_Ethnic_Diversity
INFLOWS:
Δ_Ethnic_Diversity = GRAPH(Pop_Growth_Rate)
(-0.1, 0.00), (-0.08, 0.00), (-0.06, 0.00), (-0.04, 0.00), (-0.02, 0.00), (6.94e-18, 0.00), (0.02, 0.00), (0.04, 0.00), (0.06, 0.00), (0.08, 0.00), (0.1, 0.00)

GINI(t) = GINI(t - dt) + (Δ_GINI) * dt
INIT GINI = Initial_GINI
INFLOWS:
Δ_GINI = 0

Labor_Force(t) = Labor_Force(t - dt) + (Δ_Labor_Force) * dt
INIT Labor_Force = Initial_Labor_Force
INFLOWS:
Δ_Labor_Force = Δ_Pop*Participation_Rate_1

Population(t) = Population(t - dt) + (Δ_Pop) * dt
INIT Population = Initial_Population
INFLOWS:
Δ_Pop = Pop_Growth_Rate*Population

Religious_Diversity(t) = Religious_Diversity(t - dt) + (Δ_Religious_Diversity) * dt
INIT Religious_Diversity = Initial_Religious_Diversity
INFLOWS:
Δ_Religious_Diversity = GRAPH(Pop_Growth_Rate)
(-0.05, -0.05), (0.00, 0.00), (0.05, 0.05)

Res_Empl_Share(t) = Res_Empl_Share(t - dt) + (Δ_Res_Empl_Share) * dt
INIT Res_Empl_Share = Initial_Res_Empl_Sh
INFLOWS:
Δ_Res_Empl_Share = Resource_Impact*Res_Empl_Share

Total__GNP(t) = Total__GNP(t - dt) + (Δ_GNP) * dt
INIT Total__GNP = Initial_GNP
INFLOWS:
Δ_GNP = (Exogenous_Growth+Endogenous_Growth)*Total__GNP

University(t) = University(t - dt) + (Δ_University) * dt
INIT University = Initial_University

INFLOWS:
Δ_University = University*(GNP_per_Capita-DELAY(GNP_per_Capita,1))/DELAY(GNP_per_Capita,1)

Urban_Partition(t) = Urban_Partition(t - dt) + (Δ_Urban_Partition) * dt
INIT Urban_Partition = Initial_Urban_Partition
INFLOWS:
Δ_Urban_Partition = Urban_Partition*Urban_Impact

U_Rate(t) = U_Rate(t - dt) + (Δ_U_Rate) * dt
INIT U_Rate = Initial_U_Rate
INFLOWS:
Δ_U_Rate = U_Rate*U_Impact

Water_Supplies(t) = Water_Supplies(t - dt) + (Water_Demand) * dt
INIT Water_Supplies = 0
TRANSIT TIME = 1
INFLOW LIMIT = 2000
CAPACITY = 2000
INFLOWS:
Water_Demand = Water_Use

CO2 = .5*Total__GNP
Cropland_Sh = .5
Elasticity_Res_to_GNP = -1
Employed = (1-U_Rate)*Labor_Force
Endogenous_Growth = End_Growth_Rate
Endogenous_Health_Policy = Pollution_Index*Pollution_Response
End_Growth_Rate = (1-Cropland_Sh)*(Employed-DELAY(Employed,1))/DELAY(Employed,1)+Cropland_Sh*(Cropland-DELAY(Cropland,1))/DELAY(Cropland,1)
Exogenous_Growth = .024
Exogenous_Health_Policy = 100
GNP_Index = Total__GNP/Initial_GNP*100
GNP_PC_1 = Initial_GNP/Initial_Population
GNP_per_Capita = Total__GNP/Population
GNP_per_Land = Total__GNP/Cropland
Health_Policy = Exogenous_Health_Policy+Endogenous_Health_Policy
Health_Weight = .5
Initial_ASMR = .59
Initial_Crime_Rate = 120
Initial_Cropland = 141678.8
Initial_Ethnic_Diversity = 1.6
Initial_GINI = .36
Initial_GNP = 20000*Initial_Population
Initial_Labor_Force = 549.785
Initial_Population = 1260.743
Initial_Religious_Diversity = 1.1
Initial_Res_Empl_Sh = .053
Initial_University = .16
Initial_Urban_Partition = .8130745
Initial_U_Rate = .0939

Initial_Water_PC = .71025
Natural_Increase = .013
Net_Depletion = -.007
New_Land_Policy = .025
NOx = .002*Total__GNP
Participation_Rate_1 = Labor_Force/Population
Pollution_Response = 0
Pop_Growth_Rate = Natural_Increase+Net_Mig_Rate
Pop_Index = Population/Initial_Population*100
Resource_Impact =
Elasticity_Res_to_GNP*(GNP_per_Land-delay(GNP_per_Land,1))/delay(GNP_per_Land,1)
TPM = .01*Total__GNP
Urban_Impact = -.05*(Res_Empl_Share-delay(Res_Empl_Share,1))/delay(Res_Empl_Share,1)
Urban_Rural_Mix = .1
U_Impact =
Health_Weight*.07777*((ASMR-delay(ASMR,1))/delay(ASMR,1))+(1-Health_Weight)*0.11053*((Res_Empl_Share-DELAY(Res_Empl_Share,1))/DELAY(Res_Empl_Share,1))
Water_PC =
Water_Policy*Initial_Water_PC*(1+Water_Y_Elas*(GNP_per_Capita-GNP_PC_1)/GNP_PC_1)
Water_Policy = 1
Water_Use = Population*Water_PC
Water_Y_Elas = -.20745
Net_Mig_Rate = GRAPH(GNP_per_Capita)
(15000, -0.021), (18000, -0.018), (21000, -0.015), (24000, -0.011), (27000, 0.013), (30000, 0.021), (33000, 0.026), (36000, 0.04), (39000, 0.051), (42000, 0.073), (45000, 0.099)
Pollution_Index = GRAPH(TPM)
(0.00, 0.5), (100000, 4.50), (200000, 11.5), (300000, 18.0), (400000, 33.0), (500000, 56.5), (600000, 77.0), (700000, 88.0), (800000, 92.0), (900000, 94.0), (1e+06, 98.5)

Fraser Basin Dynamic Simulation Model
Version 1.00 (Basin 1991+)
Copyright: Ruitenbeek, H.J. 1996
Software: Stella II Version 3.0

Exogenous Growth = 0.015
-0.10 — 0.10

Cropland Sh = 0.5
0.0 — 1.0

Exogenous Health Policy = 50
0 — 100

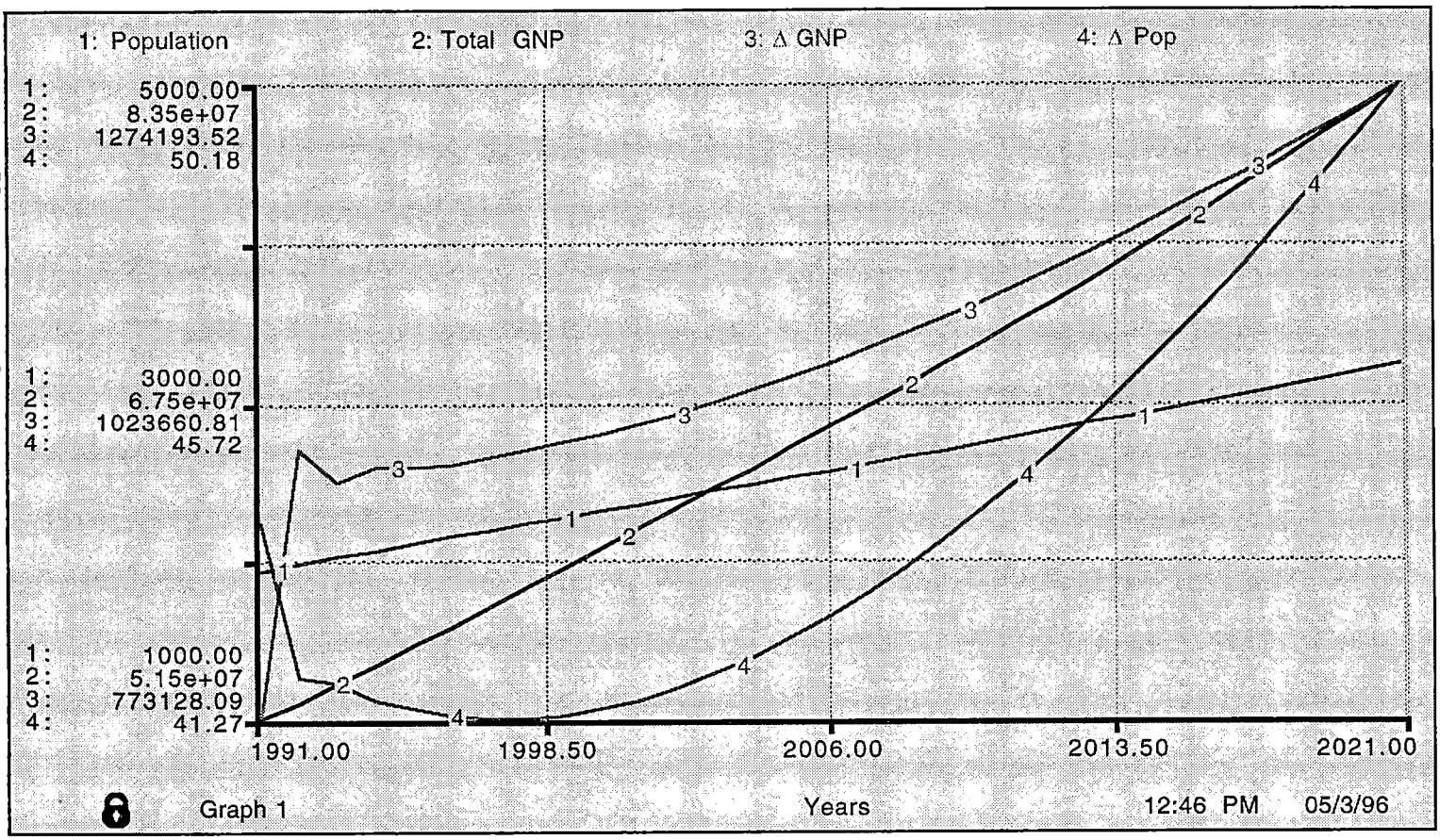
New Land Policy = -0.01
-0.10 — 0.10

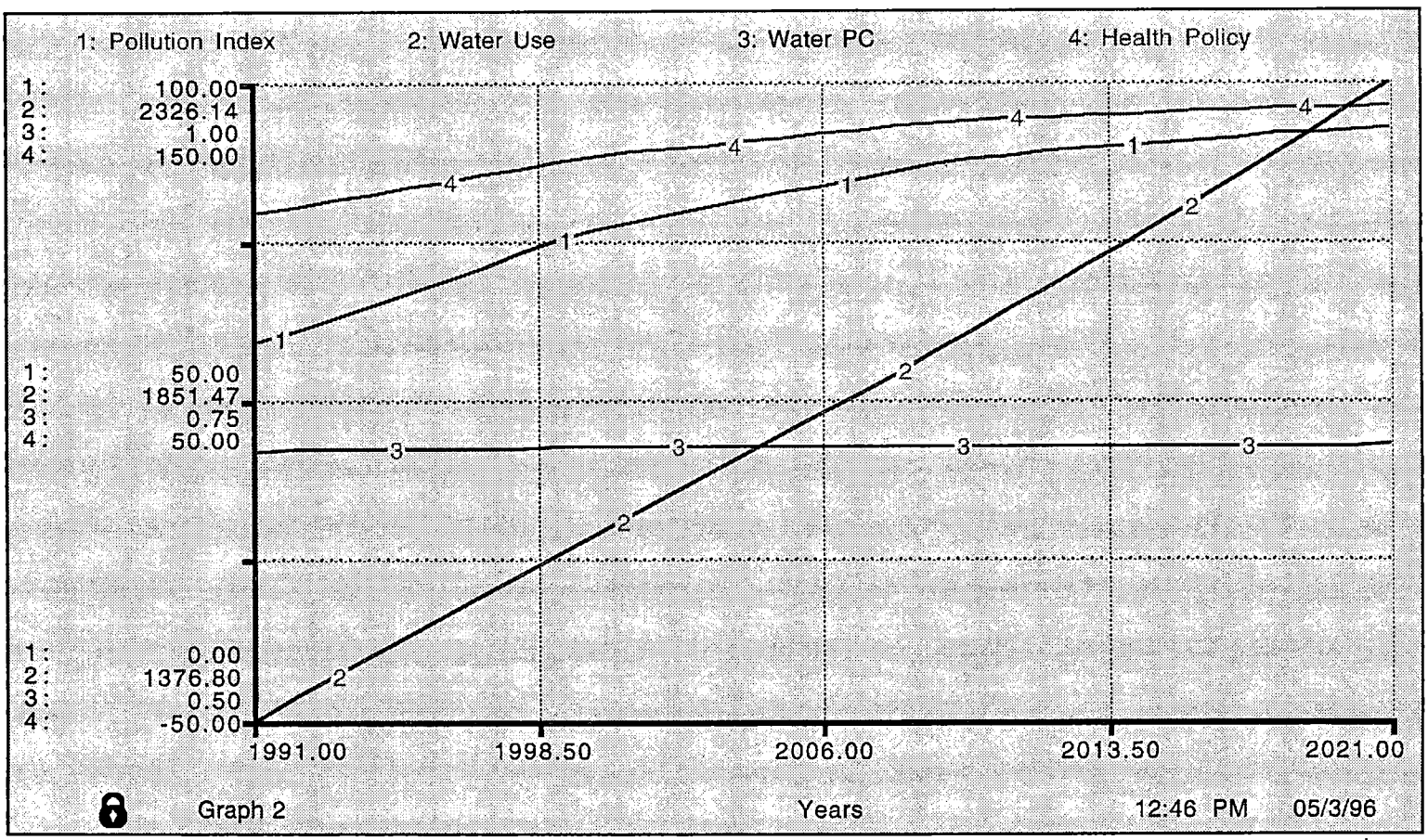
Health Weight = 0.5
0.0 — 1.0

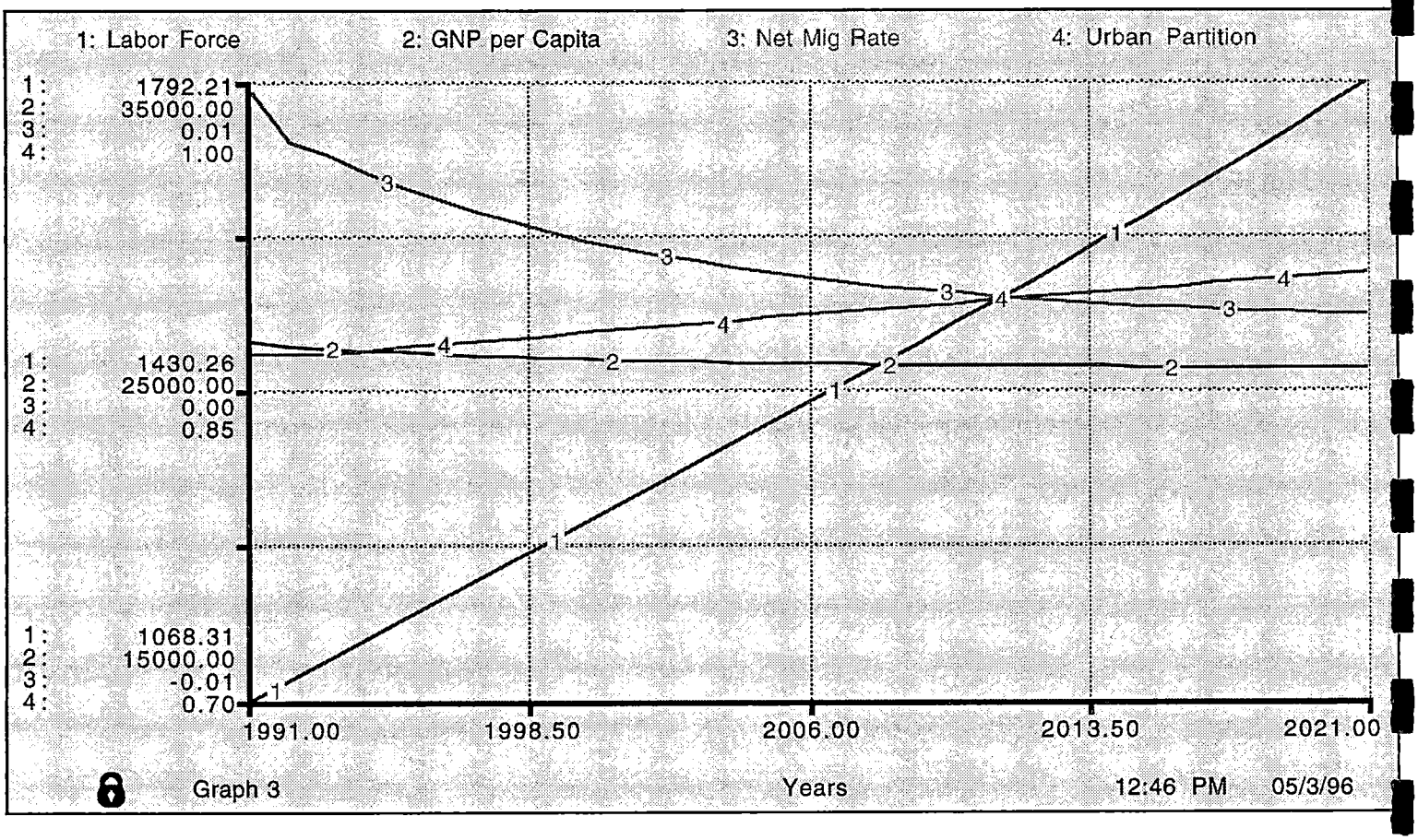
Net Depletion = -0.005
-0.05 — 0.05

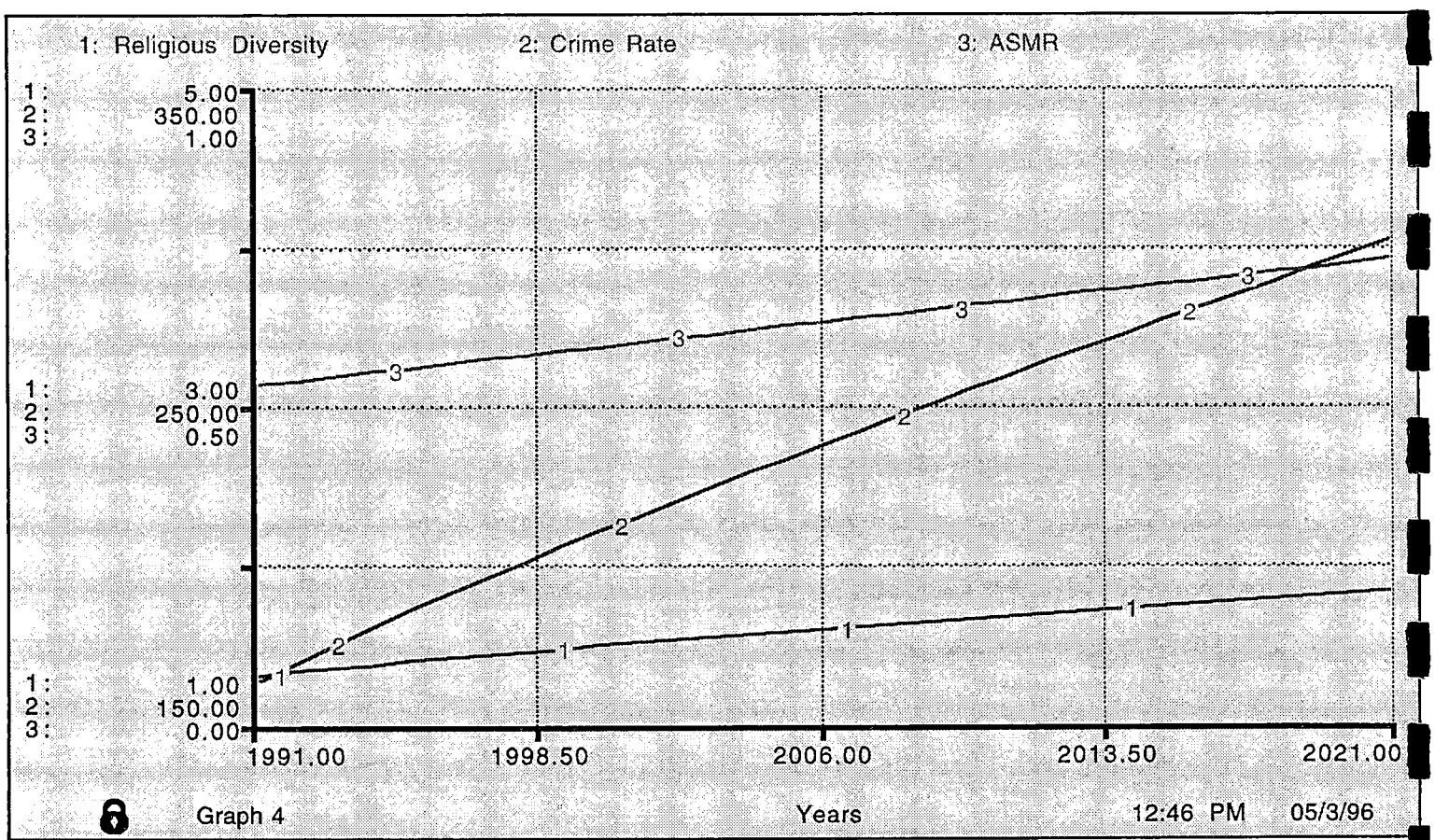
Pollution Response = 1
0.0 — 1.0

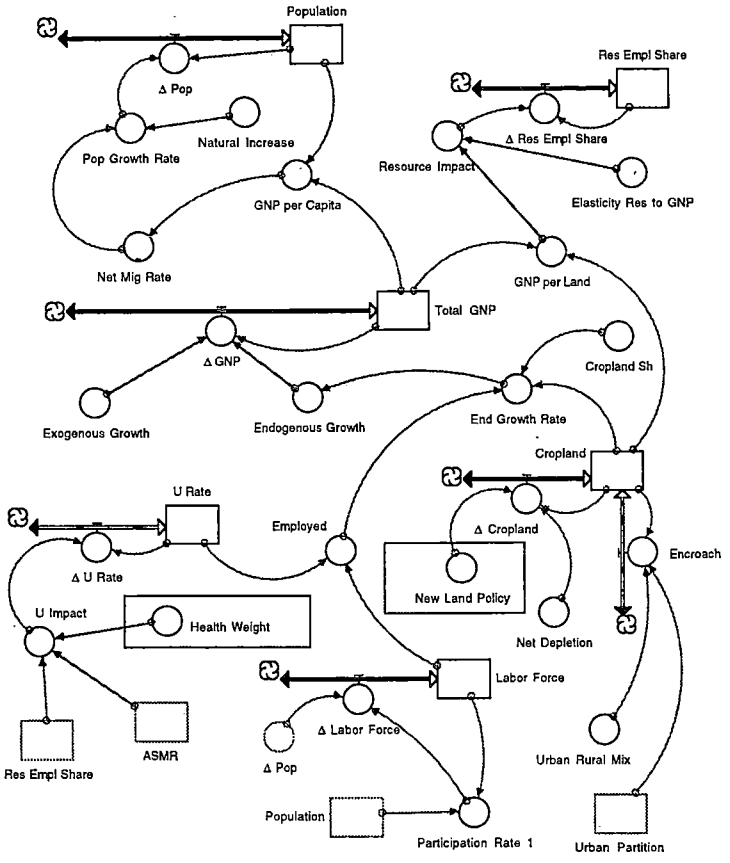
Total GNP	83,507,497
Water Use	2,326
Pollution Index	93
ASMR	0.73
Population	3,252.01
Pop Index	167.76
GNP Index	162.02


1: Population
2: Total GNP
3: Δ GNP
4: Δ Pop
1: 5000.00
2: 8.35e+07
3: 1274193.52
4: 50.18
1: 3000.00
2: 6.75e+07
3: 1023660.81
4: 45.72
1: 1000.00
2: 5.15e+07
3: 773128.09
4: 41.27
1991.00
1998.50
2006.00
2013.50
2021.00
Graph 1
Years
12:46 PM
05/3/96

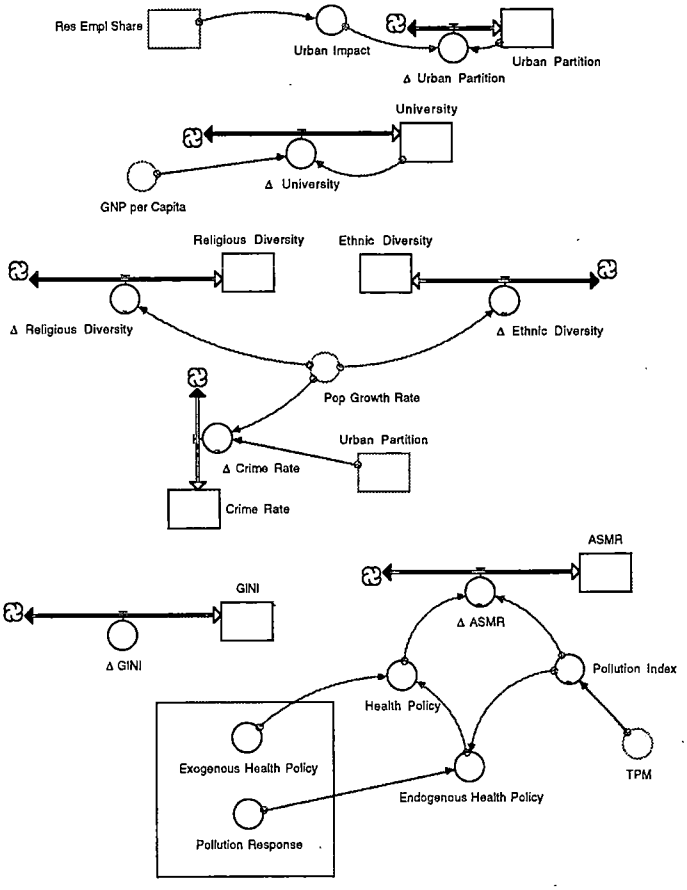

1: Pollution Index
2: Water Use
3: Water PC
4: Health Policy
1: 100.00
2: 2326.14
3: 1.00
4: 150.00
1: 50.00
2: 1851.47
3: 0.75
4: 50.00
1: 0.00
2: 1376.80
3: 0.50
4: -50.00
1991.00
1998.50
2006.00
2013.50
2021.00
Graph 2
Years
12:46 PM
05/3/96


1: Labor Force
2: GNP per Capita
3: Net Mig Rate
4: Urban Partition
1: 1792.21
2: 35000.00
3: 0.01
4: 1.00
1: 1430.26
2: 25000.00
3: 0.00
4: 0.85
1: 1068.31
2: 15000.00
3: -0.01
4: 0.70
1991.00
1998.50
2006.00
2013.50
2021.00
Graph 3
Years
12:46 PM
05/3/96

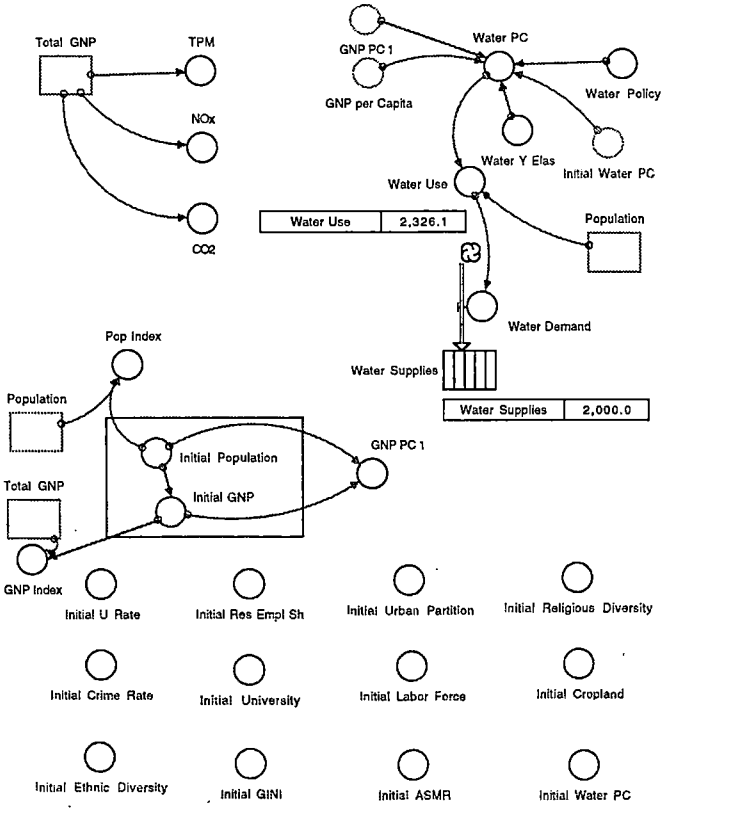

1: Religious Diversity
2: Crime Rate
3: ASMR
1: 5.00
2: 350.00
3: 1.00
1: 3.00
2: 250.00
3: 0.50
1: 1.00
2: 150.00
3: 0.00
1991.00
1998.50
2006.00
2013.50
2021.00
Graph 4
Years
12:46 PM
05/3/96


Population
Δ Pop
Natural Increase
Pop Growth Rate
GNP per Capita
Net Mig Rate
Res Empl Share
Δ Res Empl Share
Resource Impact
Elasticity Res to GNP
GNP per Land
Total GNP
Δ GNP
Exogenous Growth
Endogenous Growth
Cropland Sh
End Growth Rate
Cropland
Δ Cropland
New Land Policy
Net Depletion
Encroach
U Rate
Employed
Δ U Rate
U Impact
Health Weight
Res Empl Share
ASMR
Labor Force
Δ Labor Force
Δ Pop
Population
Participation Rate 1
Urban Rural Mix
Urban Partition

- 1 -


Res Empl Share
Urban Impact
Urban Partition
Δ Urban Partition
University
Δ University
GNP per Capita
Religious Diversity
Ethnic Diversity
Δ Religious Diversity
Δ Ethnic Diversity
Pop Growth Rate
Urban Partition
Δ Crime Rate
Crime Rate
ASMR
Δ ASMR
GINI
Δ GINI
Pollution Index
Health Policy
TPM
Exogenous Health Policy
Endogenous Health Policy
Pollution Response

- 2 -


Total GNP
TPM
NOx
CO2
GNP PC 1
GNP per Capita
Water PC
Water Policy
Water Y Elas
Initial Water PC
Water Use
Water Use 2,326.1
Population
Water Demand
Water Supplies
Water Supplies 2,000.0
Pop Index
Population
Initial Population
Initial GNP
GNP PC 1
Total GNP
GNP Index
Initial U Rate
Initial Res Empl Sh
Initial Urban Partition
Initial Religious Diversity
Initial Crime Rate
Initial University
Initial Labor Force
Initial Cropland
Initial Ethnic Diversity
Initial GINI
Initial ASMR
Initial Water PC

- 3 -

ASMR(t) = ASMR(t - dt) + (Δ_ASMR) * dt
INIT ASMR = Initial_ASMR

DOCUMENT: Response curve is a conceptual relationship showing environmental quality dependency, offset by health policy. Response is tuned to conform to 1971-1991 estimates for basin.

INFLOWS:
Δ_ASMR = GRAPH(Health_Policy-Pollution_Index)
(0.00, 0.027), (5.00, 0.0235), (10.0, 0.021), (15.0, 0.019), (20.0, 0.018), (25.0, 0.0165), (30.0, 0.0155), (35.0, 0.0135), (40.0, 0.0115), (45.0, 0.009), (50.0, 0.0065), (55.0, 0.0035), (60.0, -0.0005), (65.0, -0.0015), (70.0, -0.0025), (75.0, -0.0035), (80.0, -0.005), (85.0, -0.007), (90.0, -0.008), (95.0, -0.008), (100, -0.0095)

Crime_Rate(t) = Crime_Rate(t - dt) + (Δ_Crime_Rate) * dt
INIT Crime_Rate = Initial_Crime_Rate

DOCUMENT: Response elasticity is based on pooled cross-section data for sub-sub-basins, corrected for population growth to correspond to 1971-1991 estimates.

INFLOWS:
Δ_Crime_Rate = GRAPH(Pop_Growth_Rate*Urban_Partition)
(-0.1, -9.20), (-0.08, -8.40), (-0.06, -7.10), (-0.04, -5.00), (-0.02, -3.20), (6.94e-18, 0.00), (0.02, 6.00), (0.04, 8.00), (0.06, 9.10), (0.08, 9.50), (0.1, 9.90)

Cropland(t) = Cropland(t - dt) + (Δ_Cropland + Encroach) * dt
INIT Cropland = Initial_Cropland

DOCUMENT: Response is a function of annualized depletion, policy oriented changes in land-use, and encroachment from urbanization. Function is tuned to fit 1971-1991 estimates.

INFLOWS:
Δ_Cropland = Cropland*(New_Land_Policy+Net_Depletion)
Encroach = -Cropland*Urban_Rural_Mix*(Urban_Partition-delay(Urban_Partition,1))

Ethnic_Diversity(t) = Ethnic_Diversity(t - dt) + (Δ_Ethnic_Diversity) * dt
INIT Ethnic_Diversity = Initial_Ethnic_Diversity

DOCUMENT: Response based on fit tuned to 1971-1991 data.

INFLOWS:
Δ_Ethnic_Diversity = GRAPH(Pop_Growth_Rate)
(-0.1, 0.00), (-0.08, 0.00), (-0.06, 0.00), (-0.04, 0.00), (-0.02, 0.00), (6.94e-18, 0.00), (0.02, 0.00), (0.04, 0.00), (0.06, 0.00), (0.08, 0.00), (0.1, 0.00)

GINI(t) = GINI(t - dt) + (Δ_GINI) * dt
INIT GINI = Initial_GINI

DOCUMENT: Response reflects independence of this indicator in all correlation studies and multivariate analyses conducted for this research.

INFLOWS:
Δ_GINI = 0

Labor_Force(t) = Labor_Force(t - dt) + (Δ_Labor_Force) * dt
INIT Labor_Force = Initial_Labor_Force
INFLOWS:
Δ_Labor_Force = Δ_Pop*Participation_Rate_1

Population(t) = Population(t - dt) + (Δ_Pop) * dt
INIT Population = Initial_Population

INFLOWS:
Δ_Pop = Pop_Growth_Rate*Population

Religious_Diversity(t) = Religious_Diversity(t - dt) + (Δ_Religious_Diversity) * dt
INIT Religious_Diversity = Initial_Religious_Diversity

DOCUMENT: Response is tuned to fit 1971-1991 data.

INFLOWS:
Δ_Religious_Diversity = GRAPH(Pop_Growth_Rate)
(-0.05, -0.05), (0.00, 0.00), (0.05, 0.05)

Res_Empl_Share(t) = Res_Empl_Share(t - dt) + (Δ_Res_Empl_Share) * dt
INIT Res_Empl_Share = Initial_Res_Empl_Sh
INFLOWS:
Δ_Res_Empl_Share = Resource_Impact*Res_Empl_Share

Total__GNP(t) = Total__GNP(t - dt) + (Δ_GNP) * dt
INIT Total__GNP = Initial_GNP
INFLOWS:
Δ_GNP = (Exogenous_Growth+Endogenous_Growth)*Total__GNP

University(t) = University(t - dt) + (Δ_University) * dt
INIT University = Initial_University
INFLOWS:
Δ_University = University*(GNP_per_Capita-DELAY(GNP_per_Capita,1))/DELAY(GNP_per_Capita,1)

Urban_Partition(t) = Urban_Partition(t - dt) + (Δ_Urban_Partition) * dt
INIT Urban_Partition = Initial_Urban_Partition
INFLOWS:
Δ_Urban_Partition = Urban_Partition*Urban_Impact

U_Rate(t) = U_Rate(t - dt) + (Δ_U_Rate) * dt
INIT U_Rate = Initial_U_Rate
INFLOWS:
Δ_U_Rate = U_Rate*U_Impact

Water_Supplies(t) = Water_Supplies(t - dt) + (Water_Demand) * dt
INIT Water_Supplies = 0
TRANSIT TIME = 1
INFLOW LIMIT = 2000
CAPACITY = 2000

DOCUMENT: Water supply/demand balance. Current version of model is unconstrained as no data were available on water supply. Nominal (non-binding) constraint of 2000 set.

INFLOWS:
Water_Demand = Water_Use

CO2 = .5*Total__GNP
DOCUMENT: Carbon Dioxide index linked to io model coefficients. Estimate in emissions per year.

Cropland_Sh = .5
DOCUMENT: Weighting share of croplnad (vs employment) in iso-elastic specification of endogenously generated growth. Base estimate of 50/50 dependency assumed.

Elasticity_Res_to_GNP = -1
DOCUMENT: Elasticity of resource use to GNP. Unity assumed.

Employed = (1-U_Rate)*Labor_Force

Endogenous_Growth = End_Growth_Rate

Endogenous_Health_Policy = Pollution_Index*Pollution_Response
DOCUMENT: Health policy indicator that sets endogenously determined helath expenditures.

End_Growth_Rate =
(1-Cropland_Sh)*(Employed-DELAY(Employed,1))/DELAY(Employed,1)+Cropland_Sh*(Cropland-DELAY(Cropland,1))/DELAY(Cropland,1)
DOCUMENT: Isoelastic estimation of endogenous growth.

Exogenous_Growth = .015
DOCUMENT: Policy variable/exogenous assumption. This is the growth rate over which elements in the model have no control, e.g., external market demand or dollar fluctuations.

Exogenous_Health_Policy = 50
DOCUMENT: Baseline estimate of exogenously determined health care policy. Tuned to 1971-1991 index average of 100.

GNP_Index = Total__GNP/Initial_GNP*100

GNP_PC_1 = Initial_GNP/Initial_Population

GNP_per_Capita = Total__GNP/Population

GNP_per_Land = Total__GNP/Cropland

Health_Policy = Exogenous_Health_Policy+Endogenous_Health_Policy

Health_Weight = .5
DOCUMENT: Relative importance of health as compared to other deterministic variables in iso-elastioc specification of unemployment response.

Initial_ASMR = .53515
DOCUMENT: Rate of death by external cause. Health proxy indicator. Vital Statistics Division, BC Ministry of Health. Age standardized mortality rate per 1000 population.

Initial_Crime_Rate = 163.668
DOCUMENT: Number of criminal code offenses per 1000 resident population. BC, Ministry of Attorney General.

Initial_Cropland = 202840.1
DOCUMENT: Total area of cropland, hectares. Statistics Canada Ag Census.

Initial_Ethnic_Diversity = 1.598
DOCUMENT: Shannon Index of ethnic diversity, based on data from BC Ministry of Government Services, utilizing Census Data aggregeted to census divisions.

Initial_GINI = .3519
DOCUMENT: Income distribution index (GINI). Based on household Census Data from Statistics Canada, National Accounts.

Initial_GNP = 26589*Initial_Population
DOCUMENT: Per capita estimate based on BC Planning and Statistics Division based on revenue Canada statistics. This should be taken as a proxy for true GNP as it is an 'income' measure instead of a 'production' measure.

Initial_Labor_Force = 1068.305
DOCUMENT: Total employed and unemployed/trained labor force. Statistics Canada National Accounts division. Thousands.

Initial_Population = 1938.466
DOCUMENT: Total resident population. Thousands. Statistics Canada.

Initial_Religious_Diversity = 1.3095
DOCUMENT: Shannon Index, based on BC Ministry of Government Services derived from population census.

Initial_Res_Empl_Sh = .044299
DOCUMENT: Share of production attributavble to resource sectors (forestry, agriculture, fisheries, hunting, trapping, mining.)

Initial_University = .243622
DOCUMENT: Educational attainment. Proportion of the population 15 years and over with some university education (i.e., not necessarily a degree). BC Planning and Statistics Division, derived from Census.

Initial_Urban_Partition = .86783209
DOCUMENT: Proportion of population living in urban centre. Census.

Initial_U_Rate = .1248
DOCUMENT: Unemployment rate. Proportion of labor force unemployed. Statistics Canada National Accounts.

Initial_Water_PC = .71025
DOCUMENT: Per capita water use, cubic metres per capita per day. Based on estimates for municipalities with populations > 1000 residents. Municipal Water Use Database.

Natural_Increase = .013
DOCUMENT: Rate of natural increase from resident population. Based on current fertility estimates for Canada as a whole. WRI.

Net_Depletion = -.005
DOCUMENT: Estimated net annual depletion rate of natural resource stocks in absence of proactive policy measures.

New_Land_Policy = -.01
DOCUMENT: Proportion of cropland explicitly removed from production, annually, and placed in protected status.

NOx = .002*Total__GNP
DOCUMENT: NOx index linked to io model factors. Emissions annually.

Participation_Rate_1 = Labor_Force/Population

Pollution_Response = 1
DOCUMENT: Policy variable showing how responsive health policies are to changes in pollution levels. Policy variable from 0 to 1.

Pop_Growth_Rate = Natural_Increase+Net_Mig_Rate

Pop_Index = Population/Initial_Population*100

Resource_Impact =
Elasticity_Res_to_GNP*(GNP_per_Land-delay(GNP_per_Land,1))/delay(GNP_per_Land,1)

TPM = .01*Total__GNP
DOCUMENT: Pollution Index of Total Particulate Matter emissions (annually) linked to io model coefficients.

Urban_Impact = -.05*(Res_Empl_Share-delay(Res_Empl_Share,1))/delay(Res_Empl_Share,1)
DOCUMENT: Impact of resource employment levels on urbanization, tuned to fit 1971-91 observations.

Urban_Rural_Mix = .1
DOCUMENT: Estimated land area devoted to urban centres. (Note: this is a normalized estimates and model is relatively insensitive to errors of up to one order of magnitude.)

U_Impact =
Health_Weight*.07777*((ASMR-delay(ASMR,1))/delay(ASMR,1))+(1-Health_Weight)*0.11053*((Res_Empl_Share-DELAY(Res_Empl_Share,1))/DELAY(Res_Empl_Share,1))
DOCUMENT: Impact on unemployment, based on multivariate regressions on pooled sub-sub-basin data.

Water_PC =
Water_Policy*Initial_Water_PC*(1+Water_Y_Elas*(GNP_per_Capita-GNP_PC_1)/GNP_PC_1)
DOCUMENT: Per capita water use, responding to income shifts.

Water_Policy = 1
DOCUMENT: Explicit conservation variable to induce higher/lower water use through price effects. Because water is unpriced, price elasticities provide poor estimates. Use policy variables from 0.5-1.0 to test sensitivities.

Water_Use = Population*Water_PC

Water_Y_Elas = -.20745
DOCUMENT: Income elasticity of water demand. Based on multi-variate analysis of pooled data.

Net_Mig_Rate = GRAPH(GNP_per_Capita)
(15000, -0.021), (18000, -0.018), (21000, -0.015), (24000, -0.011), (27000, 0.013), (30000, 0.021), (33000, 0.026), (36000, 0.04), (39000, 0.051), (42000, 0.073), (45000, 0.099)
DOCUMENT: Net migration rate, per 1000 resident population. Curve was designed to reflect discontinuities to reflect 'information' and 'moving' costs as per migration literature. Tuned to fit 1971-1991 data.

Pollution_Index = GRAPH(TPM)
(0.00, 0.5), (100000, 4.50), (200000, 11.5), (300000, 18.0), (400000, 33.0), (500000, 56.5), (600000, 77.0), (700000, 88.0), (800000, 92.0), (900000, 94.0), (1e+06, 98.5)
DOCUMENT: Derived index to reflect a conceptual damage function with generally declining marginal costs as pollution increases.

Fraser Basin Dynamic Simulation Model
Version 1.00 (Basin 1991-2006)
Copyright: Ruitenbeek, H.J. 1996
Software: Stella II Version 3.0

Restore

Exogenous Growth = 0.029

-0.10 0.10

Cropland Sh = 0.5

0.0 1.0

Exogenous Health Policy = 50

0 100

New Land Policy = -0.01

-0.10 0.10

Health Weight = 0.5

0.0 1.0

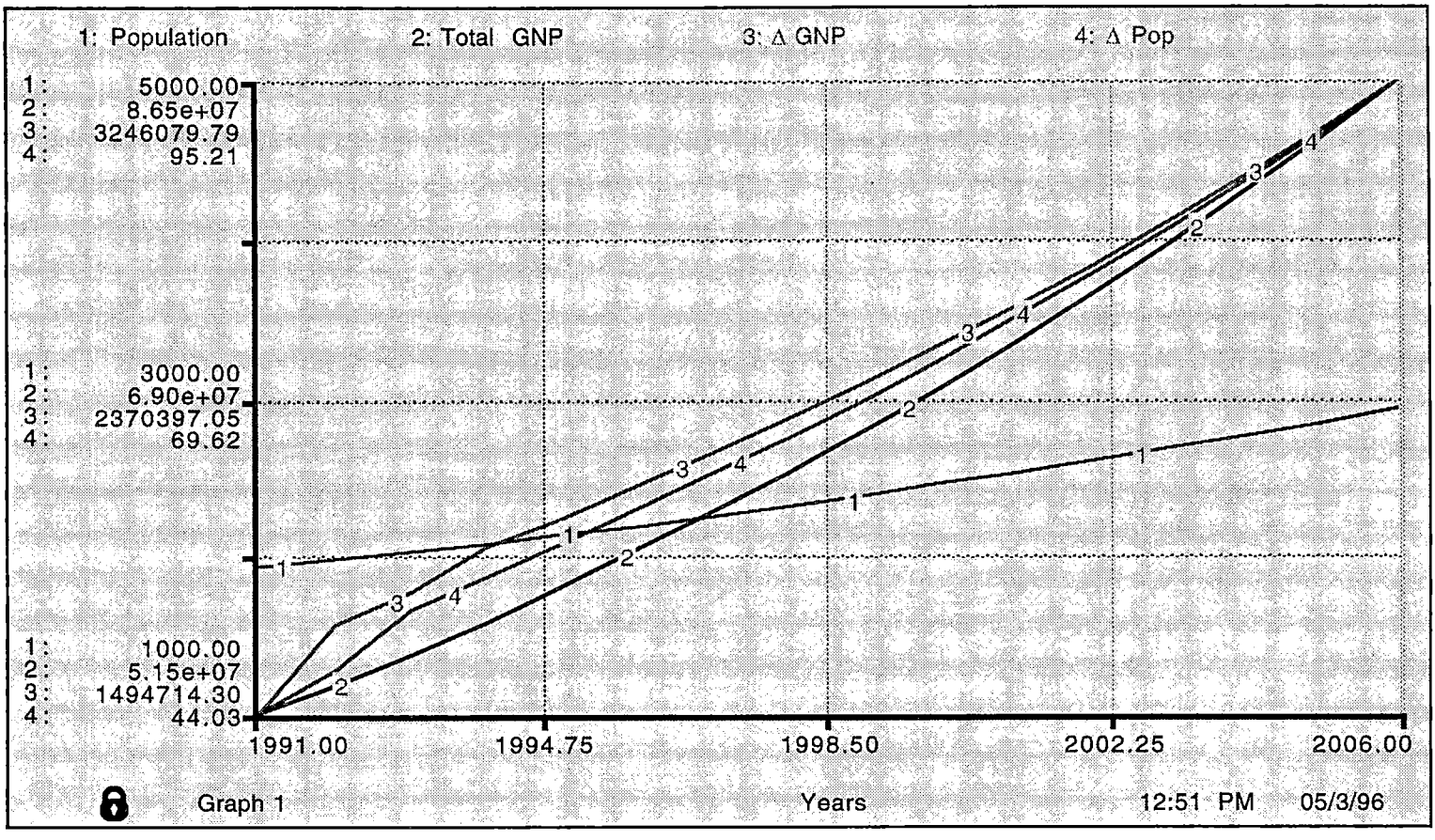
Net Depletion = -0.005

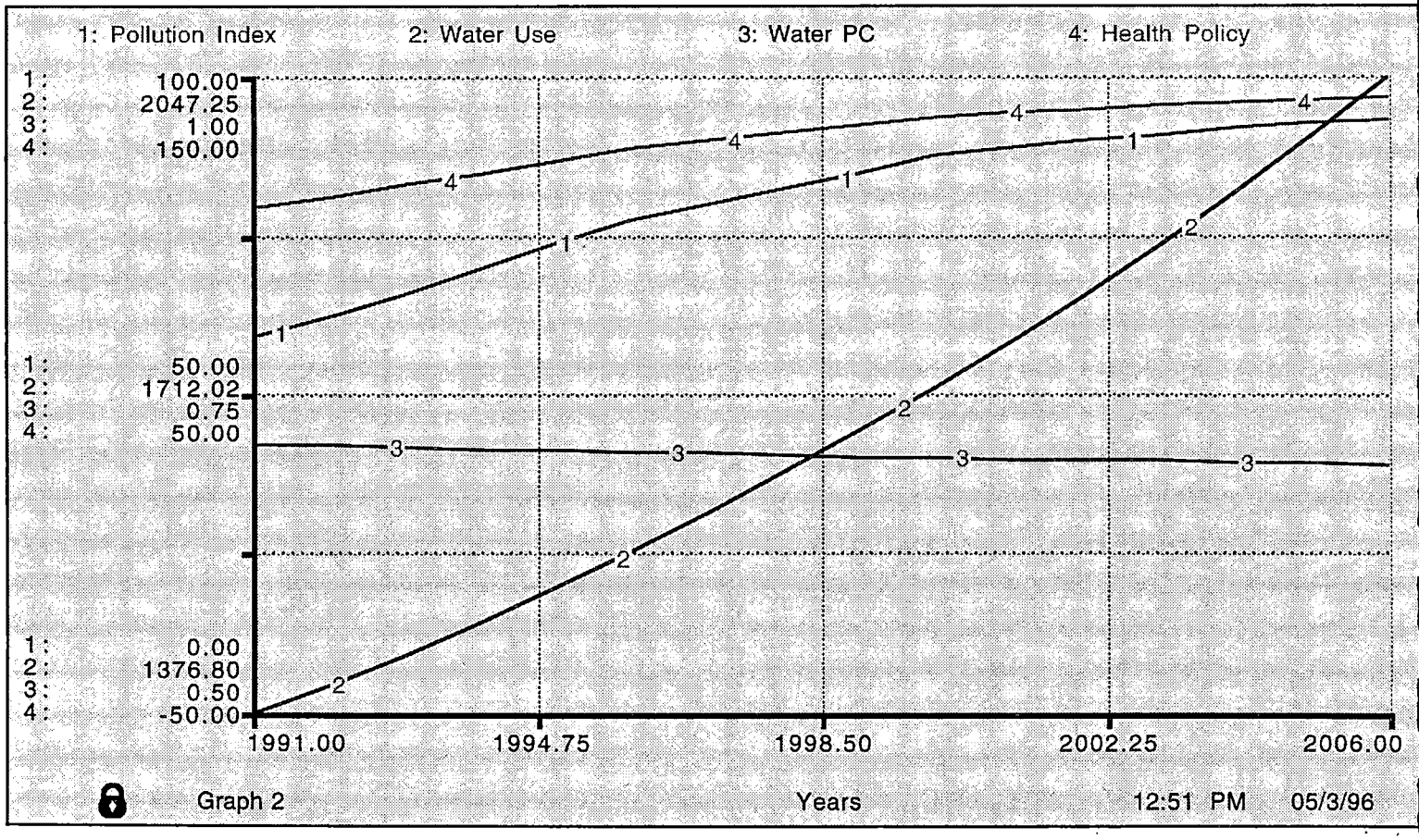
-0.05 0.05

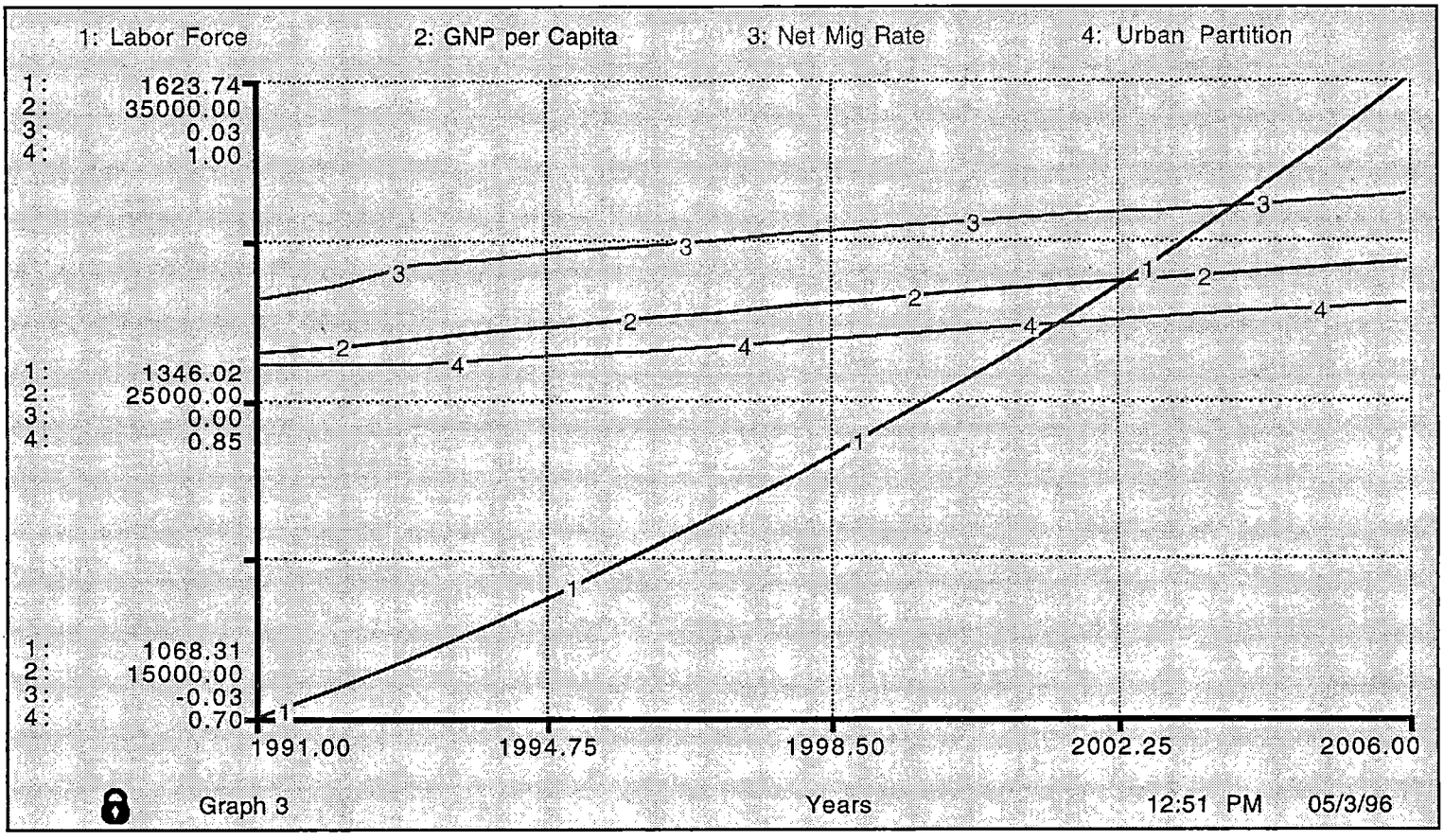
Total GNP	86,526,945
Water Use	2,047
Pollution Index	93
ASMR	0.63
Population	2,946.31
Pop Index	151.99
GNP Index	167.88

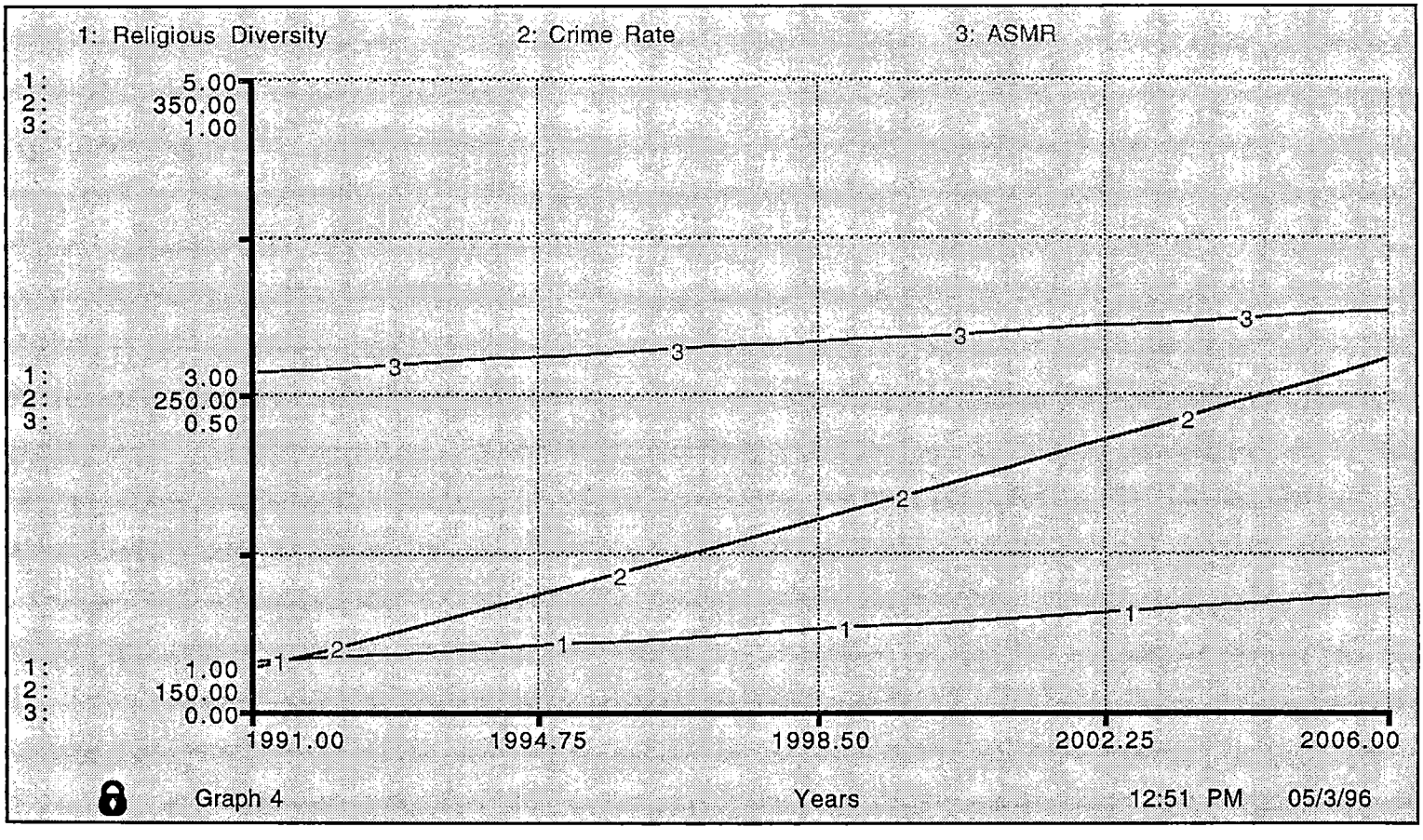
Pollution Response = 1

0.0 1.0


1: Population
2: Total GNP
3: Δ GNP
4: Δ Pop
1: 5000.00
2: 8.65e+07
3: 3246079.79
4: 95.21
1: 3000.00
2: 6.90e+07
3: 2370397.05
4: 69.62
1: 1000.00
2: 5.15e+07
3: 1494714.30
4: 44.03
1991.00
1994.75
1998.50
2002.25
2006.00
Graph 1
Years
12:51 PM
05/3/96


1: Pollution Index
2: Water Use
3: Water PC
4: Health Policy
1: 100.00
2: 2047.25
3: 1.00
4: 150.00
1: 50.00
2: 1712.02
3: 0.75
4: 50.00
1: 0.00
2: 1376.80
3: 0.50
4: -50.00
1991.00
1994.75
1998.50
2002.25
2006.00
Graph 2
Years
12:51 PM
05/3/96


1: Labor Force
2: GNP per Capita
3: Net Mig Rate
4: Urban Partition
1: 1623.74
2: 35000.00
3: 0.03
4: 1.00
1: 1346.02
2: 25000.00
3: 0.00
4: 0.85
1: 1068.31
2: 15000.00
3: -0.03
4: 0.70
1991.00
1994.75
1998.50
2002.25
2006.00
Graph 3
Years
12:51 PM
05/3/96


1: Religious Diversity
2: Crime Rate
3: ASMR
1: 5.00
2: 350.00
3: 1.00
1: 3.00
2: 250.00
3: 0.50
1: 1.00
2: 150.00
3: 0.00
1991.00
1994.75
1998.50
2002.25
2006.00
Graph 4
Years
12:51 PM
05/3/96

ASMR(t) = ASMR(t - dt) + (Δ_ASMR) * dt
INIT ASMR = Initial_ASMR
INFLOWS:
Δ_ASMR = GRAPH(Health_Policy-Pollution_Index)
(0.00, 0.027), (5.00, 0.0235), (10.0, 0.021), (15.0, 0.019), (20.0, 0.018), (25.0, 0.0165), (30.0, 0.0155), (35.0, 0.0135), (40.0, 0.0115), (45.0, 0.009), (50.0, 0.0065), (55.0, 0.0035), (60.0, -0.0005), (65.0, -0.0015), (70.0, -0.0025), (75.0, -0.0035), (80.0, -0.005), (85.0, -0.007), (90.0, -0.008), (95.0, -0.008), (100, -0.0095)

Crime_Rate(t) = Crime_Rate(t - dt) + (Δ_Crime_Rate) * dt
INIT Crime_Rate = Initial_Crime_Rate
INFLOWS:
Δ_Crime_Rate = GRAPH(Pop_Growth_Rate*Urban_Partition)
(-0.1, -9.20), (-0.08, -8.40), (-0.06, -7.10), (-0.04, -5.00), (-0.02, -3.20), (6.94e-18, 0.00), (0.02, 6.00), (0.04, 8.00), (0.06, 9.10), (0.08, 9.50), (0.1, 9.90)

Cropland(t) = Cropland(t - dt) + (Δ_Cropland + Encroach) * dt
INIT Cropland = Initial_Cropland
INFLOWS:
Δ_Cropland = Cropland*(New_Land_Policy+Net_Depletion)
Encroach = -Cropland*Urban_Rural_Mix*(Urban_Partition-delay(Urban_Partition,1))

Ethnic_Diversity(t) = Ethnic_Diversity(t - dt) + (Δ_Ethnic_Diversity) * dt
INIT Ethnic_Diversity = Initial_Ethnic_Diversity
INFLOWS:
Δ_Ethnic_Diversity = GRAPH(Pop_Growth_Rate)
(-0.1, 0.00), (-0.08, 0.00), (-0.06, 0.00), (-0.04, 0.00), (-0.02, 0.00), (6.94e-18, 0.00), (0.02, 0.00), (0.04, 0.00), (0.06, 0.00), (0.08, 0.00), (0.1, 0.00)

GINI(t) = GINI(t - dt) + (Δ_GINI) * dt
INIT GINI = Initial_GINI
INFLOWS:
Δ_GINI = 0

Labor_Force(t) = Labor_Force(t - dt) + (Δ_Labor_Force) * dt
INIT Labor_Force = Initial_Labor_Force
INFLOWS:
Δ_Labor_Force = Δ_Pop*Participation_Rate_1

Population(t) = Population(t - dt) + (Δ_Pop) * dt
INIT Population = Initial_Population
INFLOWS:
Δ_Pop = Pop_Growth_Rate*Population

Religious_Diversity(t) = Religious_Diversity(t - dt) + (Δ_Religious_Diversity) * dt
INIT Religious_Diversity = Initial_Religious_Diversity
INFLOWS:
Δ_Religious_Diversity = GRAPH(Pop_Growth_Rate)
(-0.05, -0.05), (0.00, 0.00), (0.05, 0.05)

Res_Empl_Share(t) = Res_Empl_Share(t - dt) + (Δ_Res_Empl_Share) * dt
INIT Res_Empl_Share = Initial_Res_Empl_Sh
INFLOWS:
Δ_Res_Empl_Share = Resource_Impact*Res_Empl_Share

Total__GNP(t) = Total__GNP(t - dt) + (Δ_GNP) * dt
INIT Total__GNP = Initial_GNP
INFLOWS:
Δ_GNP = (Exogenous_Growth+Endogenous_Growth)*Total__GNP

University(t) = University(t - dt) + (Δ_University) * dt
INIT University = Initial_University
INFLOWS:
Δ_University = University*(GNP_per_Capita-DELAY(GNP_per_Capita,1))/DELAY(GNP_per_Capita,1)

Urban_Partition(t) = Urban_Partition(t - dt) + (Δ_Urban_Partition) * dt
INIT Urban_Partition = Initial_Urban_Partition
INFLOWS:
Δ_Urban_Partition = Urban_Partition*Urban_Impact

U_Rate(t) = U_Rate(t - dt) + (Δ_U_Rate) * dt
INIT U_Rate = Initial_U_Rate
INFLOWS:
Δ_U_Rate = U_Rate*U_Impact

Water_Supplies(t) = Water_Supplies(t - dt) + (Water_Demand) * dt
INIT Water_Supplies = 0
TRANSIT TIME = 1
INFLOW LIMIT = 2000
CAPACITY = 2000
INFLOWS:
Water_Demand = Water_Use

CO2 = .5*Total__GNP
Cropland_Sh = .5
Elasticity_Res_to_GNP = -1
Employed = (1-U_Rate)*Labor_Force
Endogenous_Growth = End_Growth_Rate
Endogenous_Health_Policy = Pollution_Index*Pollution_Response
End_Growth_Rate = (1-Cropland_Sh)*(Employed-DELAY(Employed,1))/DELAY(Employed,1)+Cropland_Sh*(Cropland-DELAY(Cropland,1))/DELAY(Cropland,1)
Exogenous_Growth = .015
Exogenous_Health_Policy = 50
GNP_Index = Total__GNP/Initial_GNP*100
GNP_PC_1 = Initial_GNP/Initial_Population
GNP_per_Capita = Total__GNP/Population
GNP_per_Land = Total__GNP/Cropland
Health_Policy = Exogenous_Health_Policy+Endogenous_Health_Policy
Health_Weight = .5
Initial_ASMR = .53515
Initial_Crime_Rate = 163.668
Initial_Cropland = 202840.1
Initial_Ethnic_Diversity = 1.598
Initial_GINI = .3519
Initial_GNP = 26589*Initial_Population
Initial_Labor_Force = 1068.305
Initial_Population = 1938.466
Initial_Religious_Diversity = 1.3095
Initial_Res_Empl_Sh = .044299
Initial_University = .243622
Initial_Urban_Partition = .86783209
Initial_U_Rate = .1248

Initial_Water_PC = .71025

Natural_Increase = .013

Net_Depletion = -.005

New_Land_Policy = -.01

NOx = .002*Total__GNP

Participation_Rate_1 = Labor_Force/Population

Pollution_Response = .1

Pop_Growth_Rate = Natural_Increase+Net_Mig_Rate

Pop_Index = Population/Initial_Population*100

Resource_Impact =
Elasticity_Res_to_GNP*(GNP_per_Land-delay(GNP_per_Land,1))/delay(GNP_per_Land,1)

TPM = .01*Total__GNP

Urban_Impact = -.05*(Res_Empl_Share-delay(Res_Empl_Share,1))/delay(Res_Empl_Share,1)

Urban_Rural_Mix = .1

U_Impact =
Health_Weight*.07777*((ASMR-delay(ASMR,1))/delay(ASMR,1))+(1-Health_Weight)*0.11053*((Res_Empl_Share-DELAY(Res_Empl_Share,1))/DELAY(Res_Empl_Share,1))

Water_PC =
Water_Policy*Initial_Water_PC*(1+Water_Y_Elas*(GNP_per_Capita-GNP_PC_1)/GNP_PC_1)

Water_Policy = 1

Water_Use = Population*Water_PC

Water_Y_Elas = -.20745

Net_Mig_Rate = GRAPH(GNP_per_Capita)
(15000, -0.021), (18000, -0.018), (21000, -0.015), (24000, -0.011), (27000, 0.013), (30000, 0.021), (33000, 0.026), (36000, 0.04), (39000, 0.051), (42000, 0.073), (45000, 0.099)

Pollution_Index = GRAPH(TPM)
(0.00, 0.5), (100000, 4.50), (200000, 11.5), (300000, 18.0), (400000, 33.0), (500000, 56.5), (600000, 77.0), (700000, 88.0), (800000, 92.0), (900000, 94.0), (1e+06, 98.5)

Fraser Basin Dynamic Simulation Model
Version 1.00 (Shuswap 1991+)
Copyright: Ruitenbeek, H.J. 1996
Software: Stella II Version 3.0

Exogenous Growth = 0.015
-0.10 — 0.10

Cropland Sh = 0.5
0.0 — 1.0

Exogenous Health Policy = 50
0 — 100

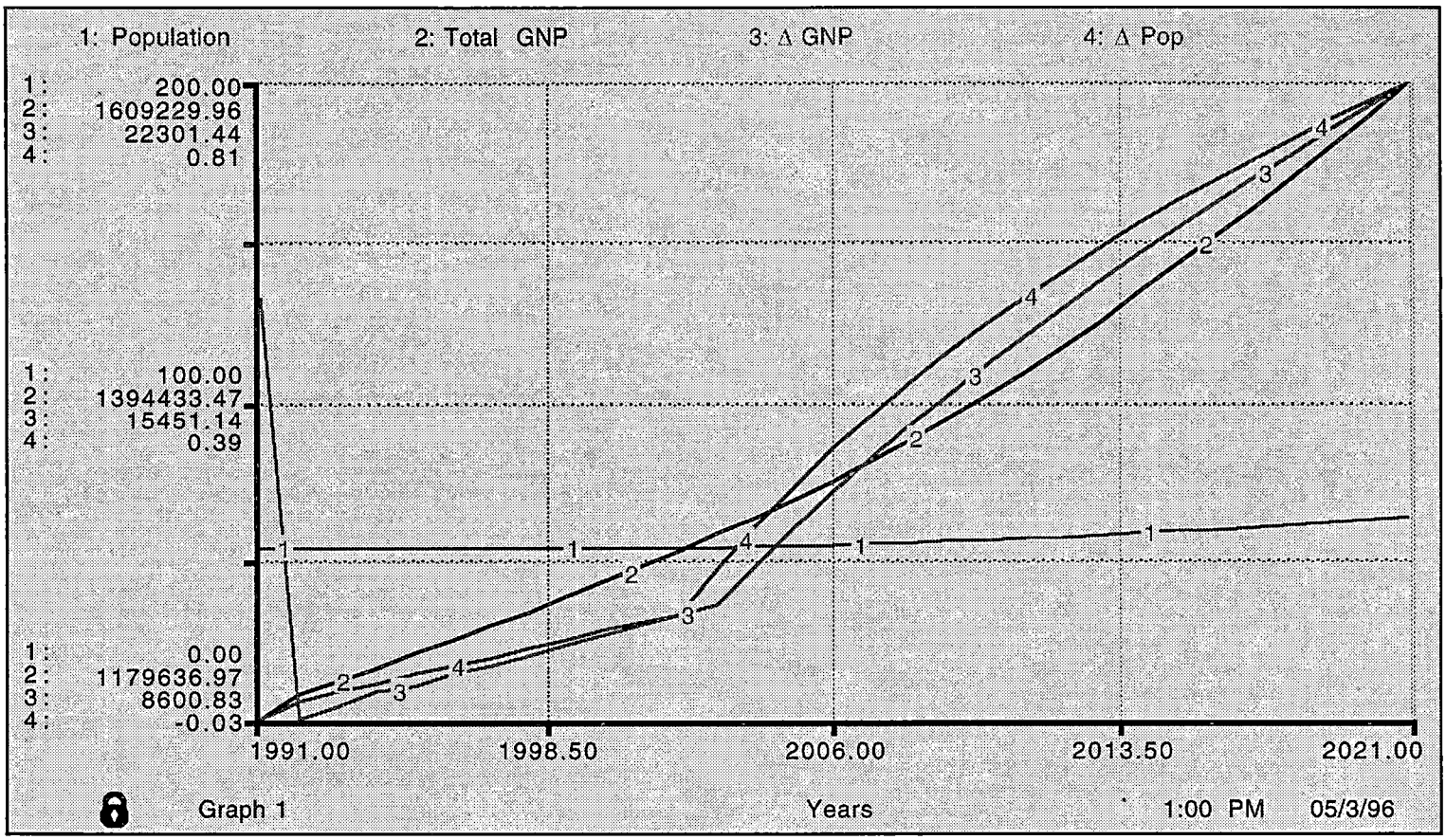
New Land Policy = -0.01
-0.10 — 0.10

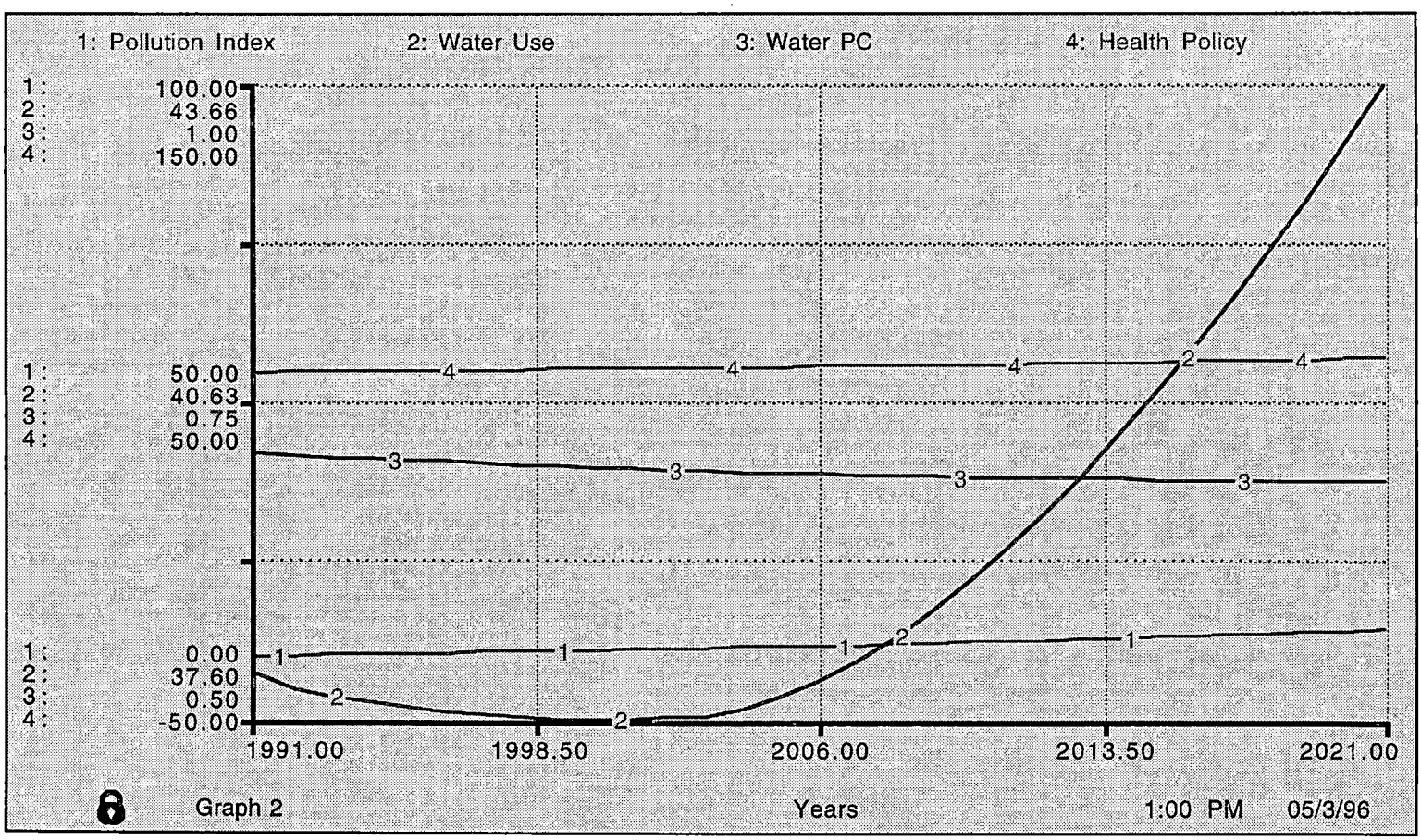
Health Weight = 0.5
0.0 — 1.0

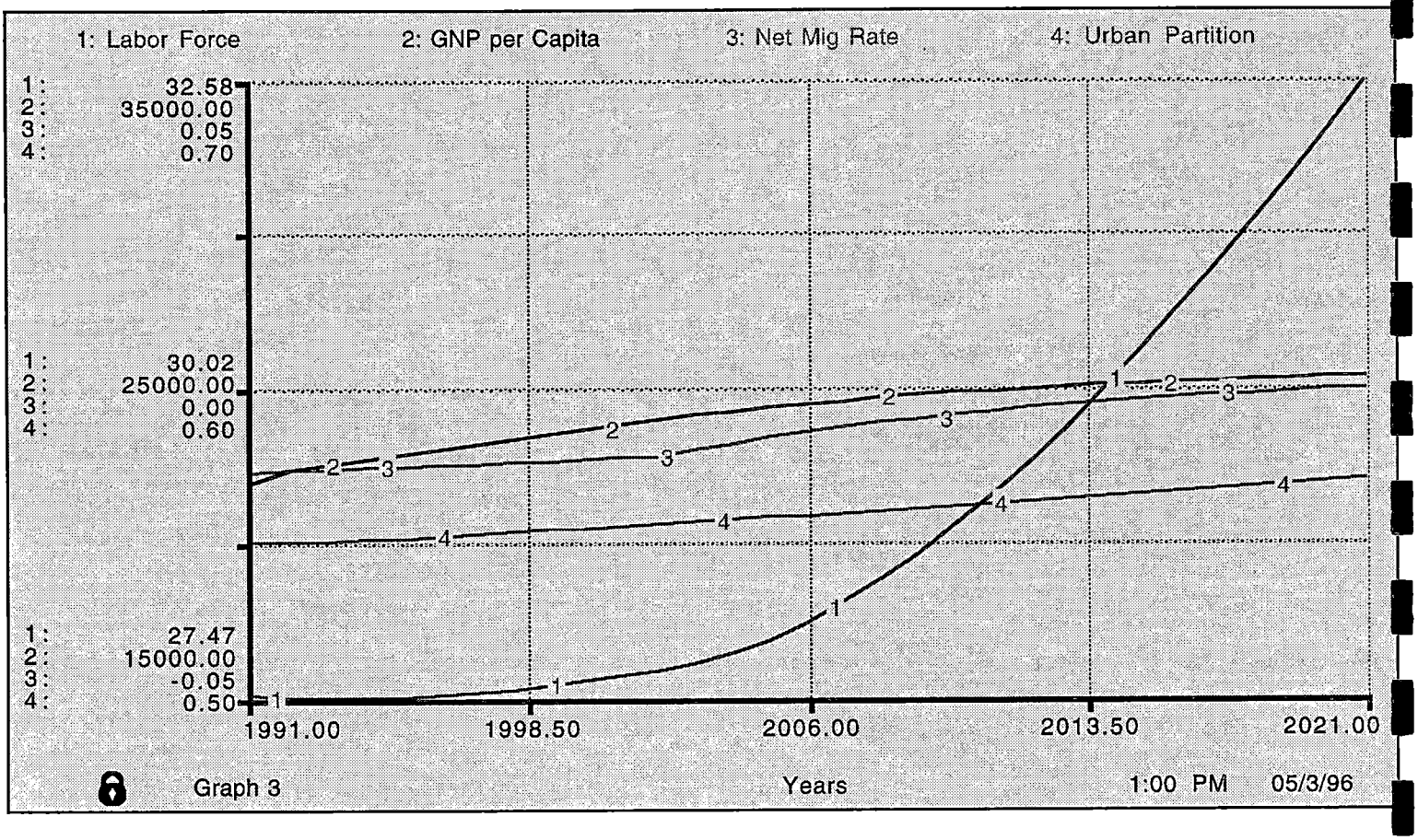
Net Depletion = -0.005
-0.05 — 0.05

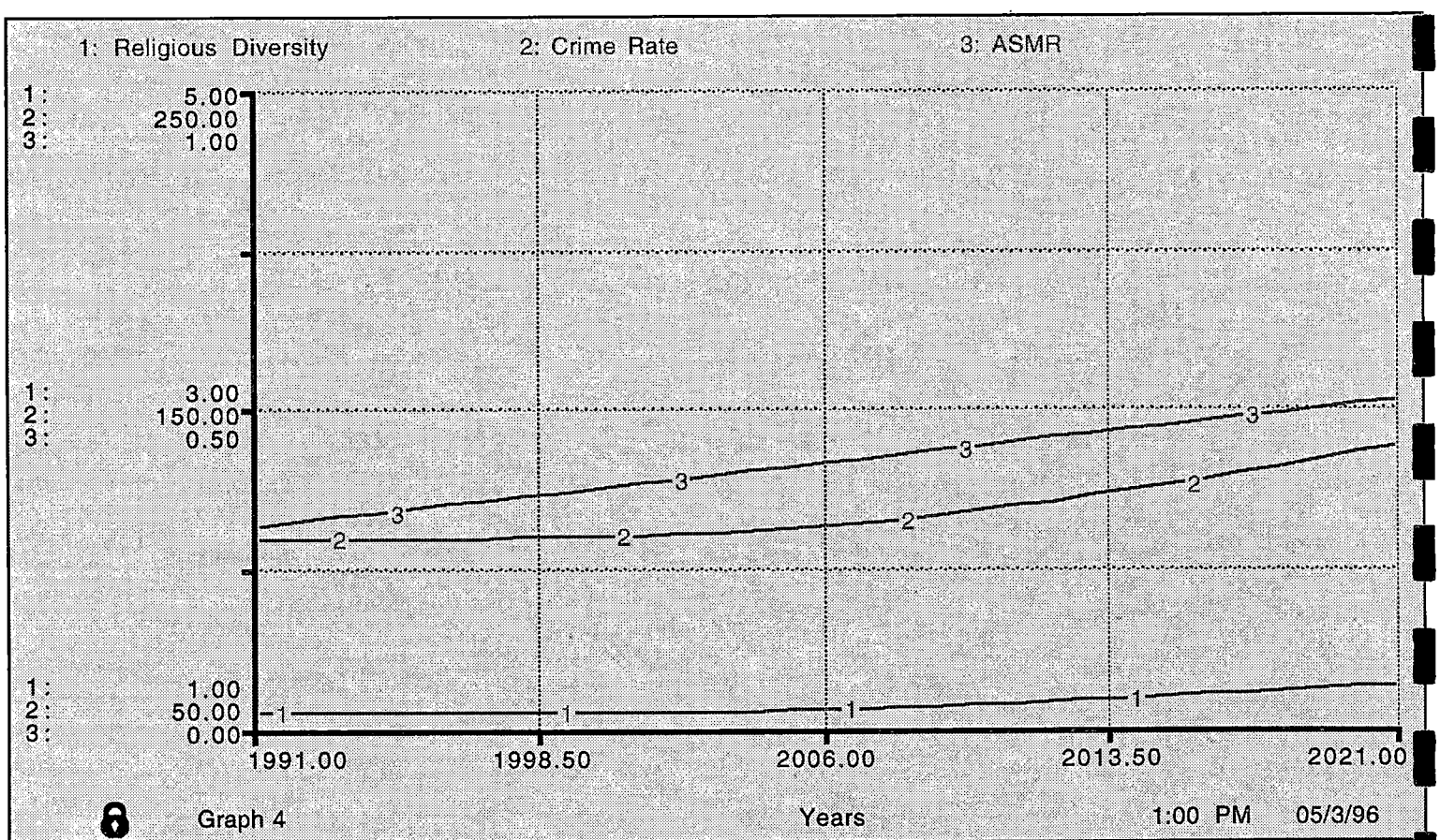
Total GNP	1,609,230
Water Use	44
Pollution Index	14
ASMR	0.51
Population	63.47
Pop Index	118.50
GNP Index	136.42

Pollution Response = 1
0.0 — 1.0


1: Population
2: Total GNP
3: Δ GNP
4: Δ Pop
1: 200.00
2: 1609229.96
3: 22301.44
4: 0.81
1: 100.00
2: 1394433.47
3: 15451.14
4: 0.39
1: 0.00
2: 1179636.97
3: 8600.83
4: -0.03
1991.00
1998.50
2006.00
2013.50
2021.00
Graph 1
Years
1:00 PM
05/3/96


1: Pollution Index
2: Water Use
3: Water PC
4: Health Policy
1: 100.00
2: 43.66
3: 1.00
4: 150.00
1: 50.00
2: 40.63
3: 0.75
4: 50.00
1: 0.00
2: 37.60
3: 0.50
4: -50.00
1991.00
1998.50
2006.00
2013.50
2021.00
Graph 2
Years
1:00 PM
05/3/96


1: Labor Force
2: GNP per Capita
3: Net Mig Rate
4: Urban Partition
1: 32.58
2: 35000.00
3: 0.05
4: 0.70
1: 30.02
2: 25000.00
3: 0.00
4: 0.60
1: 27.47
2: 15000.00
3: -0.05
4: 0.50
1991.00
1998.50
2006.00
2013.50
2021.00
Graph 3
Years
1:00 PM
05/3/96


1: Religious Diversity
2: Crime Rate
3: ASMR
1: 5.00
2: 250.00
3: 1.00
1: 3.00
2: 150.00
3: 0.50
1: 1.00
2: 50.00
3: 0.00
1991.00
1998.50
2006.00
2013.50
2021.00
Graph 4
Years
1:00 PM
05/3/96

ASMR(t) = ASMR(t - dt) + (Δ_ASMR) * dt
INIT ASMR = Initial_ASMR
INFLOWS:
Δ_ASMR = GRAPH(Health_Policy-Pollution_Index)
(0.00, 0.027), (5.00, 0.0235), (10.0, 0.021), (15.0, 0.019), (20.0, 0.018), (25.0, 0.0165), (30.0, 0.0155), (35.0, 0.0135), (40.0, 0.0115), (45.0, 0.009), (50.0, 0.0065), (55.0, 0.0035), (60.0, -0.0005), (65.0, -0.0015), (70.0, -0.0025), (75.0, -0.0035), (80.0, -0.005), (85.0, -0.007), (90.0, -0.008), (95.0, -0.008), (100, -0.0095)

Crime_Rate(t) = Crime_Rate(t - dt) + (Δ_Crime_Rate) * dt
INIT Crime_Rate = Initial_Crime_Rate
INFLOWS:
Δ_Crime_Rate = GRAPH(Pop_Growth_Rate*Urban_Partition)
(-0.1, -9.20), (-0.08, -8.40), (-0.06, -7.10), (-0.04, -5.00), (-0.02, -3.20), (6.94e-18, 0.00), (0.02, 6.00), (0.04, 8.00), (0.06, 9.10), (0.08, 9.50), (0.1, 9.90)

Cropland(t) = Cropland(t - dt) + (Δ_Cropland + Encroach) * dt
INIT Cropland = Initial_Cropland
INFLOWS:
Δ_Cropland = Cropland*(New_Land_Policy+Net_Depletion)
Encroach = -Cropland*Urban_Rural_Mix*(Urban_Partition-delay(Urban_Partition,1))

Ethnic_Diversity(t) = Ethnic_Diversity(t - dt) + (Δ_Ethnic_Diversity) * dt
INIT Ethnic_Diversity = Initial_Ethnic_Diversity
INFLOWS:
Δ_Ethnic_Diversity = GRAPH(Pop_Growth_Rate)
(-0.1, 0.00), (-0.08, 0.00), (-0.06, 0.00), (-0.04, 0.00), (-0.02, 0.00), (6.94e-18, 0.00), (0.02, 0.00), (0.04, 0.00), (0.06, 0.00), (0.08, 0.00), (0.1, 0.00)

GINI(t) = GINI(t - dt) + (Δ_GINI) * dt
INIT GINI = Initial_GINI
INFLOWS:
Δ_GINI = 0

Labor_Force(t) = Labor_Force(t - dt) + (Δ_Labor_Force) * dt
INIT Labor_Force = Initial_Labor_Force
INFLOWS:
Δ_Labor_Force = Δ_Pop*Participation_Rate_1

Population(t) = Population(t - dt) + (Δ_Pop) * dt
INIT Population = Initial_Population
INFLOWS:
Δ_Pop = Pop_Growth_Rate*Population

Religious_Diversity(t) = Religious_Diversity(t - dt) + (Δ_Religious_Diversity) * dt
INIT Religious_Diversity = Initial_Religious_Diversity
INFLOWS:
Δ_Religious_Diversity = GRAPH(Pop_Growth_Rate)
(-0.05, -0.05), (0.00, 0.00), (0.05, 0.05)

Res_Empl_Share(t) = Res_Empl_Share(t - dt) + (Δ_Res_Empl_Share) * dt
INIT Res_Empl_Share = Initial_Res_Empl_Sh
INFLOWS:
Δ_Res_Empl_Share = Resource_Impact*Res_Empl_Share

Total__GNP(t) = Total__GNP(t - dt) + (Δ_GNP) * dt
INIT Total__GNP = Initial_GNP
INFLOWS:
Δ_GNP = (Exogenous_Growth+Endogenous_Growth)*Total__GNP

University(t) = University(t - dt) + (Δ_University) * dt
INIT University = Initial_University
INFLOWS:
Δ_University = University*(GNP_per_Capita-DELAY(GNP_per_Capita,1))/DELAY(GNP_per_Capita,1)

Urban_Partition(t) = Urban_Partition(t - dt) + (Δ_Urban_Partition) * dt
INIT Urban_Partition = Initial_Urban_Partition
INFLOWS:
Δ_Urban_Partition = Urban_Partition*Urban_Impact

U_Rate(t) = U_Rate(t - dt) + (Δ_U_Rate) * dt
INIT U_Rate = Initial_U_Rate
INFLOWS:
Δ_U_Rate = U_Rate*U_Impact

Water_Supplies(t) = Water_Supplies(t - dt) + (Water_Demand) * dt
INIT Water_Supplies = 0
TRANSIT TIME = 1
INFLOW LIMIT = 200
CAPACITY = 200
INFLOWS:
Water_Demand = Water_Use

CO2 = .5*Total__GNP
Cropland_Sh = .5
Elasticity_Res_to_GNP = -1
Employed = (1-U_Rate)*Labor_Force
Endogenous_Growth = End_Growth_Rate
Endogenous_Health_Policy = Pollution_Index*Pollution_Response
End_Growth_Rate =
(1-Cropland_Sh)*(Employed-DELAY(Employed,1))/DELAY(Employed,1)+Cropland_Sh*(Cropland-DELAY(Cropland,1))/DELAY(Cropland,1)
Exogenous_Growth = .015
Exogenous_Health_Policy = 50
GNP_Index = Total__GNP/Initial_GNP*100
GNP_PC_1 = Initial_GNP/Initial_Population
GNP_per_Capita = Total__GNP/Population
GNP_per_Land = Total__GNP/Cropland
Health_Policy = Exogenous_Health_Policy+Endogenous_Health_Policy
Health_Weight = .5
Initial_ASMR = .317882552
Initial_Crime_Rate = 109.2912
Initial_Cropland = 15267.17
Initial_Ethnic_Diversity = 1.512188
Initial_GINI = .3435
Initial_GNP = 22025*Initial_Population
Initial_Labor_Force = 27.492
Initial_Population = 53.559
Initial_Religious_Diversity = 1.090376008
Initial_Res_Empl_Sh = .107849556
Initial_University = .130542636
Initial_Urban_Partition = .550309005
Initial_U_Rate = .144151026

- Initial_Water_PC = .71025
- Natural_Increase = .013
- Net_Depletion = -.005
- New_Land_Policy = -.01
- NOx = .002*Total__GNP
- Participation_Rate_1 = Labor_Force/Population
- Pollution_Response = 1
- Pop_Growth_Rate = Natural_Increase+Net_Mig_Rate
- Pop_Index = Population/Initial_Population*100
- Resource_Impact = Elasticity_Res_to_GNP*(GNP_per_Land-delay(GNP_per_Land,1))/delay(GNP_per_Land,1)
- TPM = .01*Total__GNP
- Urban_Impact = -.05*(Res_Empl_Share-delay(Res_Empl_Share,1))/delay(Res_Empl_Share,1)
- Urban_Rural_Mix = .1
- U_Impact = Health_Weight*.07777*((ASMR-delay(ASMR,1))/delay(ASMR,1))+(1-Health_Weight)*0.11053*((Res_Empl_Share-DELAY(Res_Empl_Share,1))/DELAY(Res_Empl_Share,1))
- Water_PC = Water_Policy*Initial_Water_PC*(1+Water_Y_Elas*(GNP_per_Capita-GNP_PC_1)/GNP_PC_1)
- Water_Policy = 1
- Water_Use = Population*Water_PC
- Water_Y_Elas = -.20745
- Net_Mig_Rate = GRAPH(GNP_per_Capita)
  (15000, -0.021), (18000, -0.018), (21000, -0.015), (24000, -0.011), (27000, 0.013), (30000, 0.021), (33000, 0.026), (36000, 0.04), (39000, 0.051), (42000, 0.073), (45000, 0.099)
- Pollution_Index = GRAPH(15*TPM)
  (0.00, 0.5), (100000, 4.50), (200000, 11.5), (300000, 18.0), (400000, 33.0), (500000, 56.5), (600000, 77.0), (700000, 88.0), (800000, 92.0), (900000, 94.0), (1e+06, 98.5)