

A Study of Biomass Inventory, Costing,
Processing Logistics and Equipment for the Production of Fuel
Ethanol and Co-Products in Nova Scotia

ANALYSIS OF SELECTED LOCATIONS

Final Report

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Prepared for

**Nova Scotia Departments of Energy, Agriculture and Fisheries, Economic
Development, and Bio Vision Technology Inc.**

By

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Executive Summary

This study on biomass inventory, costing, processing logistics and equipment for the production of fuel ethanol and co-products in Nova Scotia was prepared by Whale Lake Research Institute for the Nova Scotia Departments of Energy, Agriculture and Fisheries, and Economic Development.

Due to the length and complexity of the study, the results are published in two volumes. Each volume initially covers the subject material at a general level, then at the provincial level, and finally at specific sites. By using this approach, the study can be used as a tool to evaluate and plan for a bio-ethanol facility in Nova Scotia and other jurisdictions.

Specifically, the study examined nine sites in Nova Scotia for their capability to support a 160,000 wet tonnes bio-fractionation facility proposed by Bio Vision Technology Incorporated. Bio Vision plans to use steam bio-fractionation technology developed in New Zealand to separate biomass fractions for further processing into marketable products, in particular ethanol. This effort is supported by the Nova Scotia Departments of Energy, Agriculture and Fisheries, and Economic Development.

To be successful, the facility must be located near a sustainable supply of quality biomass feedstock. Bio Vision envisages running three such facilities in Nova Scotia. As part of the original proposal, eight candidate sites were selected for study: Yarmouth, Bridgetown, Windsor, Truro, Eastern Passage, Stellarton, Port Hawkesbury, and Sydney. A ninth site, Amherst, was subsequently added to cover the northwestern part of the province. The selection of the best sites depended upon a number of factors, including longterm availability and quality of feedstock, transportation considerations, and the ability of the proposed site to accommodate facility requirements.

The two volumes cover a wide range of topics related to biomass inventory, costing, and processing in Nova Scotia. The first volume, Analysis of Selected Locations, seeks to evaluate each site for its potential to supply agricultural and forestry biomass in both the immediate future and over the next 30 years. The second volume, Biomass Procurement and Processing, presents a series of tools to aid in biomass selection, procurement, processing, and management. It also provides an initial selection of feedstock for each of the best sites.

Specifically, the first volume covers the following tasks:

- a) An initial county by county biomass inventory, which will include biomass in existing wood lots, residues from existing forestry operations, residues from sawmill or other processing operations and other forms of biomass, such as hay or other non-wood fibrous materials, separated according to ownership class, and include comments on availability and affordability. Bio-waste resources is to*

be included as a separate resource (county by county) in the inventory. Types of future biomass that could be grown in the province and locations are to be included.

- b) Best option scenario for biomass resources available within a fifty (50) km and a one hundred (100) km radius from best 5 (five) sites from the following possible plant sites: Yarmouth, Bridgetown, Windsor, Eastern Passage, Truro, Stellarton, Port Hawkesbury and Sydney.*
- c) A distinction between crown and private land for the detailed radii surveys.*
- d) Analysis of availability (including seasonality, control of land, etc.) and accessibility of biomass sources for the detailed radii surveys.*
- e) Recommendation on transport options trucking resources in the detailed radii surveys.*
- f) Analysis of quantity available, species and quality considerations such as degree of decay, moisture content and presence of contaminants such as bark, dirt, etc.*

Chapter 2 provides general background information relevant to the topics of agricultural and forestry feedstock(s). Chapter 3 is a summary of the provincial state of agriculture and forestry as it relates to the proposed project. Chapter 4 examines the nine candidate sites, reviewing the status and potential of agricultural biomass, forestry biomass, and finally the accessibility of both feedstocks via a road density analysis. The cumulative analysis of the nine sites is presented in Chapter 5. The first volume also includes a number of appendices including a detailed county-by-county survey containing agricultural, forestry and soils data; the mill residues for each county; and a summary of the provincial road networks by county.

In the 2001 census, Nova Scotia had 407,046 ha of agricultural land, of this, 100,000 ha was crops, 65,000 ha was pasture, and the remaining was either treed or in transition out of agriculture. The census also showed that the province produced about 496,000 metric tonnes of hay, 40,000 tonnes of grain, and 25,000 tonnes of corn residues.

There is about 3.9 million ha of forested land in the province producing 6.07 million cubic metres of solid wood in 2002, 5.18 million cubic metres was softwood and 880,000 cubic metres of hardwood. The provincial registry of buyers shows 1.5 million tonnes of wood residues in 2003.

Based on the assessment of sites in the first volume, Windsor, Truro, Stellarton, and Bridgetown were selected as being the most promising sites in terms of providing biomass feedstock for the bio-ethanol facility. The proximity of Windsor, Truro, and Stellarton results in large overlapping areas within the 50 and 100km radii of these sites. Choosing these sites as prospective locations of the envisaged three bio-ethanol facilities will not be appropriate with respect to the biomass feedstock supply. Therefore, Bridgetown has been included to substitute Truro, which happens to be situated

approximately halfway between Windsor and Stellarton. Port Hawkesbury is also recommended because of its proximity to large quantities of hardwood, both in 50 and 100km buffer, with no major competition.

The second volume covers the following tasks:

- e) Recommendation on transport options trucking resources in the detailed radii surveys.*
- f) Analysis of quantity available, species and quality considerations such as degree of decay, moisture content and presence of contaminants such as bark, dirt, etc.*
- g) Recommendations on biomass resource availability and sustainability up to thirty years.*
- h) Estimation of delivered costs of supplying biomass to each prospective site based on a dry weight basis.*
- i) Preliminary selection of plant feedstock for three best prospective sites.*
- j) Logistic plan for biomass procurement for three best prospective sites.*
- k) Recommendations on handling and processing equipment (including on site vs. off site options) for a biomass yard and yard design (including storage considerations).*
- l) Recommendation for suitable contract formats to guarantee price and supply for 8 years.*
- m) Identification of available biomass analysis and management software and recommendation of its relevance and usefulness for the purpose of this study.*
- n) Identification of any relevant knowledge gaps or variables related to the entire biomass supply process.*

Biomass procurement will be a critical component of Bio Vision's success. This volume presents a series of tools that have been developed to aid Bio Vision in making procurement decisions. Chapter 2 covers general procurement planning, purchasing, and processing. This type of information is universal and will apply wherever Bio Vision decides to establish future operations. Chapter 3 covers longterm sustainability issues, delivered costs, and trucking resources and is specific to Nova Scotia. Chapter 4 covers biomass feedstock selection and procurement for each of the four sites. The appendices include example contract formats, the machines catalogue, a summary of trucking resource, and a list of resource people.

Recommendations and Observations

Forest Biomass

- Nova Scotia Department of Natural Resources should develop a procedure manual for measuring the quantity of residue and waste left after logging operations. This would help the province identify under-utilized biomass resources.
- Further research and incentives need to be created in order to effectively use harvest residues. Areas of study could include better use of tops and branches, brushwood bale systems, full-tree debarking and chipping, and site nutrient management.
- Short Rotation Forestry appears to have substantial potential in the longterm for supplying biomass in the province. Further research and incentive programs are needed to encourage experimentation with windrow and full field Short Rotation Forestry.

Agriculture Biomass

- Further research into biomass crops needs to be conducted to encourage the adoption of a biomass industry for the province. This would include testing new biomass plant species, modifying cultivation techniques for existing crops, and improving the agricultural technologies associated with biomass production and harvesting. Important potential species include, but are not limited to: hemp, switchgrass, and reed canary grass.
- Future investigations should be directed towards increasing Nova Scotia's agricultural biomass potential by adapting the existing infrastructure for crop production towards biomass production, maximizing the use of in-active agricultural land, and improving agronomic techniques to optimize fibre production while reducing farming input costs.
- Basing future biomass feedstock on the use of restored farmlands is questionable. In many cases, the land has already been demonstrated to be of poor quality and would be unsuitable for growing expensive feedstocks.

Facility/Bio-ethanol

- Regional Development Authorities such as CoRDA (Colchester Regional Development Authority) and other local/regional bodies are among the best resources for obtaining local contact information on arranging the purchase of forestry and agricultural feedstocks. Regional authorities often maintain the most up-to-date listing of transportation information.

- An in-depth market survey should be conducted to ensure price certainty for various feedstocks. This might include arranging price agreements with suppliers prior to building an ethanol facility.
- After suppliers are identified, actual biomass samples should be obtained and analyzed to determine physical and chemical properties. Product yields and production costs can then be estimated with greater certainty. Preliminary testing of feedstocks should be conducted on a pilot scale, if possible, before full contract implementation.
- In order to simplify contract arrangements, contracts with individuals and solitary companies should be avoided in favour of group contracts or other arrangements such as through cooperatives.
- Before negotiating contracts, Bio Vision must have a detailed understanding of operating costs in various segments of the ethanol production process. This information, along with a firm understanding of the various types, qualities, and market prices of feedstocks available will facilitate the arrangement of favourable contracts.
- Legal or other expertise will likely be required to build suitable contracts.
- Both yard design and equipment selection will require further engineering studies. These should be carried out at the preliminary stage of site selection, to ensure that individual properties meet the demands of the production facility.
- A modular approach to developing the production facility should be considered. Initially, only the necessary equipment for ethanol production might be installed, while leaving biomass-processing equipment to local contractors. On-site biomass processing technologies could be pursued later, when opportunities or economies allow.
- Software programs for biomass management are, by their nature, very specific. Proper purchasing will require full knowledge of the facility's supply and utilization systems. This means that purchasing software in the early stages of facility development may lead to inadequacies or problems. Ideally, the software will be purchased when technical needs are fully understood.
- A full-time procurement manager (or management team) will be required to build relationships with local suppliers, manage the complexities of supply timing, market competition, production needs, and the ongoing evolution of an ethanol production facility.

- Significant cost savings over the long term can be realized by automating some tasks such as recording scale weights, invoicing, inventory control, and accounting. Feedstock sampling for quality control could also be automated.
- In order to secure a long-term sustainable supply, Bio Vision should develop feedstock research capacity within the company, and partner with local knowledge-based institutions. This will allow greater innovation on the types of feedstock materials used in the process.

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Glossary

AAC	Annual allowable cut
NSDAF	Nova Scotia Department of Agriculture and Fisheries
DNR	Nova Scotia Department of Natural Resources
ha	Hectares
MT	Metric tonnes
ODT	Oven-dried tonnes
OSB	Oriented Strand Board
SRF	Short rotation forestry
t	Tonnes
yr	Year
\$	Canadian dollars unless otherwise indicated

Conversions

1 cubic metre (m³) \cong 1 tonne green wood

1 metric tonne (t) \cong 2204 lbs

1 cubic metre \cong 2.32 cord

1 cubic metre \cong 4.237 foot board measure (fbm)

1 hectare (ha) \cong 2.47 acres

1 kilometre (km) \cong 0.62 miles

1 kilogram (kg) \cong 2.204 lbs

1. Introduction

Bio Vision Technology Incorporated (Bio Vision) plans to develop the first operational bio-refinery in Nova Scotia, utilizing a renewable biomass material base. A steam bio-fractionation technology developed in New Zealand has been identified as the most promising option for separating biomass fractions for further processing into marketable products, in particular ethanol. This effort is supported by the Nova Scotia Departments of Energy, Agriculture and Fisheries, and Economic Development and is in line with their mission of promoting responsible resource management in Nova Scotia.

The proposed biomass-to-ethanol facility will require 160,000 wet tonnes of biomass per year and is estimated to produce about 30 million liters of ethanol and other commercial products. To be successful, the facility must be located near a sustainable supply of quality biomass feedstock. Bio Vision envisages running three such facilities in Nova Scotia. As part of their proposal, eight candidate sites were selected for study: Yarmouth, Bridgetown, Windsor, Truro, Eastern Passage, Stellarton, Port Hawkesbury, and Sydney. A ninth candidate site, Amherst, has subsequently been added to cover the northwestern part of the province. The selection of the three best sites depends upon a number of factors, including longterm availability and quality of feedstock, transportation considerations, and the ability of the proposed site to accommodate facility requirements.

This Report covers the following tasks:

- g) An initial county by county biomass inventory, which will include biomass in existing wood lots, residues from existing forestry operations, residues from sawmill or other processing operations and other forms of biomass, such as hay or other non-wood fibrous materials, separated according to ownership class, and include comments on availability and affordability. Bio-waste resources is to be included as a separate resource (county by county) in the inventory. Types of future biomass that could be grown in the province and locations are to be included.*
- h) Best option scenario for biomass resources available within a fifty (50) km and a one hundred (100) km radius from best 5 (five) sites from the following possible plant sites: Yarmouth, Bridgetown, Windsor, Eastern Passage, Truro, Stellarton, Port Hawkesbury and Sydney.*
- i) A distinction between crown and private land for the detailed radii surveys.*
- j) Analysis of availability (including seasonality, control of land, etc.) and accessibility of biomass sources for the detailed radii surveys.*
- k) Recommendation on transport options trucking resources in the detailed radii surveys.*
- l) Analysis of quantity available, species and quality considerations such as degree of decay, moisture content and presence of contaminants such as bark, dirt, etc.*

This report is an examination of these tasks, using data from a variety of sources, and an evaluation of all counties in terms of:

- Agriculture - crops presently harvested, yield values, and agricultural production capacity.
- Forestry - gross merchantable volumes, forest density, harvest volume, mill residues, soil capability, and potential harvest.

The agriculture and forestry information gives an indication of present activities on the land in each county. Since much of Nova Scotia's farmland is no longer productive, the county survey also includes soil classifications to allow for longterm estimates of future capacity for agricultural productivity.

The production-site survey examines the nine sites in terms of the county lands that are included in their 50-kilometre radius. Although there is 785,400 hectares of area within the 50-kilometre radius surrounding each site, the actual land area available for potential feedstock is considerably smaller after non-productive areas such as water (ocean, rivers, lakes, wetlands), roads, urban areas, and protected landscapes are subtracted. Transportation links can also influence a production-site's catchment area.

The remainder of this Report is organized as follows. Chapter 2 provides general background information relevant to the topics of agricultural and forestry feedstock(s). The third chapter is a summary of the provincial state of agriculture and forestry as it relates to the proposed project. Chapter 4 examines the nine candidate sites, reviewing the status and potential of agricultural biomass, forestry biomass, and finally the accessibility of both feedstocks via a road density analysis. The cumulative analysis of the nine sites is presented in Chapter 5, while the data that underpins the analysis is kept separate in an appendix.

Four appendices are included. The first is a detailed county-by-county survey containing agricultural, forestry and soils data. The second and third appendices show the agricultural and forestry capacity classes for the soils of Nova Scotia, respectively. In appendix 4, the mill residues for each county are presented, while in appendix 5, a summary of the provincial road networks by county is listed.

1.1 The Authors

This report was written by the following Whale Lake Research Institute researchers: Seth Cain (forestry and soils), Sandy Cook (editor), Peter Green (GIS), Larry Hughes (Project Manager), Alain Joseph (agriculture), Ariesta Ningrum (forestry), and Anne Warburton (agriculture).

2. Background

2.1 Land Issues

Nova Scotia is 53,000 square kilometers in size (Nova Scotia Government, 2002). Approximately 70% of the Nova Scotia land base is owned privately, either by a company or an individual and the remainder is crown land (Hummel, 2003). The major sources of biomass, therefore, are located on privately owned land. Provincial Crown Lands occupy a significant land area in some counties. Federal land ownership is insignificant throughout Nova Scotia and therefore does not pose a concern when calculating land potentially available for feedstock.

The biomass-to-ethanol plant requires 160,000 wet tonnes of biomass per year to operate. The total area of land required for such a plant depends upon a number of factors including the type of biomass, the yield, the availability of land, and the existing market. Table 2.1 gives an indication of the total area required based upon a given yield.

Table 2.1 Yield to Area Ratios

Yield (tonnes/ha)	1	2	3	4	5	6	7	8	9
Area (ha)	160,000	80,000	53,333	40,000	32,000	26,667	22,857	20,000	17,778

The following sample calculations and analysis for Annapolis County demonstrate site-specific yield to area ratios because the proposed Bio Vision facility will require 160,000 wet tonnes per year to operate:

- Hay yields: 4.7 to 8.5 tonnes/ha
- Lower yield: $160,000 / 4.7 = 34,042$ hectares
- Higher yield: $160,000 / 8.5 = 18,823$ hectares
- Annapolis County has 31,766 ha of farmland (total farm area). The total farm area in crops is less than the total farm area (~12,000 ha)
- 5,020 hectares of Annapolis County is under hay production

The hay production from Annapolis County could not meet the requirements of the biomass-to-ethanol facility even with a high yield (8.5 tons/hectare). Furthermore, this hay already has a market and, presumably, is not available for ethanol production.

2.2 Agricultural Biomass

2.2.1 Forages

Grasslands, forages, and pastures are the dominant ecological habitat on planet earth. Without question the most widely grown crops worldwide are hay and other crops

destined for feeding animals. Forage crops include all grasses, legume species such as alfalfa and clover, and root crops with leafy tops suitable for consumption by cattle. Forages are either fed directly to animals through grazing or harvested then baled or ensiled for feeding during the non-growing season.

The most common forage combinations in North America are mixtures of fast growing grasses and legume species such as white or red clover, alfalfa, or vetch. Legumes contain higher quantities of protein, which promote animal nutrition, and are especially important in the dairy industry. A typical combination of forage in Eastern Canada is a mix of 70% timothy grass (*Phleum pratense*), and 30% clover (*Trifolium pratense*). Alfalfa (*Medicago sativa*) is a common forage crop with high value feed and excellent nutritional properties, but it is subject to winter-kill in colder climates, and requires a high soil pH. Because of the emphasis on nutritional content of crops, agricultural products have been bred through successive generations to contain greater and greater quantities of nutrients. Many modern seed varieties also require higher fertilizer inputs to sustain maximum yields (of up to 10 tonnes per hectare).

Biomass crops are grown for their woody fibres and cellulose content, not for nutrients. This is an important distinction from other agricultural land usage. An ideal biomass crop will contain little more than cellulose in the plant's above ground structures. To achieve this, specialized crops may be grown, or traditional crops may be cultivated using modified techniques to maximize biomass and reduce the unnecessary uptake of soil nutrients.

Forage crop harvesting is usually timed carefully to maximize the content of nutrients retained in the cut plants. Drying and baling hay is carried out under very specific conditions. Any rainfall during field drying reduces nitrogen content and the subsequent value of forage as animal feed. Similarly, improperly dried and stored hay may result in fermentation or rotting. The heat generated from fermenting moist hay can be sufficient to ignite a fire.

Grass species return their nutrients to the plant roots and rhizomes after reaching maturity, flowering, and setting seed. Hay mixtures can be used as an excellent biomass crop provided they are left standing in fields until maturity. This simple change in harvest timing greatly enhances nutrient return to soils, reducing production costs, while having little effect on the biomass yield. (Bill Thomas, Agrapoint forage specialist, personal communication, 2004). Many grass species used for hay will produce larger woody stems if allowed to grow to full maturity. Reed canary grass is a fast growing forage grass, avoided by some producers because it grows quickly enough to risk becoming woody and unpalatable to cattle in a short time period, especially if the farmer is unable to mow down the crop due to weather, or other reasons. The characteristics of rapid and woody

growth, however, are highly desirable in a biomass crop. Modifications to the cultivation techniques of many common crops could provide ample biomass opportunities.

2.2.2 Corn Stover

Corn (*Zea mays*) is a fast growing member of the grass family adapted to warm climates through its C4 photosynthetic biochemical pathway. Like most C4 plants, corn prefers warm climates and rich soils. In proper conditions, corn can yield up to 40 tonnes per hectare. The vast amount of biomass produced by the plant has made it a key agricultural animal feed crop (as silage corn). Corn is a heavy feeder, requiring high fertility levels for maximum growth. A large amount of nutrient is retained in the plant biomass, and consequently, some researchers object to the use of corn residue for biomass burning or other usage. Plowing the stalks and leaves back into the soil is an important part of the agricultural cycle, but recent studies (NREL 2002) indicate that up to 50% of corn residue biomass may be removed without serious consequences to soil health. Residue quantities of 10 dry tonnes per hectare may be obtained by using this practice.

2.2.3 Cereal Straw

The leftover chaff from cereal production has been an agricultural commodity since the earliest domestication of animals. Straw is an excellent source of bedding material because of its uniformity, high carbon content, and low moisture. These characteristics enable straw to absorb odours and the wastes of animals kept in confined spaces. The high carbon content also makes straw an important biomass crop. Straw-fired electricity generation plants are located in several European countries.

2.2.4 Hemp (*Cannabis sativa* L.)

Hemp is an annual, herbaceous plant that can grow to heights of up to 4 meters. Under proper management, the plant produces a single stem with a diameter of 4 to 20 mm (OMAF, 2000). Hemp can be grown on a wide variety of soil types, but prefers a deep loosely packed soil with a pH of six or greater. Precipitation and soil moisture are critical to ensuring a good hemp crop. Long days and high levels of precipitation are well-suited to hemp production; however, poorly drained soils will not permit a good crop. Excess surface water from heavy rains can damage hemp stands; the crop is very sensitive to flooding and soil compaction. This, along with the need for the high fertilizer inputs and machine harvesting suggests that hemp crops are not well suited to marginal agricultural lands (where hay might be a possibility). Hemp is best produced under conditions similar to those required for corn production.

Hemp can be grown on the same land for several years in succession, but crop rotation practices are strongly recommended to avoid soil nutrient deficiencies and disease

problems. Yield data from studies in 1995-97 in Southwestern Ontario indicate that yield expectations should be between six to eleven tonnes of baled hemp stalks per hectare (Dragla, 1998).

Costs of production for hemp may be high due to seed costs, high fertilizer costs, and government regulations. Generally, production costs exceed \$50 per tonne (OMAF, 2000; Caldwell, 2004, personal communication). Market prices for raw hemp have been observed at \$70 to \$180 per dry tonne in Ontario, but there is considerable market volatility (OMAF, 2000). The use of both oilseed and fiber from the same hemp crop can improve economics. Commercially available seed varieties are generally better suited to only one of either oil or fiber use, but considerable yields can still be obtained from oilseed hemp varieties (greater than 7 tonnes per hectare).

Hemp fibres can be baled using unmodified hay baling equipment. Storage of properly dried bales (less than 15% moisture) is possible for several months without any loss of quality. Hemp fibre can be transported on any truck suitable for hauling hay.

2.2.5 Switchgrass (*Panicum virgatum*)

Switchgrass is a perennial grass, native to warm climates. The plant is physiologically adapted to using a C4 biochemical pathway that allows rapid growth. Several studies have indicated that switchgrass yields of 10 dry tonnes per hectare may be expected under suitable growing conditions. However, trials at the Agriculture Canada Fredericton research station have indicated that switchgrass yields are lower than for other forage crops currently grown in the region, such as timothy or reed canary grass (Bolinder et al., 2000).

There is no commercial switchgrass production in Nova Scotia, and this crop remains largely untested in the region. The data from Fredericton suggests poor potential for switchgrass production in Nova Scotia. There remain considerable knowledge gaps surrounding the cultivation of this crop, including production techniques and costs, expected yields, and market prices.

2.2.6 Reed Canary Grass (*Phalaris arundinacea*)

Reed canary grass is a tall, coarse grass that grows from 0.6 to 3 meters in height. Reed canary grass is a cool-season, sod-forming, perennial wetland grass native to temperate regions of Europe, Asia, and North America. Reed canary grass can grow on dry upland soils but does best on fertile and moist organic soils in full sun. This species can be considered invasive and thrives in most types of wetlands such as marshes, ditches, stream banks, and seasonally wet areas (WDNR, 2004). Research breeding programs are underway in Scandinavia to develop the potential of the crop for fibre production for

pulping and fuel use. Maximum yields are thought to be 12 dry tonnes per hectare (BioMatnet, 2004).

Reed canary grass is grown across Eastern Canada, but is often considered undesirable in hay fields because the bulk and low nutrient status of the crop make it a poor cattle feed. Production is similar to that of other hay crops, but for maximum fibre yield, only one cut of the stand is harvested each season. Costs of production will be equal or less than those for hay. Similarly, the market price for reed canary grass will not exceed that of hay, and could be considerably lower if producers exploit land previously considered unsuitable for production (for example, marshlands).

2.2.7 Elephant Grass (*Pennisetum purpureum*)

Although commonly referred to in the biomass literature, this African grass is not appropriate for northern latitudes because it is sensitive to frost and grows best at a mean temperature of 21°C (FAO, 2004). Elephant Grass is a perennial tropical and sub-tropical species with vigorous growth, capable of producing well over 10 dry tonnes per hectare per season under optimal conditions. Elephant Grass is difficult to propagate because it is spread by root cuttings (rhizomes). There have been no trials of elephant grass in Nova Scotia.

2.2.8 Agricultural Equipment and Transportation

Agricultural production relies on mechanical implements and powerful diesel tractors to effectively prepare, seed, and harvest cropland. The production of forage grasses and hay requires a tractor (or access to a tractor) of greater than 50 diesel horse power (HP) to run hay making equipment. Various tillage implements such as plows, disks, and harrows are needed, and mowing, raking and baling equipment will be required to harvest most biomass resources. This machinery is available on most active farms. Non-conventional crops such as hemp may require additional equipment such as sickle-bar mowers.

Transportation from farm fields can be accomplished with tractor wagons and sometimes truck-trailer arrangements. Long distance hauling of goods is similar to that of many other bulk goods and can be handled with flatbed or covered semi-trailers.

2.3 Forest Biomass

Forest biomass, also known as woody biomass, covers a wide range of sources of plant materials containing cellulose, hemicellulose, and lignin. This includes standing wood and extracted timber, residue from forest thinning and harvesting, residue from wood processing, purpose-grown forest plantations, and municipal green waste. The following section highlights the potential of each source of forest biomass for use as feedstock for bio-ethanol production.

2.3.1 Timber

In general, timber refers to wood volume in the trees that are removed from the forest as roundwood products. The various types of roundwood products are based on the type of primary processing and the resulting end product (i.e., sawlog, pulpwood, fuelwood, studwood, veneer log, or firewood). In the context of tree species, the roundwood assortments are broadly divided into two classes: softwood and hardwood. Softwood trees are characterized by having needle leaves (coniferous), while hardwood trees commonly have broad leaves (deciduous). The land capability for softwood and hardwood in the Maritimes ranges from 1 to 9 m³/ha/year commonly between 2 to 6 m³/ha/year (NSDNR, 2000).

Softwood roundwood typically has higher moisture content and lower bulk-density at the time of harvest. The moisture content of green roundwood ranges from 40-50%, which can be reduced to 20-25% by air drying over one or two year period (Sims, 2002). Typical biomass components of hardwood, softwood, and agriculture product are presented in Table 2.2.

Table 2.2 Biomass components of hardwood and softwood

	Hardwood	Softwood	Agricultural Products
Cellulose	35-48%	38-42%	35-45%
Hemicellulose	28-33%	28-33%	30-35%
Lignin	20-24%	25-30%	20-25%

Adapted from McCloy and O'Connor, 1999

Regarding ethanol production, a number of studies reviewing different processes for converting wood cellulose to ethanol suggest hardwoods give a better yield than softwoods (Lora, 2002; McCloy and O'Connor, 1999), due to lower amounts of lignin than softwoods. The presence of lignin requires more enzymes to ferment the wood fibers than cellulose and hemicellulose, resulting in lower yields and higher operating costs.

2.3.1.1 Transport

Timbers are usually transported on open flat bed trailers and truck tractors pulling a single-pole trailer (semi trailer) or twin-beam trailer (B-train). The average hauling capacity of semi trailers is 32 tonnes, while B-train trailers can haul 42 tonnes. Some of these tractors can be equipped with loaders and other logging equipment. Trucking usually starts on unpaved secondary roads and moves to public roads.

2.3.2 Forest Residues

The most common forest residue is from logging or harvesting which results from commercial logging operations where trees are cut and timber is removed from the forest. The logging residue in general may include all tops and small branches, limbs, stumps, and under-sized trees left standing. Also included in this category is residue from pre-commercial thinning or silvicultural operations. Thinning is carried out to allow the better quality trees to grow by cutting smaller or low-quality trees. The volume cut varies largely based on site conditions especially whether the thinning occurs in natural stands or softwood plantations. In the case of thinning natural stands, more than 50% of the standing volume may be cut. However, the collection of residues from these types of operations can be arduous because it must be done manually. It is not viable to use thinning or silviculture residues as commercial feedstock.

Determining the amount of residue that results from logging practices is a challenging task. The quantity of logging residue will be a function of the harvest method, the type of harvested timber, and the tree stand characteristics such as the age of the trees and the species.

One common method of estimating the quantity of logging wood residue is using a forest residue factor, which essentially relates the amount of wood residue produced to the specified amount of timber harvested. Residue generation is then estimated by multiplying the volume of timber harvested by the residue factor. As expected, these factors vary greatly by region, forest type and time. For example, in most tropical forests where advanced harvesting techniques are not used, the logging residue factor ranges between 30-50% (Koopman & Koppejans, 1997), while in the US, the logging residue can be up to a quarter of the amount of timber removed (Haynes, 1990). There are no common numbers for Canada's forests and minimal literature exists, although some jurisdictions may have started to measure harvest residuals. For example, the Ministry of Forestry of British Columbia has created a procedure manual for the Crown's forest contractors to measure the quantity of residue and waste left after logging operations (2002). The manual contains rigorous and detailed specifications and methods to estimate the residue and waste volume of different types of residual materials resulting from logging operations.

Moisture content of logging residue varies due to many factors including species, season, and region, but typically it is around 50%, and can be higher during the winter months. Heating facilities and power plants that use residues such as hogfuel, use them in the summer while their boilers still can handle higher moisture content levels (Cowie, 2004).

Due to the heterogeneous nature of forest residues, the degree of decay of this type of biomass can be expected to vary greatly especially if the material is not removed

immediately after harvest. Typical contaminants that may be present within logging residue include dirt, bark, and rocks.

2.3.2.1 Transport

When the amount of logging residue suitable for use as raw material is available in sufficient quantity from logging areas, it can be chipped on site and transported using pulp chip trailers. This will require bringing the chipper on site, which could add to the cost. In addition, if the material is not debarked on site, it will have a lower bulk density and transporting the material will be more costly.

A study has been undertaken in Finland to look for cost savings in transporting logging residue materials by using the brushwood bale system (TEKES, 2002). This involves machine-bundling the forest residue at the logging site with a baler that can be fitted onto a forwarder chassis. The bundles can then be loaded into a timber carrier, and the actual chipping process can be carried out at the facility.

2.3.3 Wood Processing Residues

Wood processing residues, or mill residues, are simply woody biomass separated from the desired wood products during processing at mills. Some of these mill residues can be used for manufacturing other products, and some may end up being disposed of as waste. Shavings from mills with dry kilns are the most desirable product for bio-ethanol production because of low moisture and contaminant levels. Sawmill residues, including shavings and chips, can be used by pulpmills to manufacture paper or used in farming as animal bedding. Dry sawdust can be sold for composite board and pulp uses, and is desirable as poultry or dairy bedding. Other residues, like bark and wood chip rejects may be used by mills for heat for drying lumber, onsite power generation, or sold to landscapers.

The quantity of residues generated by the wood industry may vary depending on the production level of the mills and available markets for residues. A study on Canada's wood residue (Canadian Forest Service, 1999) estimates that approximately 17.7 million dry tonnes of residues are generated from Canada's wood mills, of which 70% is utilized and the remaining 30% (around 5.4 million dry tonnes) are surplus. The study also estimates that approximately 78% of a sawlog is generally used in the production of primary forest products, with the remaining 22% being residue. Of the 78%, 40% is lumber and 38% is pulp chips. Of the 22%, half is bark and the other half is dry shavings and sawdust—prime materials for ethanol production.

2.3.3.1 Transport

Wood processing residues such as chips and sawdust are easily transported in covered chip vans or semi trailers. Some semi trailers may be equipped with walking floors that automatically drop the chips onto a warehouse floor. Chips and sawdust can be stored for extended periods during the winter; however, during the summer they can only be stored for one to four months depending on storage techniques (Neuhauser and Abrahamson, 1996).

2.3.4 Short Rotation Forestry

Short rotation forestry (SRF) is a process whereby fast growing tree species are grown in an intensive manner over a short time period (i.e. a few years verses 50 years). Common species include willow, hybrid poplar, and other warm climate species such as cottonwood. Rotation durations vary between 3-4 to 10-15 years. It appears from our research that SRF is not practiced commercially anywhere in Canada. However, a substantial amount of research has been conducted in southern Quebec, Ontario, and other provinces. Based on these studies it appears that rain fed yields range from 7-11 dry t/ha/yr at an approximate cost of \$63-\$95 per dry tonne (Girouard et al, 1995).

An economic assessment of agro-forestry in Saskatchewan has revealed that SRF is not yet economically viable based on a market price of about \$34/t (Lindenbach-Gibson 2000). This study was based on a 16-year rotation and an average yield of 8 dry t/ha/yr. A final major limitation for the use of SRF for ethanol production is that it is difficult to separate bark from wood fiber on small hardwoods. If trees are grown on a very short rotation (three to four years) stem size is quite small and the debarking processes results in excessive wood loss. The most efficient SRF method is a three to four year rotation and full tree chipping directly to a chip van. This process maximizes yield and minimizes harvesting costs. By placing the van at a distance from the chipper, bark and foliage, which is much lighter than wood chips, falls out. Bark can also be sorted using processes such as the "Massahake process". This requires a small industrial plant that uses a complex mechanical procedure that produces clean chips and hog fuel. This has been developed into an industrial facility in Finland. The capital cost of this plant is reported to be about three million USD and to have a capacity of 51 m³/hr.

2.3.4.1 SRF Process

The basic process involves preparing abandoned or marginal farmland through agricultural methods. At this point herbicides and sometimes insecticides and fertilizers are added to the soil to control competition and pests after planting. Trees are planted mechanically at a variety of densities (the Swedish double-row system plants at 15,000 trees/ha). Under the most rapid systems trees grow for three years except for the first

rotation, which is four years because initial establishment is slower and trees are cut back after the first year to promote multiple stems. Weed control is extremely important the year of establishment, nutrients (chemical fertilizers and/or organic sources) are applied in the spring, early summer, (or both) after cutback, and after each coppice harvest. The best time to harvest is in the dormant season. This ensures the best regeneration the next spring as nutrients are withdrawn from the leaves and stored in the roots. Likewise, important nutrients are lost from the site if leaves are removed. Depending on the rotation length and species as many as seven or eight coppice harvests are expected following establishment (Neuhauser and Abrahamson, 1996). Depending on the operation irrigation, chemical pest control, and yearly fertilization may also be used. Similarly, animal control may be needed for deer and rabbits.

2.3.4.2 Agro Forestry

Plantation form is not the only method of SRF. Another common one is to plant trees in rows in farmland as windbreaks or windrows. This method has a variety of benefits. First, it allows farmers to diversify income. Second, large SRF plantations often suffer from water shortages but this is less acute when trees are planted in rows. Third, though trees take up productive land, crop yield increases of approximately 5%-10% are generally experienced over a distance of 10-15 times the height of the windbreak (including the land taken up by the windbreak) (Samson and Chen 1995). Fourth, grown in rows, per tree growth is much higher as well as per ha yields. Larger trees are potentially more useful for pulp, Oriented Strand Board (OSB), and bio-energy. Samson and Chen (1995) report that windbreak yields in Ontario range from 25 to 9.7 dry t/ha/yr depending on the number of rows.

2.3.4.3 Yields in SRF

Under irrigation, fertilization, or both, potential yields are much higher. Samson and Chen (1995) report a threefold improvement in yield with irrigation. Although yields in fertilization studies are not quantified as well as yields in irrigation studies, fertilization appears to have the potential to double yields. Innovative fertilization and irrigation schemes using treated municipal wastewater, sewage and pulp mill sludge, can be used to improve yields and economics of SRF. Drip irrigation and mechanical watering, and fertilizer applications are also used (Hartsough and Yomogida, 1996). Table 2.3 presents a list of studies of rain-fed, unfertilized SRF yields for poplar and willow.

Table 2.3 Summary of SRF rain fed production data on poplar or willow

Location	Species	Yield (ODT/ha)	Source
Europe			
Austria	Willows	10.5	
Denmark	Willows	8.1	Ledin and Alriksson 1992
England	Willows & poplars	6.0-11.0	Ledin and Alriksson 1992
France	Poplars	7.9	Ledin and Alriksson 1992
Sweden	Willows	11	Auclair and Bouvarel 1992
North America			
Ontario	Poplars	2-3	Ledin and Alriksson 1992
Pennsylvania	Poplars	10.4	
Minnesota	Willows	3.0-4.7	Hendry 1990
Wisconsin	Poplars	8.3	Ledin and Alriksson 1992
Minnesota	Poplars	6.9	Riemenschneider and Netzer 1996
Washington	Poplars	18.8	Wright et al. 1993

Adapted from Samson and Chen 1995

2.3.4.4 Equipment

Special machinery is required for SRF, including planting equipment, harvesters, forwarders or skidders, debarkers, chippers, chip vans. Unfortunately, conventional forestry equipment is not well suited to SRF operations. Conventional equipment machinery is inefficient and overly rugged because it has been designed for forest conditions and larger more variable tree sizes (Yomogida and Hartsough 1996). Numerous machines have been created or adapted for SRF. Some models use farm tractors; others are separate machines. The reports of the Short Rotation Woody Crops Working Group are a good starting point for a full review of various SRF machinery and manufacturers as well as SRF in general.

3. Nova Scotia Summary

3.1 Agriculture

Agriculture is a relatively minor economic industry in Nova Scotia, and represents 0.9% of provincial gross domestic product (GDP) in 2002 (NSDoF, 2003). The agriculture industry employs close to 10,000 people directly in production and agricultural services (Robinson and MacDonald, 2000), and up to 56,000 more in food retail, wholesale, and the food service industry.

Provincial land use for agriculture in 2001 was 407,046 ha of the total 5,300,000 ha of land area in Nova Scotia, or approximately 7.7% (Statscan, 2002). The total land area for agriculture includes areas such as woodlots and unimproved land, therefore the total land in agricultural production is considerably lower. In Nova Scotia, 28% of farm land is used for crop production, 16% is held in pasture, and 56% of farm usage is categorized as for 'other uses' (NRCan, 2004). The major crops grown in Nova Scotia are hay and forage crops, followed by corn for grain or silage, and various cereal crops. The crops are cultivated on approximately 100,000 ha of land (Census of Agriculture 2001) of this, 65,000 ha are used for hay and pasture.

3.1.1 Nova Scotia's Current Agricultural Biomass

The geographic location of agricultural activities in the province is concentrated in a few regions. The most prominent area is the Annapolis Valley where high quality soils and a beneficial microclimate allow a variety of cash crops to be produced. Colchester and Cumberland counties are also highly productive, taking advantage of the flat and fertile flood plains surrounding the Bay of Fundy. Pictou and Antigonish counties are productive, especially towards the coastline on the Northumberland Strait. Most other regions of the province have poor soil conditions that limit agricultural production.

Seven counties (Annapolis, Antigonish, Colchester, Cumberland, Hants, Kings, and Pictou) contain 83% of the agricultural land in production (Census of Agriculture, 2001). Kings county is the most active region with 20,585 ha of land in production, representing 21% of agricultural land use in the province (see Figure 3.1).

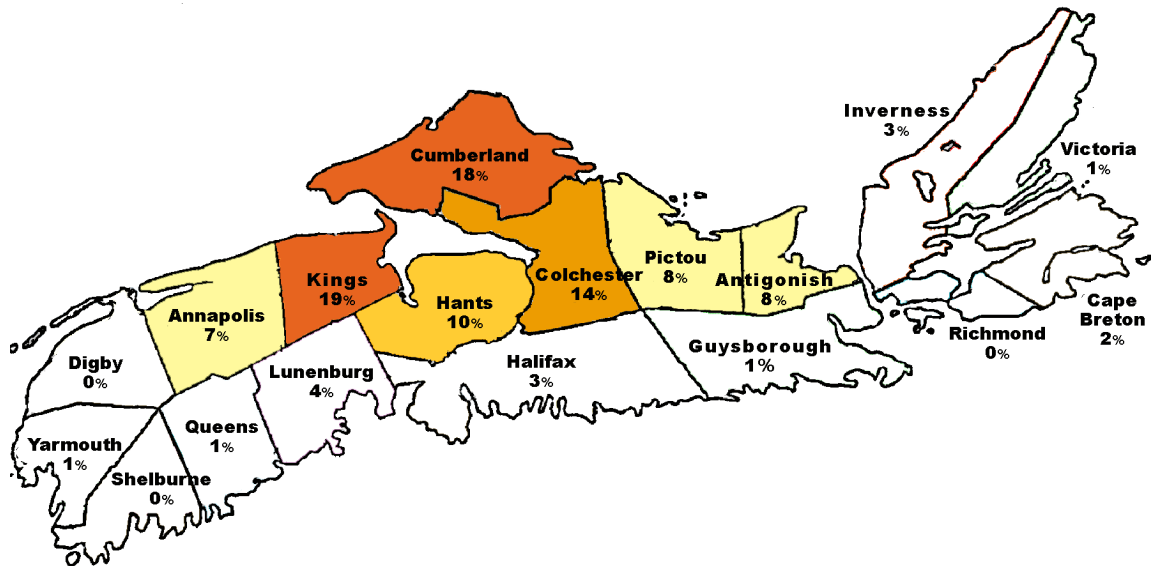


Figure 3.1 Seven counties are responsible for 83% of agriculture in Nova Scotia.

The percentage of total NS improved land is indicated for each county.

Land for hay and alfalfa represents 78% reported cropland use in the 2001 census of agriculture. Grains such as wheat, barley, oats, and rye represent 11% of 2001 cropland use, corn for grain and silage represents 6%, and potatoes and soybeans are 2% and 1% respectively. Forage is one of the highest yielding crops in our climate, generally producing two harvests per growing season, one in July and another in August or September. Average yields for hay in Nova Scotia from 1993 to 2002 were 6.2 tonnes per hectare. The estimated hay production in 2001 was 496,000 metric tonnes (Robinson, 2002).

Total grain production in 2001 was approximately 40,000 metric tonnes. Straw from cereals such as wheat, barley, oats and rye has been a source of biomass in agriculturally active regions of Sweden and Denmark. In Nova Scotia cereal production represents 11% of land use (10,700 ha). Straw residue left over from grain production is generally harvested and baled. Straw yield data is not collected in Nova Scotia, but straw to grain ratios are known for most crops. Values range from a ratio of 4:1 to 2:3, however because of different amounts of stubble left in the field, and some of loss of material in harvesting and baling, a ratio of 1:1 is a reasonable rule of thumb (SAFRR, 2004). Based on this, an estimated 40,000 tonnes of grain straw is produced annually in Nova Scotia. In Eastern Canada, straw is a premium product used for animal bedding and erosion control. There is generally a shortage of straw in the local market, which influences the straw price.

Corn production occurs on 5,392 ha of Nova Scotia cropland (6%), with slightly more than half of that production (2,809 ha) dedicated to silage corn. With silage corn the entire plant is harvested, leaving no residue. However, grain corn is grown on 2,583 ha of

land, producing 19,700 tonnes of grain in 2002 (Robinson, 2003) and an estimated 50,000 tonnes of residue. This residue consists of the stalks and stover and has been studied as a biomass source. Research conducted by the United States National Renewable Energy Laboratory (NREL) suggests that up to 50% of this residue can be removed for use on a sustainable basis (NREL, 2002). This implies that up to 25,000 tonnes of corn residue may be currently underutilized within the province.

3.1.1.1 Limitations on Biomass Availability

An important distinction must be drawn between the amount of produced biomass, and the amount of available biomass. The majority of hay grown in the province is used to feed the province's 100,000 cattle. A consumption of 10 kg of hay per day per animal would amount to 365,000, or roughly 74% of total hay production.

The growth of hay and forage crops is subject to adequate precipitation. In drought years, yields may decrease substantially. In 1999, there was a shortage of hay in Nova Scotia, suggesting that the amount of 'surplus' hay in the province is limited. Similarly, the quantity of available straw may be constrained since it is used for bedding for animals, erosion control, and other uses. There is limited straw in the province and straw currently sells in the Truro market for a higher price than hay.

3.1.1.2 Seasonal Considerations and Market Prices

The earliest hay cuts are late in June. In a good summer, most farms manage to get two harvests. Early grains such as barley will produce straw in early August, while winter wheat and other grains are not harvested until September. The price of hay and straw varies depending on the season, year, and other market factors. However, price values for hay generally range between \$80 and \$120 dollars per tonne, while straw sells for slightly more.

3.1.2 Under-Utilized Land

Statistical data reveals the observed trend that agriculture has declined in Nova Scotia. Pasture and forage lands are often among the earliest fields taken out of production because they do not produce any cash crops. In Nova Scotia, the quantity of pasture and seeded hay crops has been in decline for decades. Planted hay crops decreased from a high of 274,548 hectares in 1919 to a low of 60,705 hectares in 1972 (see Figure 3.2).

The data for total farmland in the province also shows the change in occupation and economic structure over the province's history. In 1891 the 'total area in farms' was measured at 2,460,857 hectares (6,080,695 acres), by 1991 this had undergone an astounding six-fold decline to 397,046 hectares. The current land area in farms is 407,046 hectares (Statistics Canada, 1941, 2001 Census). It is important to note that 100 years

ago, most of the population considered agriculture as part of their occupation and much of the property in the province was designated as 'farmland'.

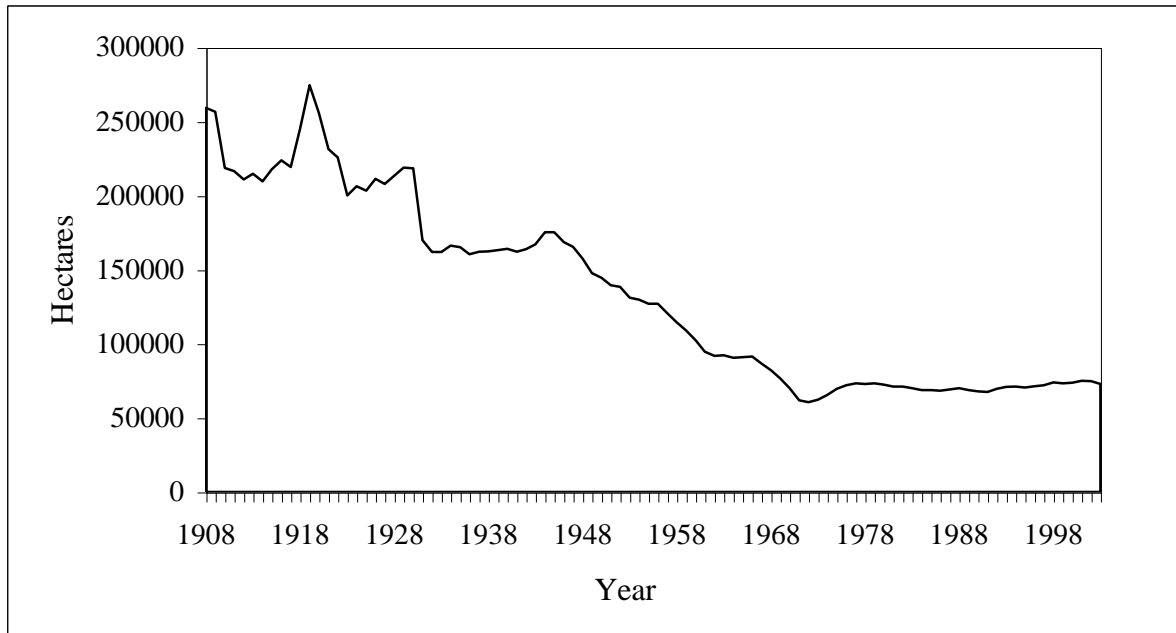


Figure 3.2 Decline in hay production in Nova Scotia from 1908 to 2003.

Land-use statistics for abandoned agricultural land at the county level are not immediately obtainable. By using only statistics and production records, it is difficult to determine exactly where land use changes have occurred; a preferred approach would be to employ geospatial tools such as satellite imagery. Unfortunately, this technology has only been available in the last 30 years.

In order to gain a greater understanding of the changes in Nova Scotia's agricultural production, data have been compiled from Statistics Canada census information for the years: 1971, 1981, 1986, 1991, 1996 and 2001.

The format of census questioning has had several important changes over this thirty-year period. The previous system of classifying land as 'Improved' (cleared, tilled, or otherwise modified to increase agricultural output), or 'Unimproved' (natural areas of grasslands or other wild crops which are used for agriculture) was terminated in 1991. In 2001, the category known as improved pastureland was changed to 'Tame or seeded pasture' and unimproved pasture was changed to 'Natural land for pasture'. The change in terminology causes some variation in the way respondents answer the census surveys, introducing some error in comparing 2001 to previous years. The new classification scheme is still evolving, but has its roots firmly in the standard applied since Confederation. Data from 1971 (one of the last years to follow the old format) are shown in Figure 3.3.

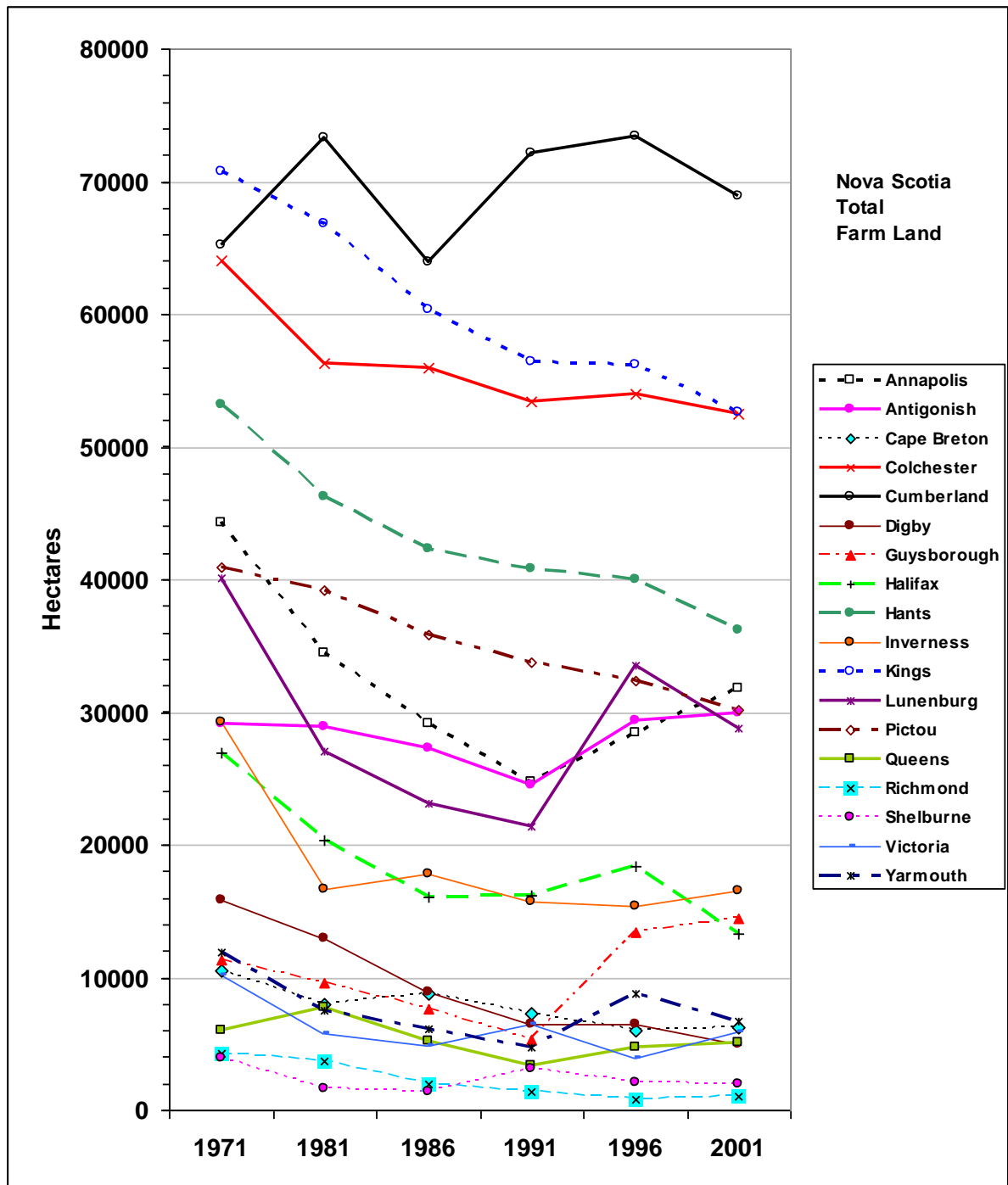


Figure 3.3 Total area of farms in Nova Scotia 1971 to 2001.

[Statistics Canada data]

It is important to note that the source of this data is questionnaire based, and not from direct empirical sources such as satellite photos or surveying. Changes to the way in which questions are posed can influence how respondents answer questions, and

ultimately change the data collected. Statistics Canada is confident that its data falls within 95% confidence intervals.

Table 3.1 and Figure 3.3 to Figure 3.5 allow a visual interpretation of agricultural productivity for the various census divisions in Nova Scotia (in this case, the counties). It is possible to discern which counties are most productive and it is possible to observe the rate of increase or decrease in land use patterns for each region.

Table 3.1 Categorical subdivisions of land use employed by Statistics Canada.

Showing quantities of land in hectares and the percent of total farmland using 1971 Census data. The total amount of land in Nova Scotia was recorded as 5,284,281 ha.

Category	Area	Percent
Land in Crops	98,326 ha	18%
Improved Pasture	43,461 ha	8%
Fallow	2,538 ha	0.5%
Other	11,898 ha	2.2%
<i>Total Improved Land</i>	<i>156,223 ha</i>	<i>29%</i>
Unimproved (natural) Pasture	33,586 ha	15%
Newly Broken Ground	1,006 ha	0.2%
Woodland	299,615 ha	56%
Other Unimproved	81,813 ha	6%
<i>Total unimproved land</i>	<i>381,573 ha</i>	<i>71%</i>
<i>1971 Nova Scotia Total Farm Area</i>	<i>537,796 ha</i>	<i>100%</i>

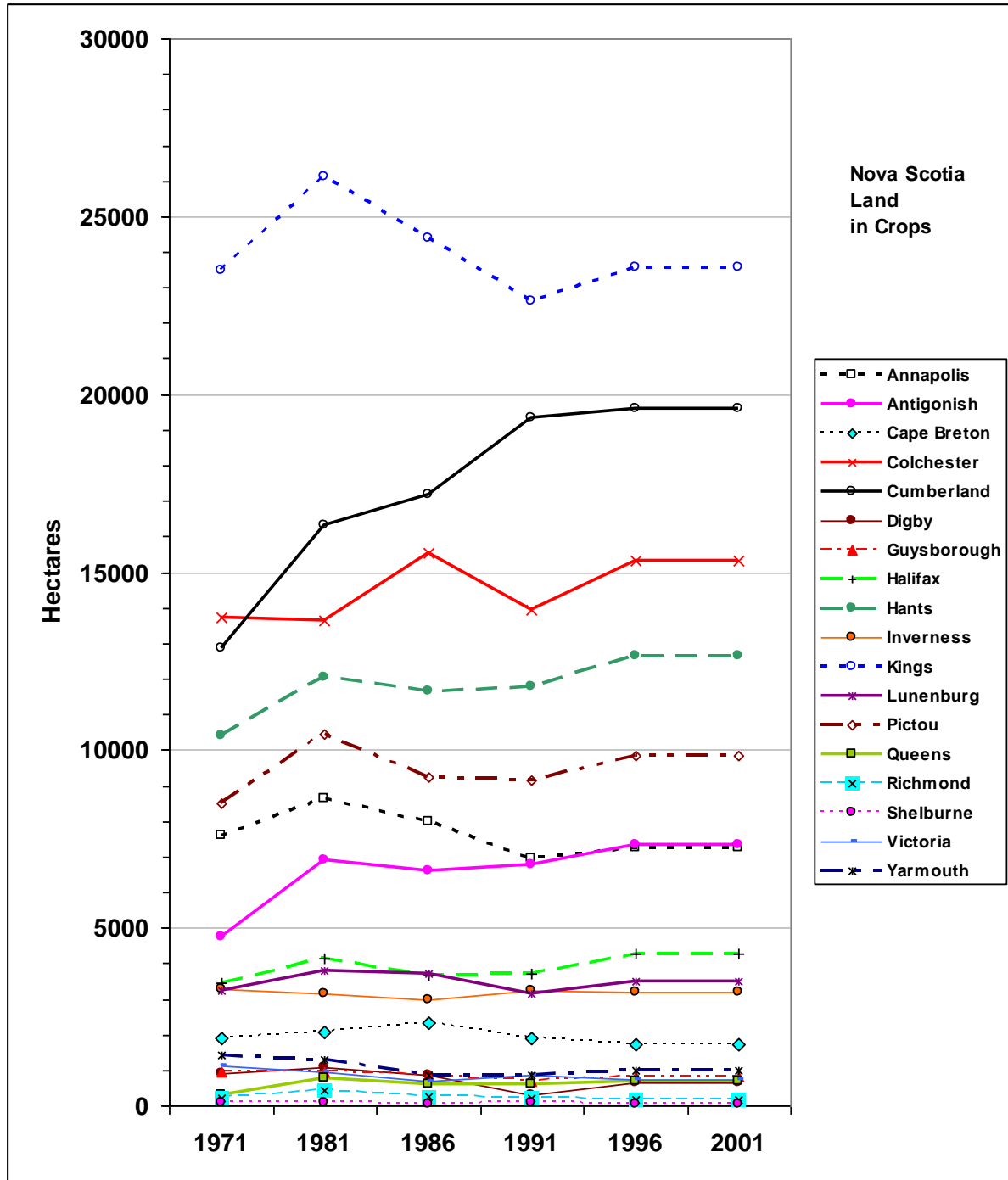


Figure 3.4 Lands in crop for Nova Scotia from 1971 to 2001.

[Statistics Canada data]

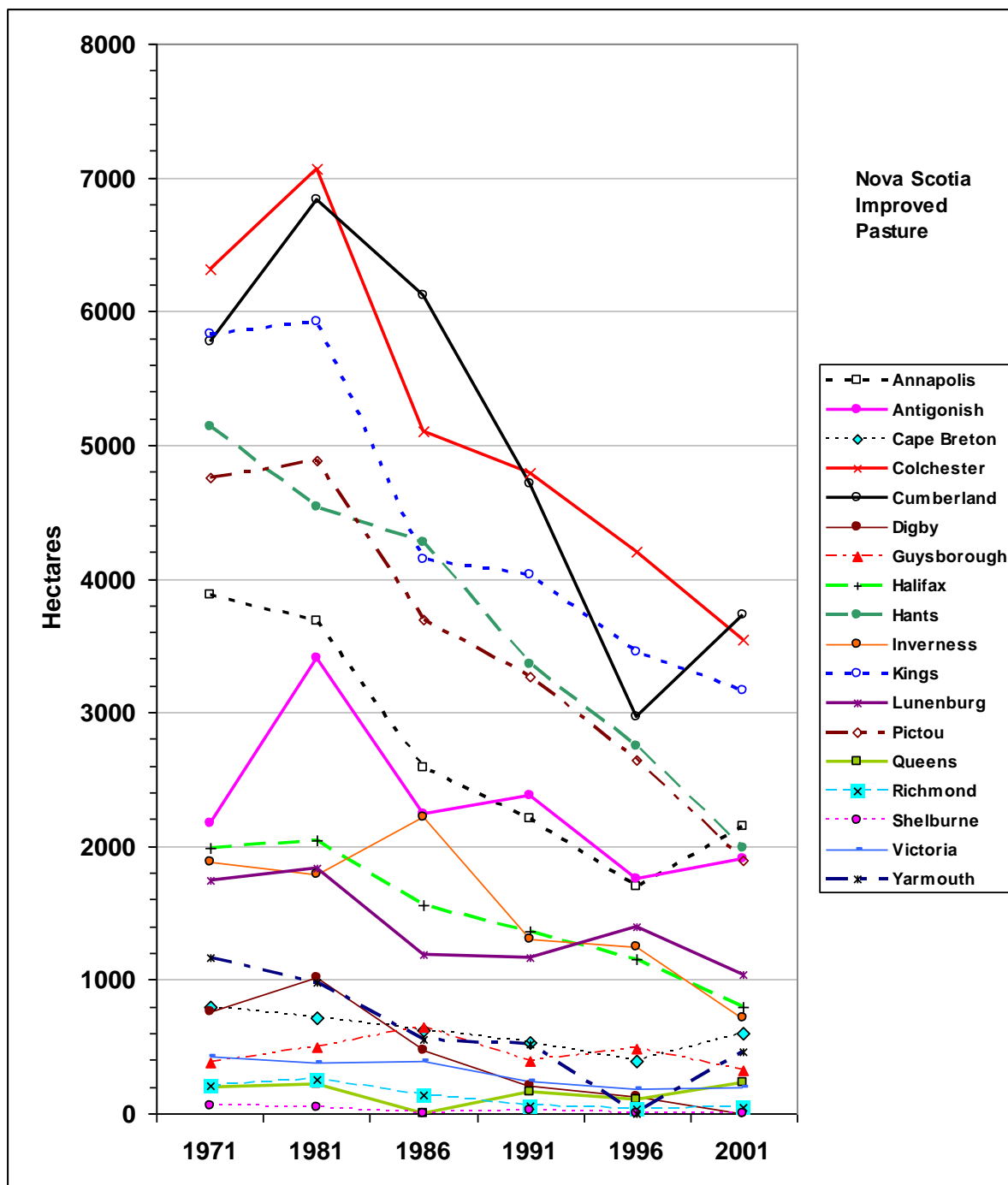


Figure 3.5 Improved pasture in Nova Scotia from 1971 to 2001.
[Statistics Canada data]

3.2 Comments on Land-use Analysis

Traditionally, the amount of total farmland was seen as the sum of two main sub-categories: 'improved land', 'unimproved land'. Improved land was further subdivided into 'land under crops,' 'improved pasture', and 'summer fallow'. Unimproved land includes woodlots areas, natural or wild pastures, and 'other' unimproved land.

In Nova Scotia, the practice of leaving land fallow (unused or 'resting') is not common. Land in this category generally represents less than one percent of the total farm area in a given county. Therefore, the sum of pasture areas and land under crops corresponds very closely to the total quantity of improved agricultural land.

Unimproved lands make up the largest quantity of farmland in the province, representing 65% of the Nova Scotia's agricultural land in 2001. The term 'unimproved' is misleading, suggesting that the land could be rendered more productive, or that it is awaiting cultivation efforts. In fact, this type of land is often used as woodlots or held as private property.

The Agricultural Land Identification Project (ALIP) data set produced in 1997 by NSDAF (Nova Scotia Department of Agriculture and Fisheries) offers some additional insight into on-farm land use. This data is presented in Appendix 1.

The decline in agricultural land and areas devoted to pasture is clear from the above figures. There may be opportunities to re-introduce agriculture to some regions, especially in pasturelands. However, time and economic constraints may limit such an endeavor. Unmanaged pastureland will revert to alders and low-grade forest in a period as short as 10 years. Cultivation efforts are most likely to be successful on land that has been out of agriculture for less than five years.

3.3 Changes in Land Use

The earliest pasture record available from Statistics Canada is a provincial total of 101,948 ha for 1911, this compares with the 2001 figure 22,774 ha. Clearly, a great deal of pasture is no longer in production. In this analysis, thirty years has been selected as the upper horizon under which land would be capable of re-introduction to agriculture. Since 1971 in Nova Scotia as a whole, there has been a net loss of 20,560 hectares of improved pasture (seeded, as opposed to naturally occurring). This loss is nearly 50% of the total pasture recorded in 1971. If this land were farmed at current production levels for hay (6.2 t/ha), it could produce roughly 125,000 dry tonnes of biomass.

Interestingly, the quantity of land in crop production has increased over the same time. Thus, there are few opportunities to take advantage of underutilized croplands -- little more than a few hundred hectares in select counties. The net gain of 20,964 hectares of crop production land effectively balances the 20,560 hectare loss in pastureland over 30 years. It is unlikely that this is a simple trade-off in land use. Over the past thirty years, the data suggest that the recorded loss of Nova Scotia farmland is occurring on portions of farms that are not in active production, such as woodlots. This may be partially related to how land is classified by census respondents.

Using Pictou County as an example, it becomes evident that the ability to capitalize on underutilized land on a large scale involves several difficulties. Based on census data, over the thirty-year time-span from 1971 to 2001, Pictou County had the greatest loss in pasturelands, with a decrease of 2862 hectares. The ten-year change from 1991 to 2001 was a decrease of 1382 hectares, and the five-year change from 1996 to 2001 was a loss 752 hectares. Data from provincial sources confirms the census findings, indicating that there is inactive agricultural land. The 1997 Nova Scotia Agricultural Land Information Project (ALIP) measured 3734 ha of inactive land in Pictou County (see Appendix 1).

The Statistics Canada data for Pictou County indicates that the total quantity of biomass that could be generated on the 30 year difference of 2862 hectares at Nova Scotia's average hay yield (6.2 dry t/ha) is 17,744 tonnes; on the ten-year land difference this becomes 8568 tonnes, and for five years, 4663 tonnes of hay biomass. Such yields could not be obtained immediately. Recovering the land would likely take three to five years. Data for the remaining 17 counties in Nova Scotia is presented in Appendix 1.

The establishment years for hay crops have low productivity (roughly half that of normal in year one). The initial year of cultivation has high production costs associated with field preparation (clearing, plowing, seedbed prep), and involves numerous inputs: agricultural limestone, fertilizer, and seed. There is a reasonable likelihood that any land which is abandoned from production is among the least profitable for farming. Generally speaking, productive land is purchased by neighboring farm operations (if such exist) rather than falling out of production. This is a subtle form of natural selection in which only the profitable farmlands in the Province are maintained in agriculture. Exceptions and opportunities in the Nova Scotia marketplace do exist, but successful innovations in agriculture generally occur with high-value crops rather than low value ones.

A successful biomass operation will require inexpensive feedstocks. In agriculture, the ability to produce an inexpensive crop (the eventual feedstock) depends upon low production costs and high productivity, and neither of these can be found on marginal or abandoned lands. The quantity of biomass which could be generated from abandoned farmland is relatively small compared to other sources of biomass in Nova Scotia, such as underused forestry resources and mill wastes. Obtaining these resources is more likely to result in favorable economic returns for a biomass operation.

Although Nova Scotia's "heyday" may have passed in terms of agricultural activities, new crops and an increased interest in biomaterials and biofuels offer the hope that the agricultural potential of the region might once again be put into active use. The creation of high value markets for agricultural products is the most favorable means to this end

3.3.1.1 Future Opportunities

The temperate climate and high precipitation levels in Nova Scotia make it a high yielding region for many types of agricultural products. Presently, specific agricultural fibre and agricultural biomass crops are not grown commercially within the province. There is evidence to support the potential for crops such as hemp, switchgrass, and other grass species. Short rotation agro-forestry may also be possible with species such as willow, poplar, ash, and alder. However, data on current production costs and technologies are limited for these crops with respect to the region, and unfortunately, the necessary farm infrastructure and sales markets for alternative crops do not yet exist. There has been considerable research into unconventional crops where biomass production is more common, such as in Scandinavia (BioMatNet, 2004). So-called 'alternative' crops like hemp and reed canary grass may present important opportunities for biomass production in Nova Scotia's future.

Nova Scotia possesses large quantities of salt-marsh and dykeland meadows which are not considered as agricultural resources. These areas produce large quantities of non-agricultural biomass (such as reeds, sedges, and other species), but could be used to produce crops such as reed canary grass. A different way of thinking about these resources in the province may allow a future harvest of inexpensive and plentiful biomass materials.

3.4 Forestry

The forest area in the province covers 3.9 million hectares of land. Unlike most Canadian provinces, the majority of forestland in Nova Scotia is privately owned. Small woodlot owners control 21% and large industrial enterprises own 48%. Crown land accounts for 28% of the forested land and the remaining 3% is federal land in the form of national parks.

The forest resource consists of approximately 45% softwood type, 33% hardwood type, and the remaining mixed wood (NRCan, 2003). Differing local climate and soil characteristics across the province result in different predominant forest types and tree species over the region. Softwood has become increasingly popular in the last three decades due to increased demand by the wood industry. Over the most recent five-year period, softwood harvests have exceeded the sustainable supply level (NSDNR Working Paper, 2002). For hardwood, the harvest level in general is well below the sustainable supply level.

There are two types of agreements under which the wood for industry is supplied from Nova Scotia's crown land: Longterm License and Management Agreement, and the ten-year Volume Utilization Agreement. Two major pulp and paper companies, Stora Enso and Kimberly-Clark hold the longterm licenses, which were established via specific Acts

and reviewed upon the term renewal. Ten-year volume agreements are currently held by 22 sawmills and one wood processing facility.

The management of wood supply from small private woodlands is implemented through a number of regulations (Forest Sustainability Regulations, Wildlife Habitat and Watercourse Protection) and silviculture programs to help achieve sustainable harvest levels on small woodlots.

Under the Forest Sustainability Regulations, all registered buyers¹ acquiring annually 5,000 m³ of wood or more will be required to provide for silviculture on the private forest land based on the amount of their harvest volume. This can be achieved by implementing their own silviculture program, hiring a silviculture contractor, or paying into the Sustainable Forestry Fund, based on the rate of \$3.00/m³ for softwood and \$0.60/m³ for hardwood. The silviculture program is administered by the Registry of Buyers. At 160,000 wet tonnes per year of softwood this would cost \$480,000. Using hardwood this would cost \$96,000. Wood residues are exempt from this fee.

3.4.1 Timber

Forest timber is one of the primary products generated in Nova Scotia. In 2002, around 6.07 million cubic meters of solid wood volume was harvested from approximately 55,000 hectares of forest area (Registry of Buyers 2003). Out of this, 85% was softwood (around 5.18 million cubic meters) and 15% was hardwood (880,000 cubic meters). The 1999 DNR's Forest Inventory estimates the provincial gross merchantable wood volume from crown, federal, and private lands as 271.9 million cubic meters for softwood and 121.4 million cubic meters for hardwood (detail of county distribution is provided in Appendix 1).

The main user of wood is sawmills and pulp and paper mills. Current market price for tree-length softwood ranges from \$28-\$60/tonne, while for sawlogs it varies from \$38-\$65/tonne and the average price for studwood is \$63/tonne (Atlantic Forestry Review January 2004). The large variations in price are attributed to a number of factors, namely tree species, cutting specifications, whether the product is delivered or available roadside, and trucking costs. In most cases, these prices reflect roadside cost. The price also varies across the region, and may be subject to negotiations with the buyers.

¹ Under the Forest Acts, the Nova Scotia government through the Department of Natural Resources established the Registry of Buyers in 1998, aiming to provide tools for collection of data and information on the acquisition of primary forest products, export/import of primary forest products, and generation of secondary forest products. The Registry defines registered buyers as those who own or operate a facility processing primary forest products, import or export primary forest products to or from Nova Scotia, sell firewood (more than 1000 m³/year), and buy forest products to produce energy. Currently there are 357 buyers in Nova Scotia registered with the Registry of Buyers.

Larger price variation is observed for hardwood, from \$28/tonne for pallet logs, \$44-80/tonne for general sawlogs and over \$200/tonne for veneer logs (Atlantic Forestry Review, July 2003). In addition to tree species, large varieties of hardwood log specifications greatly determine the pricing; therefore, harvesting/cutting techniques are important aspects that need to be taken into account.

3.4.2 Forest Residues

Discussions with a number of associations and private woodlot owners reveal that quantifying exactly how much residue is left after logging operations has never been a particular concern. The current practice is to leave some or all of the leaves, small branches, and bark on the ground to return nutrients to the soil, which is important for maintaining longterm site productivity. Large amounts of wood and stump and dead trees may be left intact to provide habitats for certain wildlife animals, which is required under Forest Sustainability, and Wildlife Habitat and Watercourse Protection Regulations.

If the amount of logging residue is significant and contains materials that still have calorific value, some woodlot owners sell a part of the harvesting residue as hogwood to biomass-fueled heating and power plants. The current market price for this hogfuel is between \$3-6/tonne (not including transport). Chipping may be needed to reduce the wood residue to desired size. Debarking is not usually done if the residue is sold as hogfuel. This material may not be well suited to producing bio-ethanol as debarking smaller material results in large volume losses of wood fibre.

In the case of hardwoods large limbs do represent a significant useable form of feedstock for ethanol production. Larger limbs and branches have traditionally been left as harvest residue as they are too crooked to be used in most forest products and are difficult to chip in consistent size. However, roadside debarking and chipping of hardwood limbs can increase harvesting returns. A study by St. Anne-Nackawic Pulp Company Ltd. in 1977 showed that full tree chipping of hardwoods could increase yields of pulp chips by 14.7%. This processing usually occurs roadside, and the bark and foliage material must then be dragged back into the site in order to maintain site productivity. This amount of in-the-woods-processing increases costs but some contractors do have this capability.

3.4.2.1 Longterm Supply/Potential Future Supply

As previously mentioned, the quantity of logging residues generated is directly proportional to the demand for commercial timber that determines the volume of timber harvested and the harvesting methods used. Therefore, the future generation of logging residue can be estimated provided an appropriate residue factor is known and projections of demand for wood and future trends of harvest level can be established. It is important to note that fluctuations in the quantity is highly anticipated; therefore forest residue may

be good only as a complementary feedstock, rather than the main feedstock for bio-ethanol production.

3.4.3 Wood Processing Residues

The Registry of Buyers keeps track of the amount of mill residue per year based on the quantity reported by the registered mills. Table 3.2 shows the amount of wood processing residues produced based on Registry of Buyers recorded for the period 2000-2001.

Table 3.2 Mill residue listed as Secondary Forest Products by Registry of Buyers (tonnes)

Product	2000	2001	2002
Decorative Bark/Bark Mulch	5,290	8,042	13,418
Fuel chips/pellets	80,244	70,505	125,287
Sawdust	48,800	40,540	47,551
Sawmill pulp chips	1,265,305	1,196,392	1,371,902
Shavings	750	1,934	295
Total	1,400,389	1,317,413	1,558,453

The quantity of products in the above table represents the amounts that have been sold as reported by the buyers, and does not include the quantity consumed internally, for example as fuels in the drying kilns or material that is unused. This can represent a significant portion.

In order to correct for deficiencies in the Registry of Buyers record, 2002 mill roundwood volume data was used to estimate a corrected residue value for each mill. The assumptions used were: 22% residue produced from each tonne of wood processed, comprising 12% bark and 10% of mixed shavings, sawdust, and slabs (Canadian Forest Service, 1999). Depending on the debarking and sorting process, the proportion of the bark in the residue may range from a few percent to 50%. The amount of chip material from sawmills was assumed to be 38% of wood processed. In large softwood sawmills this volume is already purchased by pulp and paper mills; however, in hardwood sawmills and smaller softwood sawmills this material may be available for bio-ethanol production at a very low cost.

Based on this assessment, the estimated wood-processing residue in Nova Scotia is 2,225,780 tonnes. The major forms of residue generated are presented in Table 3.3. A county-by-county assessment of mills is presented in Appendix 1.

Table 3.3 Estimated amount of wood processing residue in Nova Scotia (tonnes)

Product	Softwood	Mixed	Hardwood
Chips	410,130	613,090	389,920

Slab, shavings, sawdust	107,930	158,840	102,610
Bark	129,520	190,610	123,130
Subtotal	647,580	962,540	615,660
Total	2,225,780		

The current market price of sawdust and shavings in Nova Scotia is in the range of \$6 to \$10/tonne, with the price of dry shavings and sawdust at the high end of the range. Transport costs vary depending on the distance.

3.4.3.1 Longterm Supply/Potential Future Supply

Competition for mill residues may come from biomass-fueled heat and power plants, farming, and landscape industry, and pulp and paper mills. With an increase in fuel price, mills may be forced to utilize more of their residues. In addition, wood-waste pellet industries that make use of wood processing residues are growing due to increasing overseas demand of pellet fuels. The MacTara pellet plant consumes around 160,000 tonnes/year of sawdust and bark, and Shaw Resources pellet plant requires 25,000 tonnes/year of sawdust from local suppliers.

3.4.4 Short Rotation Forestry

In order for SRF to become a viable biomass source for commercial production of bioethanol, increasing awareness of its potential is necessary. SRF has not been studied in Nova Scotia.

To be commercially successful, site selection is critical. A site must have the right soil, rainfall, and temperature characteristics as well as geographic proximity to industrial sites. Fertilization and irrigation greatly improve yields however they both involve environmental and fiscal costs (Arnold, 1996). Our research shows that production costs for SRF range from \$63-\$95/odt roadside. However, it is difficult to compare yields and assess the potential for SRF in Nova Scotia as sites, costs, and growth conditions can vary substantially and are difficult to assess.

If it appears to be a financially viable option, the next step would be to develop a knowledge base and staff to support landowners interested in starting SRF. Therefore, based on costs, the time required to develop SRF, and the lack of local knowledge, SRF has limited potential to become a source of biomass for commercial bio-ethanol production in the near future.

The following issues must be addressed in order for SRF to contribute as a feedstock for bio-ethanol production or the provincial biomass supply:

- Support from DNR for the initial development of the industry;
- A provincial or maritime source of high quality planting stock of willows or hybrid poplars;
- Development of cooperatives for purchasing equipment or the use of contractors;
- The careful management of process costs;
- Lowering process costs through innovation such as reduced chip van weights, improved machinery, and reduced handling;
- Careful evaluation of price support mechanism available for agricultural products and other forms of energy;
- Innovative ideas such as the use of SRF as part of municipal wastewater and sewage treatment. Currently few municipalities in the whole province treat sewage or wastewater. If coupled with SRF this might provide a cheap form of sewage treatment with substantial economic benefits. The environmental aspects would have to be fully evaluated.

3.4.5 Nova Scotia Forestry - Current Potential

As mentioned in the introduction, different local climatic and soil characteristics across the province result in different predominant forest types and tree species over the region and varying productivity. Yarmouth and Shelburne counties, for example, are dominated by low-productivity black spruce bogs, whereas Cumberland and Colchester counties are a mix of productive softwood, hardwood, and mixed-wood stands. Different areas of the province have also been more intensively harvested and managed, especially the central region.

Each county appendix entry contains a number of informative forestry statistics including current harvest levels, gross merchantable volume, forest capability, and wood residues from existing mills. Current harvest levels indicate the level of forestry activity in the county, the productivity of the area, and the current pressure on the resource. Gross merchantable volume (the total standing economically viable wood volume) indicates the amount of resource available for the future. Forest capability indicates the general productivity of the county and its potential for improved forestry such as plantations and SRF. Wood residues levels are potentially very important for Bio Vision as these indicate concentrated sources of inexpensive pre-processed biomass. These statistics are discussed in detail in the explanation for the county appendixes.

Though useful as individual pieces of information, this information has been aggregated in order to provide a current province-wide picture of forestry as it applies to bio-ethanol

production. In order to create the picture, each county has been ranked using gross merchantable volume, wood density (m^3/km^2), average harvest level for years 2001 and 2002, and the mill residues within the county. Wood density was used in order to compensate for size differences in the counties. For example, Halifax County is large and therefore has a very high gross merchantable volume but other counties are actually more productive on a square kilometre basis. Using these four pieces of information, a weighted rank has been created, with gross merchantable volume, wood density, and mill residues all weighted at 30% and harvest level weighted at 10%. This information has been presented graphically in Figure 3.6.

The central part of the province is the best area based on this ranking system because of high harvesting and mill residues levels, and solid volume measures. However, the western region is also productive. The main weakness of this ranking system is that it does not incorporate competition sources for hardwood and wood residues. It also does not incorporate unused sustainable harvest volume. Unused sustainable harvest volume is not calculated on county basis and requires significant manipulations in order to be estimated on a county basis. It has been included in the site assessments.

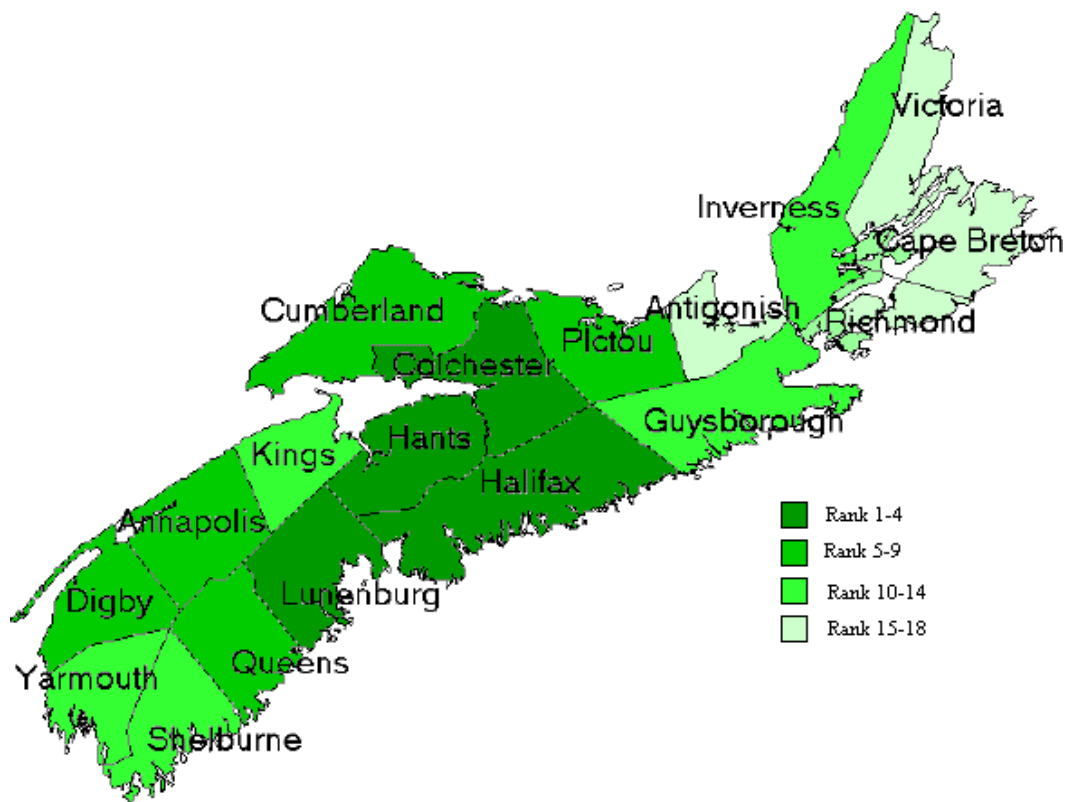


Figure 3.6 County ranking of forestry potential

3.4.6 Nova Scotia Forestry - Longterm Supply

It is commonly stated that there is a significant amount of unused hardwood available in the province. The softwood market on the other hand is a mature industry with a large capacity in both sawmills and pulp and paper mills. The province has undertaken a large silviculture program in order to ensure the longterm supply of forest products. This program is now operational and it is expected that the sustainable harvest (or AAC - annual allowable cut) for the province, for both softwood and hardwood, will rise. However, the most significant increases are expected for softwood with small increases in hardwood volume (DNR Forest Planning and Research, 2000).

Due to the complex structure of forest ownership in Nova Scotia precise inventories of standing volume, harvested volume, and sustainable harvest levels are difficult to achieve. However, the Forest Planning and Research division at DNR does forecast “potential” harvest levels for the province that can be thought of as a sustainable harvest level. This modeling process excludes all inoperable and unproductive forestlands such as parks, protected areas, and extreme slopes. The modeling includes current silviculture efforts (hence the increasing potential harvest) and includes full harvesting which increases during the model as more volume becomes available (Beyeler, personal communication, 2004). For example, Forest Planning and Research’s 2000 model predicted that in 2003, 6.337 million cubic meters of softwood could be harvested whereas the Registry of Buyers reported a harvest level of 5.18 million cubic meters indicating that there was approximately 1.15 million cubic meters of unused sustainable softwood harvest. For hardwoods, the provincial level forecast has shown a sustainable harvest of approximately 1.810 million cubic meters with the registry of buyers showing 0.880 million cubic meters, indicating approximately 0.93 million cubic meters of unused hardwood volume.

This modeling process is done at a provincial and forest region level but not at a county level. The forest regions and their associated counties are shown in Figure 3.7.

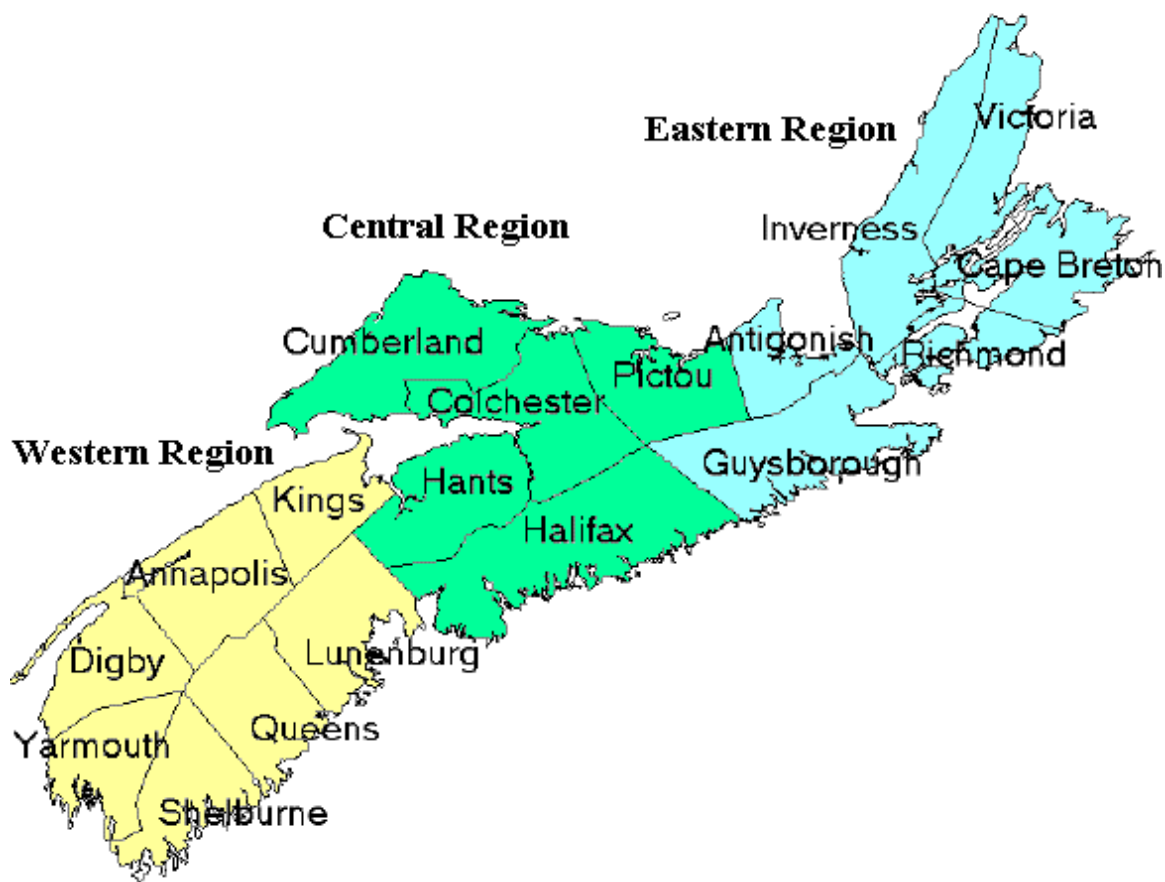


Figure 3.7 Nova Scotia DNR Forest Regions

Figure 3.8 through Figure 3.11 show the current harvest levels for both softwood and hardwood and the potential harvests for the province and the three regions. A number of basic trends can be seen. For example, in the Central region both the hardwood and softwood current harvest levels are near or above potential levels (regionally unsustainable softwood harvest). This is to be expected, as the majority of the mills in the province, including two of the largest consumers of hardwood, Northern Fiber Terminal and HC Haynes, are located in this region. However, the Western and Eastern regions have significant unused potential hardwood volume of approximately 450,000 m³/year and 410,000 m³/year respectively. These regions also have significant unused softwood volume with approximately 540,000 m³/year in the Western region and 700,000 m³/year in the Eastern region.

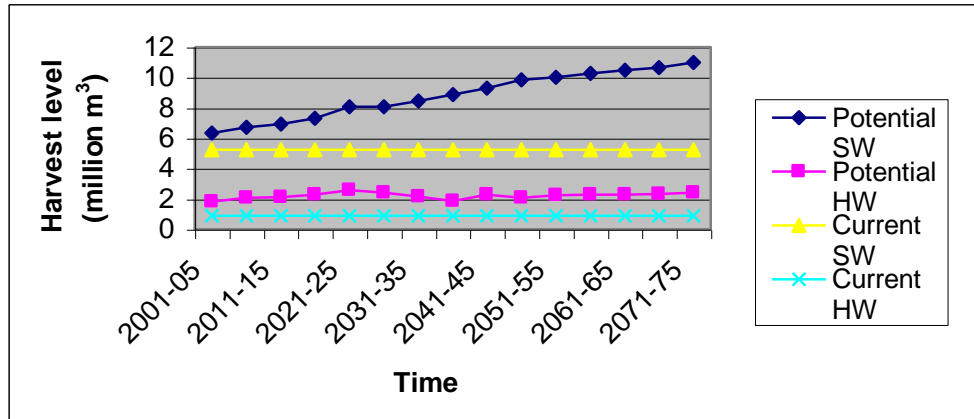


Figure 3.8 Current vs. potential harvest levels for the Province

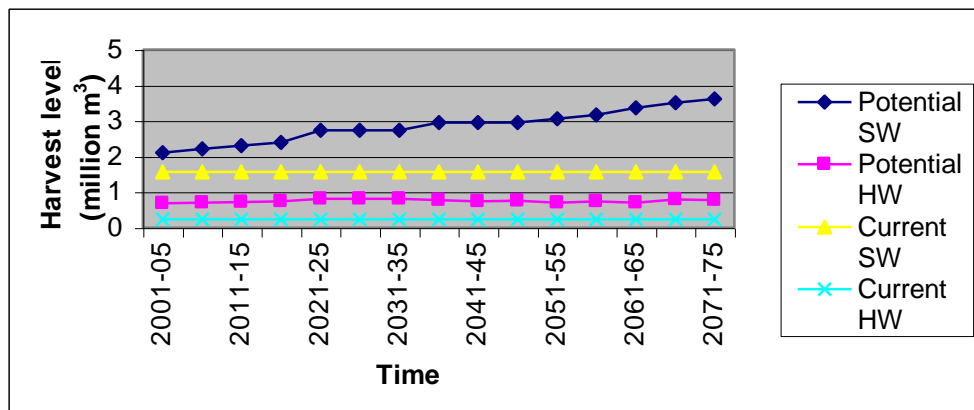


Figure 3.9 Current vs. potential harvest levels for the Western region

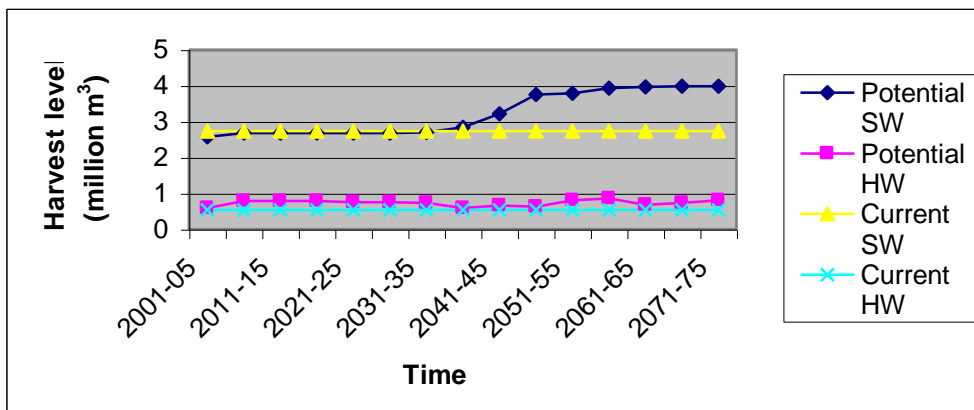


Figure 3.10 Current vs. potential harvest levels for the Central region

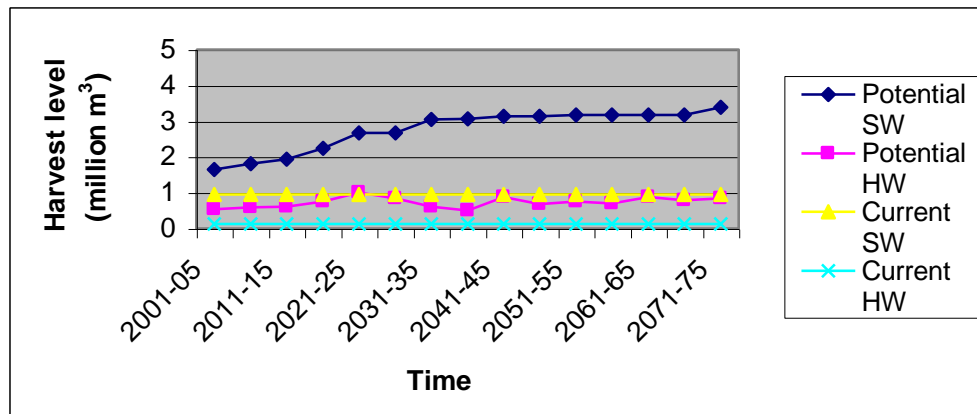


Figure 3.11 Current vs. potential harvest levels for the Eastern region

Considering the current harvest level and the potential of harvest level, there will be an ample supply of roundwood as a feedstock for ethanol production in the province. Strong competition is expected to come from other users including sawmills, pulp and paper mills, and pellet mills. Although at present the growth of the sawmill industry has slowed due to the uncertainty caused by the softwood lumber dispute with the US which imposes duties on lumber coming from Canada, negotiations to exclude the Maritimes from the agreement are being forcefully pursued, and there is a considerable level of optimism that growth will again increase in the near future.

3.4.6.1 Hurricane Juan Impact

In the aftermath of Hurricane Juan, the Forest Inventory Division of DNR carried out a preliminary damage assessment. According to this assessment, approximately 73,000 ha of forest area have been damaged, mostly in the central region of Nova Scotia. This represents about eight million cubic meters of merchantable wood volume. Full assessment of the effects of Hurricane Juan will be published by DNR in the near future. This loss is expected to decrease the sustainable harvest level in the short run, but at very minimal rate, and should not affect the longterm projection of harvest levels (Beyeler, personal communication, 2004).

3.5 Bio-wastes

Eighteen organic composting facilities in Nova Scotia receive around 130,000 tonnes per year of organic materials, which includes yard wastes (excess leaves, brush, and plants), sawdust, and wood shavings. Contract collection companies gather these wastes from residential and commercial premises regularly. Two of the largest facilities, each with 25,000 tonne-capacity are located in Halifax, with 70% of the green waste coming from

residential customers (Pemberton, 2004). The collection/hauling rate varies depending on the distance and individual rate proposed by the collecting company, while the tipping fee is usually around \$60-70/tonne of waste (Traver, personal communication, 2004).

Normally, yard wastes and wood shaving wastes are not separated from the rest of the waste materials at the facility; thus, records of how much of the waste is yard wastes and sawdust/shavings are not available. The quantity generated varies, peaking during the spring and fall. Based on these aspects including low volumes of dispersed sources, variations in quality, limited information on hauling costs, extra separation, and unpredictability of available materials, the potential of using organic waste for bio-ethanol production appears to be very limited.

Similarly, recycled cardboard boxes do not seem to constitute a reliable source for ethanol production feedstock. Minas Basin Pulp and Power has been exclusively using recycled fibers from old corrugated board to manufacture linerboard and coreboard. The liner board is sold to Maritime Paper Products to be used to make new cardboard boxes and roll cores for carpet and newsprint. The Minas facility in Hantsport is able to produce 100,000 tonnes per year of linerboard and coreboard. The resource for their production feedstock is collected throughout Nova Scotia and other places. However, Minas Basin Pulp and Power is currently facing heavy competition for this resource. China has a strong market for recycled cardboard that is causing the price of recycled fiber to increase thereby creating a competitive market for the material. All recycled cardboard in the province is used either by the Minas Basin facility or sold to China.

Other types of wood waste, such as used pallets and wood wastes from furniture industry, are also produced in Nova Scotia. Sources for these wastes include Environment Depots in the province and furniture manufacturer such as Scanwood Limited, located in Burnside. The quantity of these types of waste tend to vary greatly, and therefore hard to estimate. Their availability could range from one-time-only to continuously available. A continuous demand, however, exists for these types of wastes. According to the Solid Waste Resource Management Division of Nova Scotia Department of Environment and Labour, a number of pallet manufacturers, Adult Service Centres, and biomass power plant, are among the pallet recyclers in the province. Recycled pallets are used to produce new pallets, firewood, birdhouses, and used as fuel. Large buyers of the used pallets include Scotia Pallets (Goshen) and Industrial Packaging (Dartmouth). Further information on the haulers, recyclers, and other waste-resource related contacts are available from the Resource Recovery Fund Board (RRFB) website: Business Directory of Solid Waste, Reuse, and Recycling and Composting Contacts in Nova Scotia. The RRFB also facilitates Materials Exchange, an on-line trading program for various recyclable materials (<http://www.nsmaterials.com/>).

3.6 Transportation

Transportation for forestry and agriculture biomass is well developed in Nova Scotia. Trucking companies are located throughout the province and individual truck owners are well distributed. Trucking capacity for forest products is focused around existing mills; for example, Weymouth in the west and Port Hawkesbury in the east. Traditionally, trucking focused on flatbeds for roundwood transport. However, since all three pulp and paper mills use chips as their primary feedstock and numerous other companies use wood wastes, there is a large chip van/truck capacity. On the agricultural side a substantial amount of transport occurs within farms or between farms often using smaller vehicles. However, for Bio Vision's needs, flatbeds can be used to haul most agricultural biomass or chip vans may be used for unbaled material.

Trucking companies or individual owners control the majority of trucking capacity in the province. This is a significant advantage for Bio Vision as these groups work on a contract basis (not owned or controlled by large mills) and should be available for hire by Bio Vision. The basic nature of trucking also indicates that it is highly mobile and none of the potential sites are without some trucking capacity. However, various companies specialize in certain forms of trucking and may have limited capacity to supply a large new facility. Therefore, full discussion must occur with potential trucking companies before the facility is operational. This will allow companies to purchase new equipment or to divert capacity.

In general, Nova Scotia has a well-developed road network. All agricultural lands are easily accessible and approximately two-thirds of the forestry land is immediately accessible (an extremely high percentage in Canada). Furthermore, in most areas approximately 90% of the land is accessible with minimal road construction. Over half of the large inaccessible areas are contained within parks and protected areas. The Nova Scotia Atlas shows the remaining roadless areas and half the land is either unproductive (marsh or swamp) or in mountainous terrain. These lands lie mostly in the western and eastern regions areas. The road network is assessed in detail, by site, in Chapter 4 using the National Topographic Data Base (NTDB).

4. Site Summaries

4.1 Interpreting the Summaries

4.1.1 Forestry Information

The assessment of forestry biomass potential for each site is carried out based on a number of characteristics: quantity of mill residue, current harvest level, potential harvest, and soil capability (not necessarily in order of importance). The quantity of residue from the mills located within 50km and 100km buffer has been estimated and presented in Appendix 5.

The current harvest levels for each site were estimated based on harvest volumes in 2001 and 2002 using data from the Registry of Buyers. Potential harvest volume represents the difference between the sustainable harvest volume as projected by the Forest Planning and Research office (NS DNR, 2000), for the period 2001-2035, and the current harvest volume, which is assume to be approximately constant throughout this same period. Forestry data are available on a county or regional basis. To be able to use the data for site analysis purposes, all wood volumes are estimated proportionally using the percentage of each county (or region) that falls within the buffer area. Negative potential harvest volume, as indicated by a zero in the table, indicates that the softwood or hardwood is currently being harvested at the rate that surpasses its sustainable harvest level. Soil capability for forestry has been assessed visually using the Forestry Capacity Classes map presented in Appendix 3.

4.1.2 Interpreting Road Information

Each site's road network has been assessed based on the amount, distribution, and arrangement of higher order paved roads (including Arterial, Trunk, Collector, Local Highways, as well as major local roads) and the amount of large tracts of land that are currently without any type of road. The NTDB, which incorporates road information from a variety of sources, has been used to create visual maps for each site showing all classes of roads, major water bodies and reserved lands (for example, parks, protected areas, and DND property). In forestry, all land within 350 meters of a road is considered easily accessible for harvesting. In fact, 350 meters is often used as the optimal skidding/road spacing distance. Nevertheless, land more than 350 meters from a road can still be accessed without building another road; however, machine productivity declines. Based on this, all roads have been buffered by 350 meters on both sides to indicate the amount of land that is immediately accessible. The road network map for each site is displayed in Appendix 5. The exact age of the data contained within the NTDB is difficult to determine because multiple sources were used. However, this data has been

verified using the 2001 Nova Scotia Atlas. In about 20% of the large roadless areas the Nova Scotia Road Atlas shows newly constructed roads or older roads that are not included in the NTDB.

For each site, a number of important road network characteristics are presented. Highway density and total road density comes directly from the GIS analysis of the NTDB; these are good indicators of accessibility and general coverage. Highway arrangement has been assessed visually and indicates how well the highway network feeds into a particular site along with the general distribution of highways. Highway arrangement is ranked using a qualitative descriptor (excellent, good, poor, very poor). The final characteristic is large areas without roads. Though Nova Scotia has a very well-developed road network, there are still large areas that do not have any road access. These are plainly visible in the maps in Appendix 5. Many of these areas lie in unproductive (swamp) or rough terrain. However, there are still large areas ranging from a few hundred to 20,000 ha plus in size. Over the longterm, roads may be constructed in these areas although it may take upwards of a decade or more to fully access a 20,000 ha area.

4.2 Amherst

Amherst is located at the extreme west of the province in Cumberland County, bordering New Brunswick (see Figure 4.1). It is on the TransCanada Highway 104 and is serviced by the CN mainline from Halifax to Montreal.



Figure 4.1 Amherst inside 50-kilometre and 100-kilometre radii

Both radii around Amherst encompass part of New Brunswick, the Bay of Fundy and the Northumberland Strait. In the 50km case, after removing these areas and waterways,

369,087 hectares remain (representing about 6.6 percent of the provincial landmass), while the 100km radii leaves 1,037,263 hectares (over 18 percent of the landmass). The counties that fall within the radii are listed in Table 4.1.

Table 4.1 County Land Area

	County Area (ha)	Area of county (ha)		Percentage of county	
		50 km	100 km	50 km	100 km
Colchester	366,643	35,312	254,923	9.63	69.53
Cumberland	436,586	335,234	436,586	76.79	100.00
Hants	314,349		199,121		63.34
Kings	222,908		120,655		54.13
Pictou	289,632		32,542		11.24

4.2.1 Agriculture

Amherst has access to two of Nova Scotia's most agriculturally productive counties: Cumberland and Colchester. When selecting a 100km radius for biomass procurement, the areas of Hants and Kings Counties are also included, but these are largely inaccessible due to the intrusion of the Minas Basin. It should be noted that if New Brunswick data is included in the calculations of how much feedstock is produced in the Amherst area, then productivity surrounding this site may be notably higher than represented in this report.

4.2.2 Forestry

The forestry biomass potential from Nova Scotia within the radii of survey for Amherst is not significant. A couple of medium sized mills (acquiring 50,000 m³/year) are situated within 50km of Amherst that provide mill residues. This increases within a 100km buffer zone. However, strong competition is expected to come from Keywood Recovery for wood chips. Current harvest level is moderate compared to other sites within the Central Region. Potential harvest is limited within the 50km radius, but increases in the 100km radius covering Pictou, Colchester and Hants counties.

Table 4.2 Forestry Biomass Availability and Potential

Characteristics	50km	100km
Mill Residue (tonnes)	60,000	431,280
Current harvest Softwood (m ³)	503,619	1,595,885
Current harvest Hardwood (m ³)	98,405	306,833
Potential harvest volume Softwood (m ³)	-10,538	25,118
Potential harvest volume Hardwood (m ³)	38,105	146,308
Soil Capability for Forestry (predominant)	4-5	4-5

4.2.3 Transportation

Overall, Amherst has a good road system that includes a good highway network. However, the Minas Basin is a significant barrier for efficient transportation within the 100km radius.

Table 4.3: Road characteristics

Characteristic	50km	100km
Hwy density (km/km ²)	0.151	0.175
Hwy arrangement	Good	Poor
Total Road Density (km/km ²)	1.003	1.138
Areas without road	Low	Low

4.3 Bridgetown

Bridgetown is located in Annapolis County, between the North and South Mountains on the Annapolis River (see Figure 4.2). The major transportation link through Bridgetown is Highway 101.

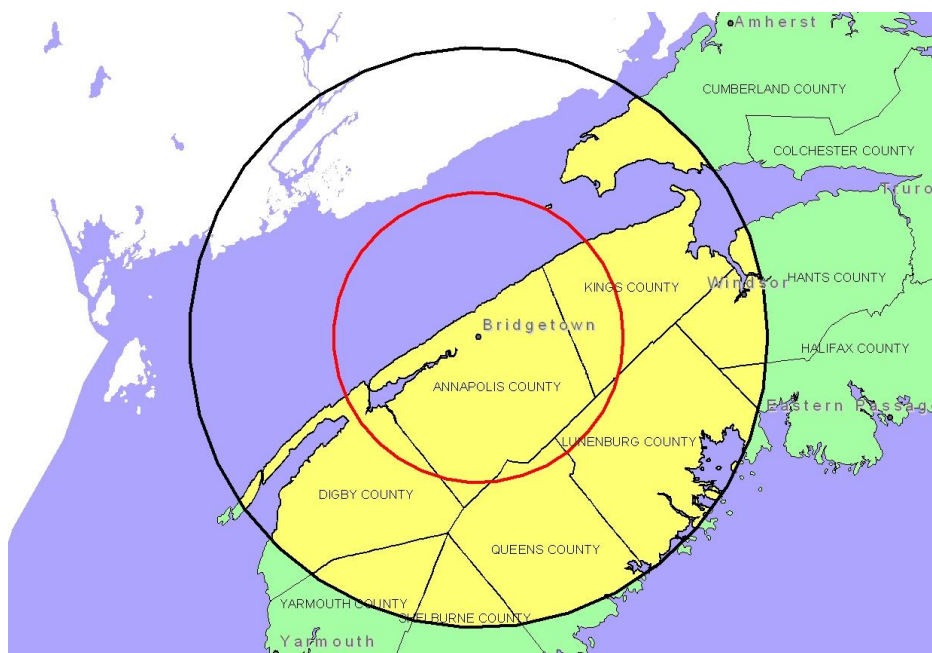


Figure 4.2 Bridgetown inside 50-kilometre and 100-kilometre radii

Both the 50km and 100km radius around Bridgetown include a large portion of the Bay of Fundy, as well as New Brunswick land. The removal of the Bay of Fundy and other waterways leaves 449,488 hectares of Nova Scotia land area (representing approximately eight percent of the provincial landmass) for the 50km radius, while 100km radius leaves 1,547,050 hectares (about 28 percent of the province). Each county that falls within the 50km radius of Bridgetown is shown in Table 4.4. The Table also indicates the

corresponding land area of each county within the 50km zone, and calculates what percentage of the county's total land area that represents.

Table 4.4 County Land Area

	County Area (ha)	Area of county (ha)		Percentage of county	
		50 km	100 km	50 km	100 km
Annapolis	336,236	328,377	336,236	97.66	100.00
Cumberland	436,586		78,582		18.00
Digby	272,852	28,633	250,212	10.49	91.70
Halifax	596,889		13,211		2.21
Hants	314,349		82,239		26.16
Kings	222,908	83,886	222,908	37.63	100.00
Lunenburg	313,356	15,386	301,326	4.91	96.16
Queens	278,525	12,244	239,547	4.40	86.01
Shelburne	263,131		60,627		23.04
Yarmouth	235,043		72,733		30.94

4.3.1 Agriculture

The lands immediately adjacent to Bridgetown provide some agricultural capacity, but are limited by poor soils as one moves towards the interior of the province. At a 50km radius, the Bridgetown site would have access to almost all of the production in Annapolis County, and portions of Kings County, both highly productive regions of the province. Increasing the radius to 100km adds available biomass from the remainder of Kings County and portions of Hants County, giving the site access to 40% of the agricultural lands within the province. The soils and climate of this region allow for a wide variety of crops to be grown.

4.3.2 Forestry

The availability of forestry biomass is limited within a 50km distance of Bridgetown, but a large quantity of forestry biomass, in particular hardwood, is found within the 100km radius. Competition for this resource would come from Brooklyn Power Inc., which currently uses 450,000 tonnes/year of hogwood for fuel, and Louisiana-Pacific Canada that uses hardwood as their primary production feedstock. These groups are considered competitors, as they are large consumers of cheap biomass (residues and low-grade hardwood).

Table 4.5 Forestry Biomass Availability and Potential

Characteristics	50km	100km
Mill residue (tonnes)	0	885,840
Current harvest Softwood (m ³)	380,519	1,579,045
Current harvest Hardwood (m ³)	54,951	240,083

Potential harvest volume Softwood (m ³)	219,220	768,557
Potential harvest volume Hardwood (m ³)	128,028	469,627
Soil Capability for Forestry	4-5 (3)	4-5 (3-6)

4.3.3 Transportation

Bridgetown's road network suffers from large portions of land that are almost completely without roads, including Kejimikujik National Park, the Tobeatic Wilderness area, and large areas of unproductive forests in Yarmouth and Shelburne counties. This results in low road densities. Areas without roads are protected lands. As far as major highways are concerned, the transportation system does not center on Bridgetown, thereby increasing hauling distances.

Table 4.6 Road characteristics

Characteristic	50km	100km
Hwy density (km / km ²)	0.120	0.110
Hwy arrangement	Good	Poor
Total Road Density (km / km ²)	0.955	0.800
Areas without road	Low	Moderate

4.4 Eastern Passage

Eastern Passage is located near Dartmouth on the Eastern Shore region of the province (see Figure 4.3). The proximity of this location to the Halifax Regional Municipality (HRM) gives it access to an extensive transportation infrastructure.

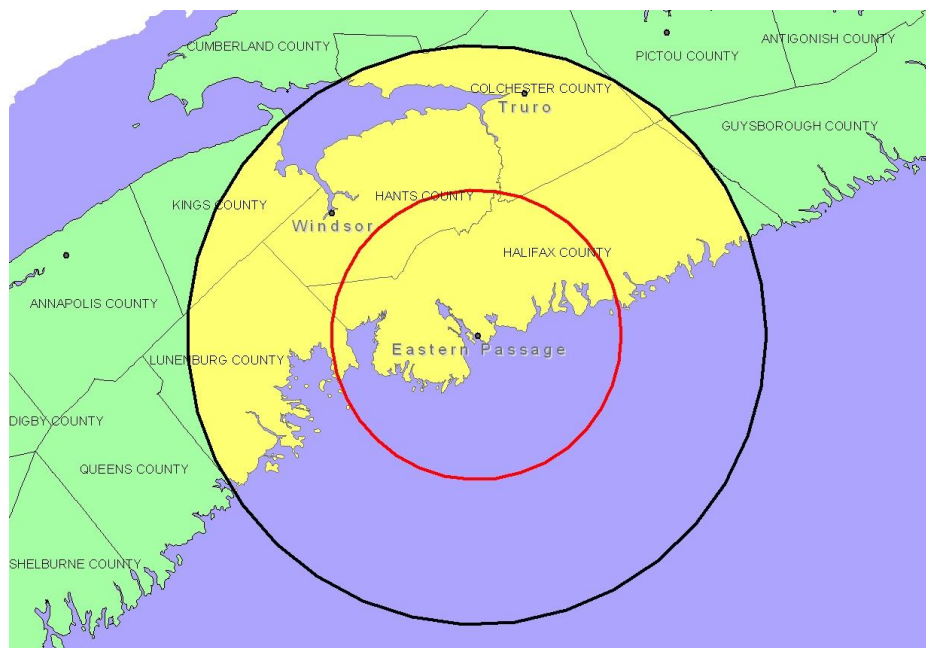


Figure 4.3 Eastern Passage inside 50-kilometre and 100-kilometre radii

The 50km radius around Eastern Passage takes in the Atlantic Ocean and other waterways (including the Bedford Basin). In the 50km case, after water bodies are removed, 378,765 ha remain (representing 6.8 percent of the provincial landmass). In the 100km case, 1,447,748 hectares remain (about 27 percent of the province). Each county that falls within the 50km radius of Eastern Passage is listed in Table 4.7. The table also indicates the corresponding land area of each county within the 50km zone and calculates what percentage of the county's total land area that represents.

Table 4.7 County Land Area

	County Area (ha)	Area of county (ha)		Percentage of county	
		50 km	100 km	50 km	100 km
Colchester	366,643	1,299	244,197	0.35	66.60
Cumberland	436,586		206		0.05
Guysborough	423,120		5,032		1.19
Halifax	596,889	322,573	574,496	54.04	96.25
Hants	314,349	69,414	314,349	22.08	100.00
Kings	222,908		104,326		46.80
Lunenburg	313,356	10,679	269,282	3.41	85.94
Pictou	289,632		5,389		1.86
Queens	278,525		140		0.05

4.4.1 Agriculture

Eastern Passage has access to a large portion of Halifax County within the 50km study zone. This is not among the more productive regions in the province and the presence of the built-up urban environment reduces the quantity of available land. At 100km however, this site has access to all of Hants County and portions of Kings and Colchester counties, providing an entry to much of the most productive regions in the province.

4.4.2 Forestry

Potential wood volume available is very limited in the immediate area surrounding of Eastern Passage, and modestly available within the 100km radius. The presence of multiple medium- and large-sized mills within 100km radius represents significant potential mill residue that could be used as feedstock. The Northern Fiber Terminal in Sheet Harbour, which is currently acquiring around 200,000 tonnes of chips per year for overseas markets, would be a strong competitor. The soil capability around the site is classified as moderately-to-severely limited for the growth of commercial forests. The forestry biomass data is presented in Table 4.8.

Table 4.8 Forestry Biomass Availability and Potential

Characteristics	50km	100km
Mill residue (tonnes)	532,560	1,314,120
Current harvest Softwood (m ³)	543,108	1,853,976
Current harvest Hardwood (m ³)	105,680	346,616
Potential harvest volume Softwood (m ³)	-6,198	146,568
Potential harvest volume Hardwood (m ³)	43,350	220,981
Soil Capability for Forestry	5-6(4)	4-5(6,7)

4.4.3 Transportation

Eastern Passage's road densities are skewed upward by the presence of HRM though in reality the road densities in the outer areas are no higher than in other sites. However, the proximity to Halifax does result in an excellent highway network for the site. Some areas of the Eastern Shore are without roads, hence the decline in the 100km radius (see Table 4.9).

Table 4.9 Road characteristics

Characteristic	50km	100km
Hwy density (km / km ²)	0.256	0.175
Hwy arrangement	Excellent	Excellent
Total Road Density (km / km ²)	1.551	1.223
Areas without road	Low	Moderate

4.5 Port Hawkesbury

Port Hawkesbury is located at the southern end of Cape Breton Island (see Figure 4.4). Access to and from the Island requires crossing the Canso Causeway. Transportation infrastructure includes 100 series highways, rail, and a large port. The presence of a large pulp mill (Stora-Enso) and other industrial activity in the area is also notable.

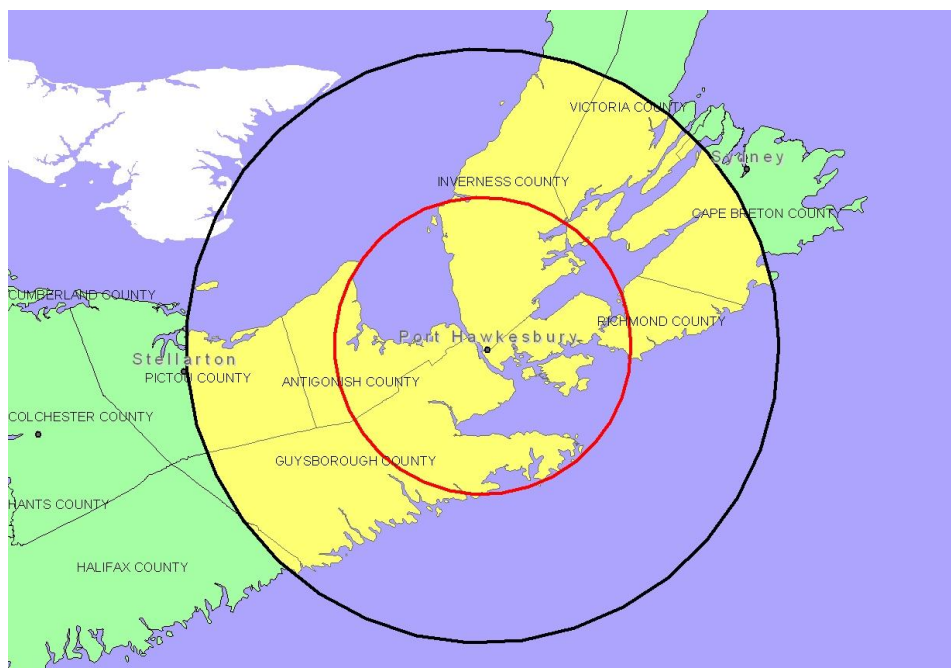


Figure 4.4 Port Hawkesbury inside 50-kilometre and 100-kilometre radii

The 50km radius around Port Hawkesbury includes the mainland of Nova Scotia, Cape Breton Island, St. Georges Bay, the Strait of Canso, and Chedabucto Bay. When the waterways are removed from the 50km radius, 483,310 hectares remain (representing 8.6 percent of the provincial landmass). In the 100km case, 1,362,283 hectares remain (about 24 percent of the province). Each county that falls within the 50km and 100km radii of Port Hawkesbury is listed in Table 4.10. The table also indicates the corresponding land area of each county within these zones and calculates the percentage of the county's total land area that represents.

Table 4.10 County Land Area

	County Area (ha)	Area of county (ha)		Percentage of county	
		50 km	100 km	50 km	100 km
Antigonish	148,711	77,864	148,711	52.36	100.00
Cape Breton	265,881		143,346		53.91
Guysborough	423,120	185,950	409,325	43.95	96.74
Halifax	596,889		7,975		1.34
Inverness	392,462	152,357	284,541	38.82	72.50
Pictou	289,632		138,491		47.82
Richmond	133,739	75,168	133,739	56.21	100.00
Victoria	294,419	2,863	130,157	0.97	44.21

4.5.1 Agriculture

The counties of Cape Breton Island have low agricultural productivity. At 50km, the Port Hawkesbury site has access to limited productive land, in Inverness and Antigonish counties. The potential of this site does not improve greatly at 100km, although portions of Pictou County become accessible.

4.5.2 Forestry

The current harvest level in the Eastern Region is generally very low, therefore the forest area surrounding Port Hawkesbury, and even stretched to 100km radii, represents a significant amount of wood available to be utilized. In addition, soil capability in these areas does not pose significant limitations for growing forest plantations. In terms of mill residue availability, Stora Enso is the only large mill located in the proximity and it currently uses only softwood (see Table 4.11).

Table 4.11 Forestry Biomass Availability and Potential

Characteristics	50km	100km
Mill residue (tonnes)	0	30,000
Current harvest Softwood (m ³)	284,590	918,806
Current harvest Hardwood (m ³)	39,349	138,415
Potential harvest volume Softwood (m ³)	397,808	1,001,854
Potential harvest volume Hardwood (m ³)	171,811	449,560
Soil Capability for Forestry	4(5,7)	4-5(6,7)

4.5.3 Transportation

Port Hawkesbury has some weaknesses in its road network including a number of large areas without roads and below average highway and total road densities. In terms of roads, this is a below average site, as highlighted in Table 4.12.

Table 4.12 Road characteristics

Characteristic	50km	100km
Hwy density (km / km ²)	0.132	0.121
Hwy arrangement	Good	Poor
Total Road Density (km / km ²)	0.952	0.897
Areas without road	Moderate	High

4.6 Stellarton

Stellarton, south of New Glasgow on the Northumberland Strait, is centrally located along the length of the Province (see Figure 4.5). The area is serviced primarily by 100 series highways.

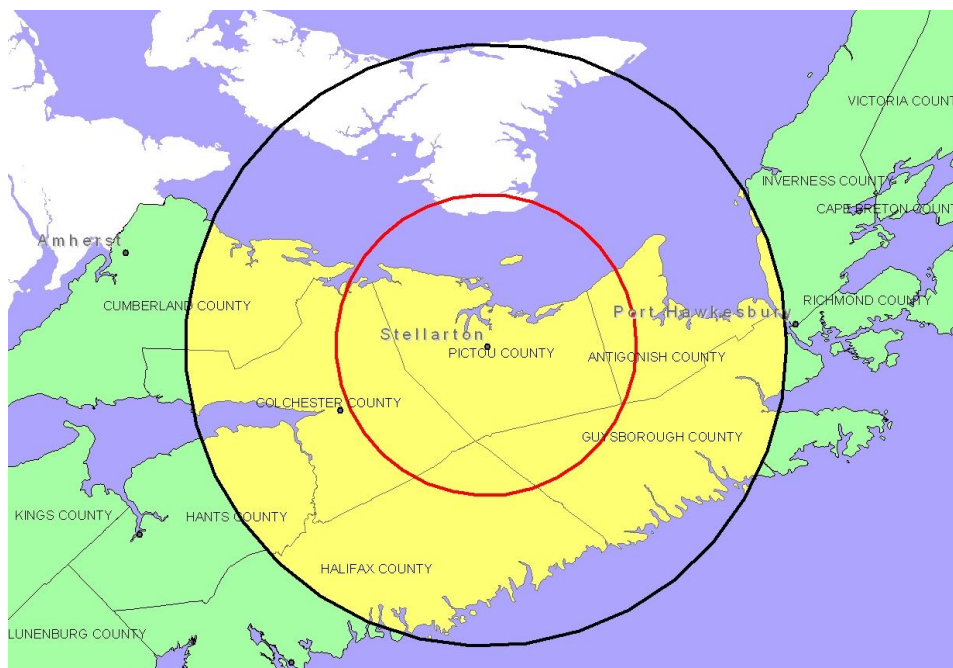


Figure 4.5 Stellarton inside 50-kilometre and 100-kilometre radii

The 50km and 100km radius around Stellarton includes the Northumberland Strait and parts of Prince Edward Island. When these areas and waterways are removed, 565,506 ha (50km) and 1,730,237 ha (100km) remain. Each county that falls within the two radii is listed in Table 4.13. The table also indicates the corresponding land area of each county within the two areas and calculates what percentage of the county's total land area that represents.

Table 4.13 County Land Area

	County Area (ha)	Area of county (ha)		Percentage of county	
		50 km	100 km	50 km	100 km
Antigonish	148,711	40,054	148,711	26.93	100.00
Colchester	366,643	139,366	341,958	38.01	93.27
Cumberland	436,586		143,502		32.87
Guysborough	423,120	63,710	355,938	15.06	84.12
Halifax	596,889	39,597	373,339	6.63	62.55
Hants	314,349		107,322		34.14
Inverness	392,462		12,214		3.11
Pictou	289,632	289,632	289,632	100.00	100.00

4.6.1 Agriculture

Stellarton is centered in Pictou County, which has a significant hay and pasture capability. At 50km, this site also provides access to portions of Colchester and

Antigonish counties. Increasing the radius to 100km allows greater access to Colchester, and opens portions of Cumberland and Hants Counties in the more productive regions of the province. However, areas to the east and south of Stellarton are generally non-productive.

4.6.2 Forestry

Stellarton offers a viable selection of types of forestry biomass available within both survey radii, as well as providing good soil capability for forestry (see Table 4.14).

Table 4.14 Forestry Biomass Availability and Potential

Characteristics	50km	100km
Mill residue (tonnes)	165,000	1,125,840
Current harvest Softwood (m ³)	696,329	2,004,321
Current harvest Hardwood (m ³)	132,646	374,633
Potential harvest volume Softwood (m ³)	70,210	380,326
Potential harvest volume Hardwood (m ³)	84,241	308,818
Soil Capability for Forestry	4(3,5)	4-5(6,7)

4.6.3 Transportation

Although Stellarton has a slightly less dense road network than some other counties, the distribution of highways and secondary roads is excellent, resulting in thorough road coverage except in a small portion of the eastern shore (see Table 4.15).

Table 4.15 Road characteristics

Characteristic	50km	100km
Hwy density (km / km ²)	0.147	0.146
Hwy arrangement	Excellent	Excellent
Total Road Density (km / km ²)	1.117	1.088
Areas without road	Low	Moderate

4.7 Sydney

Sydney is located on the northeastern portion of Cape Breton Island (see Figure 4.6). The region has an established industrial infrastructure including port facilities, rail, and 100 series highways.



Figure 4.6 Sydney inside 50-kilometre and 100-kilometre radii

The 50km radius around Sydney includes the Atlantic Ocean and the Bras d'Or Lakes, while the 100km radius encompasses most of the Island. In the 50km radius, when these waterways are removed, 377,142 ha remain (representing about 6.7 percent of the provincial landmass), while in the 100km case, 1,017,834 ha remain (about 18 percent of the provincial landmass). The counties that falls within the two radii and their associated percentages are listed in Table 4.16.

Table 4.16 County Land Area

	County Area (ha)	Area of county (ha)		Percentage of county	
		50 km	100 km	50 km	100 km
Cape Breton	265,881	264,323	265,881	99.41	100.00
Inverness	392,462	0	352,655	0	89.86
Richmond	133,739	7,759	125,258	11.54	93.66
Victoria	294,419	113,950	293,670	77.02	99.75

4.7.1 Agriculture

Although the Sydney area has considerable agricultural potential, production is limited in this region and indeed all of Cape Breton Island. A 50km radius encircles the majority of Cape Breton County that has only 1,794 hectares of cropland. Increasing the radius to 100 km introduces production from the entire Island, but this amounts to only 7% of the agricultural cropland in Nova Scotia or 6,379 hectares. This site has very limited potential relative to other locations.

4.7.2 Forestry

As with other sites located within the Eastern Region, Sydney has high potential for unused woods. In fact, Sydney has the greatest amount of unused wood within a 50km radius, and second greatest for the 100km radius. Potential for collecting mill residue is essentially nil as there are no mills located within the radii of survey, as shown in Table 4.17.

Table 4.17 Forestry Biomass Availability and Potential

Characteristics	50km	100km
Mill residue (tonnes)	0	0
Current harvest Softwood (m ³)	291,679	597,452
Current harvest Hardwood (m ³)	40,330	82,608
Potential harvest volume Softwood (m ³)	397,808	835,135
Potential harvest volume Hardwood (m ³)	171,811	360,691
Soil Capability for Forestry	4-5 (6,7)	5-6 (7)

4.7.3 Transportation

The rough topography of the highlands and the irregular geography of the Bras D'or Lakes contribute to a poor road network for Sydney. Large areas of land are without roads (excluding the parks and protected areas) and the road density is low even after considering protected areas (see Table 4.18).

Table 4.18 Road characteristics

Characteristic	50km	100km
Hwy density (km / km ²)	0.147	0.114
Hwy arrangement	Good	Very Poor
Total Road Density (km / km ²)	0.965	0.793
Areas without road	High	High

4.8 Truro

Truro is a transportation hub for the Province. It is an important throughway en route to New Brunswick and for north-south travel within Nova Scotia (see Figure 4.7). The town has access to the 100 series highways and rail infrastructure. There are six industrial parks located within and adjacent to Truro.

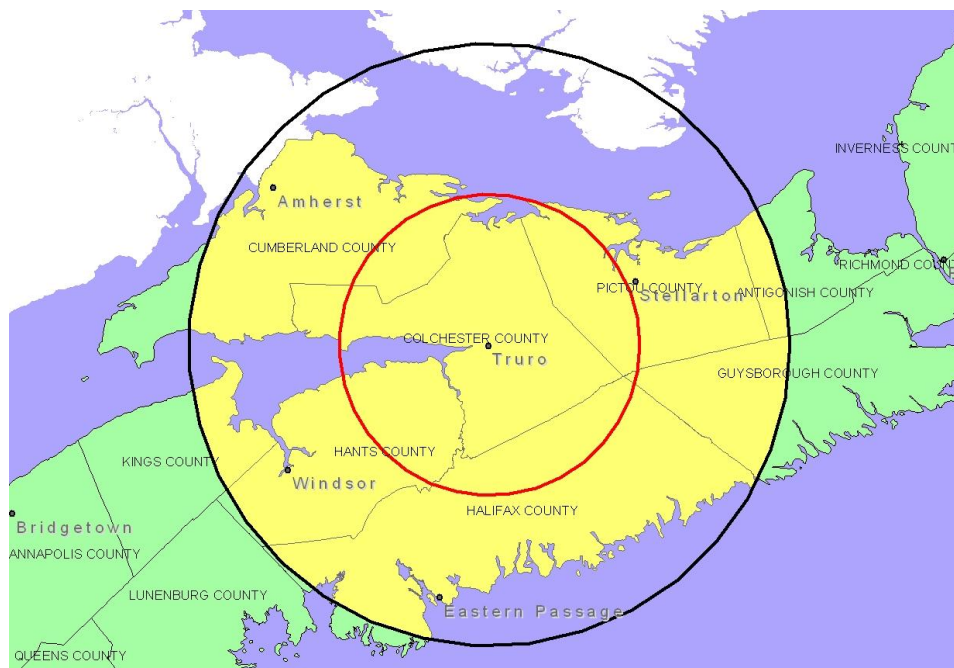


Figure 4.7 Truro inside 50-kilometre and 100-kilometre radii

The 50km radius around Truro includes Amet Sound (Tatamagouche Bay) and Cobequid Bay, while the 100km radius extends to Prince Edward Island, the Minas Basin, and the Atlantic Ocean. When the 50km radius waterways are removed, 732,172 hectares remain (representing over 13 percent of the provincial landmass). The land remaining in the 100km radius after waterways and protected areas are removed is 2,083,034 hectares or 37 percent of the province. The counties associated with Truro are listed in Table 4.19.

Table 4.19 County Land Area

	County Area (ha)	Area of county (ha)		Percentage of county	
		50 km	100 km	50 km	100 km
Antigonish	148,711		38,005		25.56
Colchester	366,643	337,723	366,643	92.11	100.00
Cumberland	436,586	69,351	377,491	15.88	86.46
Guysborough	423,120	952	135,490	0.22	32.02
Halifax	596,889	104,876	568,547	17.57	95.25
Hants	314,349	111,881	308,258	35.59	98.06
Kings	222,908		54,365		24.39
Pictou	289,632	112,474	289,632	38.83	100.00

4.8.1 Agriculture

Truro is centered in one of the main agricultural areas of Nova Scotia. At 50km, this location offers access to the majority of Colchester, large portions of Hants and Kings, and

a fraction of Cumberland, giving it immediate access to nearly 20% of the agricultural land in the province. At 100km, the Truro location gains access to greater portions of Cumberland and Hants counties, both agriculturally important counties; however, much of Kings County, the heart of agriculture in Nova Scotia, remains outside the radius. This site is among the better locations for agriculture.

4.8.2 Forestry

As with most sites within Central Region, woods surrounding Truro have been heavily harvested and the remaining unused quantity wood is not significant. However, the amount of residue from the mills is quite significant. In addition to Keywood Recovery, competition for hardwood may come from Truro's H.C. Haynes hardwood mills (acquiring 150,000 tonnes/year of hardwood) that produce an assortment of hardwood products for export markets. The forestry data for Truro is listed in Table 4.20.

Table 4.20 Forestry Biomass Availability and Potential

Characteristics	50km	100km
Mill residue (tonnes)	829,560	1,179,840
Current harvest Softwood (m ³)	1,001,187	2,740,615
Current harvest Hardwood (m ³)	195,633	527,547
Potential harvest volume Softwood (m ³)	-20,155	110,763
Potential harvest volume Hardwood (m ³)	75,976	271,636
Soil Capability for Forestry	4 (3)	4-5 (6)

4.8.3 Transportation

As the transport hub of the province, the highway network for Truro is excellent although in the 100km radius some of the eastern area does not flow efficiently towards Truro. Furthermore, some areas are inaccessible south of Windsor and along the eastern shore, as shown in Table 4.21.

Table 4.21 Road characteristics

Characteristic	50km	100km
Hwy density (km / km ²)	0.172	0.166
Hwy arrangement	Excellent	Good
Total Road Density (km / km ²)	1.245	1.163
Areas without road	Low	Moderate

4.9 Windsor

Windsor, centrally located within the province on the Fundy Shore, is considered a gateway to the Annapolis Valley region of Nova Scotia (see Figure 4.8). Windsor has

access to the 100 series highways, rail, and is in close proximity to agricultural land for the province.

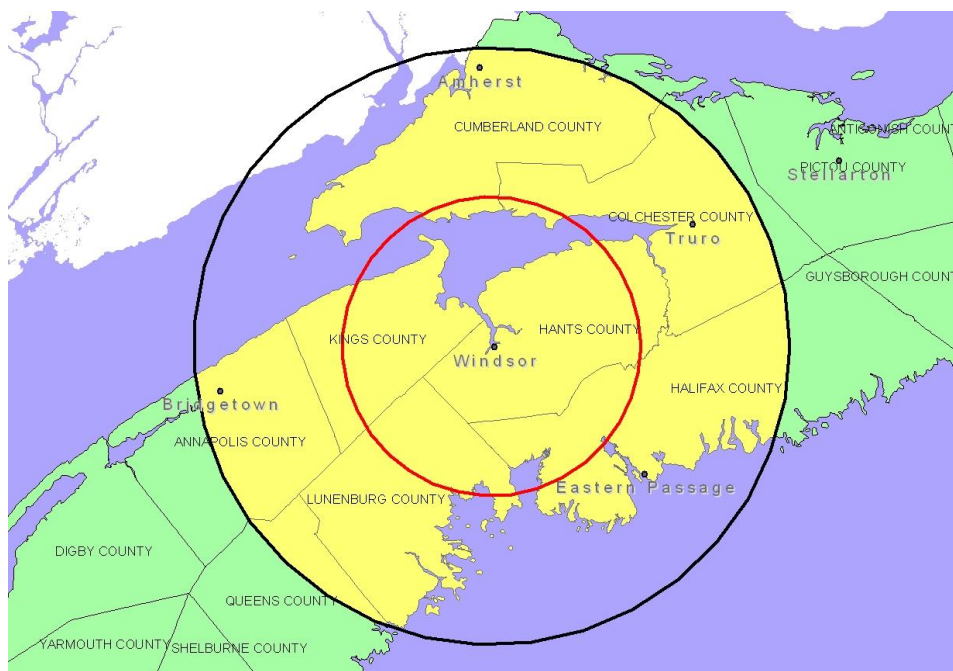


Figure 4.8 Windsor inside 50-kilometre and 100-kilometre radii

The 50km radius around Windsor includes Scots Bay, the Minas Basin, the Avon River, Mahone Bay, and St. Margarets Bay. The 100km radius includes New Brunswick, the Bay of Fundy, much of central Nova Scotia, and the Atlantic Ocean. When these waterways are removed from the 50km radius, 620,992 ha remains (11 percent of the provincial landmass), while removing the non-Nova Scotian landmass and water leaves an area of 2,100,391 hectares (37 percent of the province). Each county that falls within the Windsor radii is listed in Table 4.22.

Table 4.22 County Land Area

	County Area (ha)	Area of county (ha)		Percentage of county	
		50 km	100 km	50 km	100 km
Annapolis	336,237	0	201,255	0	59.86
Colchester	366,643	9,089	298,156	2.48	81.32
Cumberland	436,586	12,141	378,530	2.78	86.70
Halifax	596,889	99,385	391,977	16.65	65.67
Hants	314,349	271,931	314,349	86.51	100.00
Kings	222,908	154,803	222,908	69.45	100.00
Lunenburg	313,356	101,273	313,338	32.32	99.99
Queens	278,525	0	57,538	0	20.66

4.9.1 Agriculture

The Windsor site location gives nearly equal access to both Kings and Hants Counties within a 50km radius, accessing approximately 25% Nova Scotia's crop production land. At 100km, the Windsor-centered region takes in the greatest portion of agricultural land of any of the nine sites, covering all of Kings and Hants Counties, and the productive regions of Colchester, Cumberland, Annapolis and Halifax Counties. This is the best potential site if one considers only agricultural production and potential.

4.9.2 Forestry

Along with Stellarton, Windsor is also able to provide a good mix of forestry biomass potential within its 50km radii, although the wood residue potential is not as high as Stellarton. Louisiana-Pacific would be the main competition within 50km buffer. The forestry information for Windsor is shown in Table 4.23.

Table 4.23 Forestry Biomass Availability and Potential

Characteristics	50km	100km
Mill residue (tonnes)	9,000	1,032,840
Current harvest Softwood (m ³)	741,512	2,525,333
Current harvest Hardwood (m ³)	134,283	460,517
Potential harvest volume Softwood (m ³)	108,669	332,687
Potential harvest volume Hardwood (m ³)	110,351	359,480
Soil Capability for Forestry	4-5(3,6)	4-5(3,6)

4.9.3 Transportation

Within the 50km radius, the highway network is well developed and flows towards Windsor. However, in the larger region, the Minas Basin makes transportation inefficient and areas in the western edge of the site do not flow towards Windsor. Surprisingly, there are a number of large areas without roads southwest of Windsor (see Table 4.24).

Table 4.24: Road characteristics

Characteristic	50km	100km
Hwy density (km / km ²)	0.173	0.165
Hwy arrangement	Excellent	Very Poor
Total Road Density (km / km ²)	1.191	1.171
Areas without road	Moderate	Low

4.10 Yarmouth

Yarmouth is located on the Southern-most tip of the Province (see Figure 4.9). The area is serviced by two 100-series highways and has access to major shipping ports.

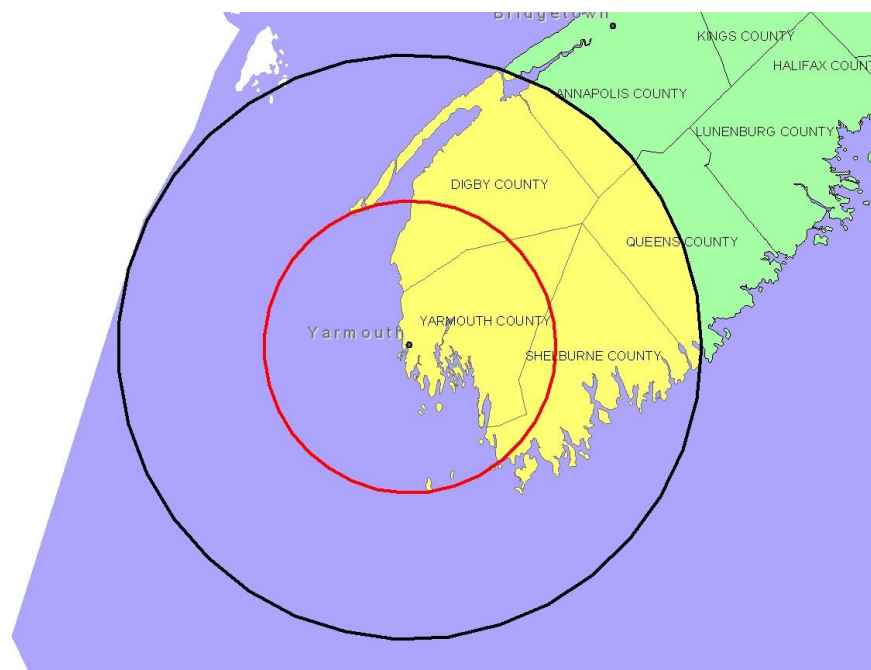


Figure 4.9 Yarmouth inside 50-kilometre and 100-kilometre radii

Both the 50km and 100km radii around Yarmouth include the Gulf of Maine. When the Gulf of Maine and other waterways are removed, 286,180 ha remain in the 50km radius (five percent of the province) and 880,300 hectares remain in the 100km radius (16 percent of the province). The counties with the two radii are shown in Table 4.25.

Table 4.25 County Land Area

	County Area (ha)	Area of county (ha)		Percentage of county	
		50 km	100 km	50 km	100 km
Annapolis	336,237	0	61,732	0	18.36
Digby	272,852	62,708	272,852	22.98	100.00
Queens	278,525	0	124,457	0	44.68
Shelburne	263,131	41,850	263,131	15.90	100.00
Yarmouth	235,043	205,958	235,043	87.63	100.00

4.10.1 Agriculture

The Yarmouth site is the southernmost of the potential locations under review. Only limited crop production occurs in this region, with less than 2% of Nova Scotia's cropland accessible within a 50km radius. Increasing the procurement radius to 100 km gives little improvement, adding only the southernmost fraction of Annapolis County and portions of relatively unproductive Queens County. This is arguably the least interesting location for agricultural biomass.

4.10.2 Forestry

Yarmouth presents a moderate quantity of potential wood volume available within the radii of survey. Strong competition may come from the J.D Irving mill at Weymouth that is using mixed softwood and hardwood for their production feedstock (see Table 4.26).

Table 4.26 Forestry Biomass Availability and Potential

Characteristics	50km	100km
Mill residue (tonnes)	45,000	305,280
Current harvest Softwood (m ³)	252,228	777,481
Current harvest Hardwood (m ³)	36,424	112,276
Potential harvest volume Softwood (m ³)	145,311	447,914
Potential harvest volume Hardwood (m ³)	84,864	261,589
Soil Capability for Forestry	4 (5 ,7)	5 (4 ,6 ,7)

4.10.3 Transportation

Along with Sydney, Yarmouth has an extremely poor road network. In fact, in the 50km radius Sydney is slightly better. Yarmouth's road network lacks sufficient density and an efficient arrangement. It appears that large portions of Yarmouth and Shelburne counties are undeveloped due to unproductive or low productivity swampy land. Road densities are also skewed downwards because of the presence of numerous protected areas.

Table 4.27 Road characteristics

Characteristic	50km	100km
Hwy density (km / km ²)	0.130	0.089
Hwy arrangement	Poor	Poor
Total Road Density (km / km ²)	0.631	0.500
Areas without road	High	High

5. Analysis

5.1 Agricultural Analysis

The relative merits of the individual sites have been weighed in terms of the estimates of biomass produced within the area surrounding the location, the capability of each area for agricultural production, and the quantity of underutilized agricultural land. Comparisons are based on a 50km and 100km biomass collection radius from each location.

Estimating the biomass production within a given circular radius requires special analysis data that is not collected in Canada. The smallest geographical units under which agricultural data is recorded is at the county by county level, collected every five years by Statistics Canada and presented in the Census of Agriculture. Accurate data is available for land use and types of crops grown, expressed in hectares per crop type (this data is presented in the county appendices). Crop yields are estimated from survey responses received from a large sample of agricultural producers (Robinson, D., personal communication). These numbers are available only at the provincial level.

It is possible to calculate the approximate production of crops for each county by multiplying land area devoted to a crop by the provincial average yield for that crop type. For the sake of this calculation, the agricultural system in the province was simplified to consider a hypothetical crop producing four tonnes of biomass per hectare. This figure is a weighted number representing the two principle biomass crops in Nova Scotia: hay and forage (averaging 6.2 tonne/ha) and grain straw (2.5 tonne/ha). Biomass figures for each county were then estimated.

In order to assess the spatial distribution for the production of biomass relative to each site location, it was necessary to assume a uniform distribution of agricultural production with the land area of a given county. This is a potentially dangerous assumption because production may in fact be concentrated in a few small areas that are dispersed throughout a county. However since the counties in Nova Scotia are relatively small the error in this approach is not so much that the biomass might not exist, but that it may be available at a certain number of kilometers plus or minus from the location. GIS analysis was used to calculate the percentage of a county within a given radius (50km or 100km) and the resulting matrix of percentages was applied to biomass estimates for each county to give an indication of biomass available for each of the nine locations.

Agricultural capacity information from Natural Resources Canada was assessed by visual estimation to determine the relative quantity of each agricultural capability class within a given radius. This information was tabulated and then ranked. Capability data does not correspond to current production, but is an important indicator of a location's ability to increase agricultural output and maintain longterm sustainable harvesting.

The quantity of underutilized agricultural land (the difference between the 2001 and the 1991 level of land use) was factored into the site analysis by combining the ten year changes in the land used for crop production and land used for pasture (total improved land). The aggregate quantity of derelict land was used in ranking the nine sites under consideration. The amount of biomass potentially generated from underutilized land (at moderate yields of four t/ha) averages approximately 10% of the current biomass production figures. A weighting of 10% was assigned to the potential for underutilized land in the final ranking.

The site assessment for agricultural biomass potential was carried out based on the characteristics discussed in Chapter 4. Each of the characteristics has been assigned the following weights. The weighted-averages were then summed and ranked to give the analysis presented Table 5.1 and Table 5.2 for the 50km and 100km radii, respectively:

- Quantity of biomass currently produced – 65%
- Agricultural Capability of region – 25%
- Potential for underutilized land – 10%

Table 5.1 50km Agricultural Ranking

Site	Current Production		Capability	Underutilized Land	Rank
	Tonnes	Rank			
Amherst	86,903	5	2	9	5
Bridgetown	78,702	4	4	6	4
Eastern Passage	23,906	7	5	1	7
Port Hawkesbury	32,924	6	3	8	6
Stellarton	89,028	3	3	2	3
Sydney	13,108	8	3	3	8
Truro	132,678	2	1	7	2
Windsor	140,242	1	3	4	1
Yarmouth	6,381	9	6	5	9

Table 5.2 100km Agricultural Ranking

Site	Current Production		Capability	Underutilized Land	Rank
	Tonnes	Rank			
Amherst	260,225	3	2	8	3
Bridgetown	207,086	5	6	6	6
Eastern Passage	199,213	6	3	3	5
Port Hawkesbury	91,983	7	4	4	7
Stellarton	234,319	4	1	7	4
Sydney	31,707	8	5	1	8
Truro	329,325	2	1	5	1
Windsor	377,518	1	2	9	1
Yarmouth	18,299	9	7	2	9

5.2 Forestry Analysis

The site assessment for forestry biomass potential was carried out based on the characteristics discussed in Chapter 4. Each of characteristics has been assigned the following weight:

- Quantity of mill residue available – 25%
- Current softwood production – 5%
- Current hardwood production – 20%
- Potential softwood harvest – 5 %
- Potential hardwood harvest – 40%
- Forestry capability – 5%

The weighting is based upon optimizing the use of hardwood species as feedstock, since hardwood gives a better ethanol yield than softwood. Potential harvest for hardwood is assigned the highest weight, as it implies the available unused hardwood is within the desired radii. A certain quantity of hardwood would also be available in the form of current hardwood production/harvest; however, there will be more competition to acquire such materials. Therefore, current hardwood production numbers are assigned a lesser value for analysis than the unused hardwood. Mill residue offers relatively low priced feedstock materials; therefore, mill residue is assigned 25%. The remaining characteristics are each assigned 5% to reflect the potential of each site. The results of the overall rankings are presented in Table 5.3 and Table 5.4 for 50km and 100km, respectively.

Table 5.3 50km Forestry Biomass Ranking

	Mill Residue	Current		Potential harvest		Forest Capability	Rank
		SW	HW	SW	HW		
Amherst	4	5	5	8	9	4	9
Bridgetown	7	6	6	3	3	5	6
Eastern Passage	2	4	4	7	8	8	7
Port Hawkesbury	7	8	8	2	2	3	5
Stellarton	3	3	3	6	6	2	3
Sydney	7	7	7	1	1	7	3
Truro	1	1	1	9	7	1	1
Windsor	6	2	2	5	4	6	2
Yarmouth	5	9	9	4	5	3	8

Table 5.4 100km Forestry Biomass Ranking

	Mill Residue	Current		Potential harvest		Forest Capability	Rank
		SW	HW	SW	HW		
Amherst	6	5	5	9	9	1	8
Bridgetown	5	6	6	3	1	2	1
Eastern Passage	1	4	4	7	8	4	6
Port Hawkesbury	8	7	7	1	2	4	5
Stellarton	3	3	3	5	5	4	4
Sydney	9	9	9	2	3	6	7
Truro	2	1	1	8	6	3	3
Windsor	4	2	2	6	4	2	2
Yarmouth	7	8	8	4	7	5	9

5.3 Transportation Analysis

As stated in Chapter 4, each site's road network has been assessed based on the amount, distribution, and arrangement of higher order paved roads and the amount of large tracts of land that are currently without any type of road. To perform the analysis for road/accessibility, all four of these characteristics have been equally weighted; for example, a value of 25% has been assigned to each category. If a site has been evaluated and a particular characteristic deemed to be 'Excellent', that characteristic is then assigned a value of 25. A site ranked 'Very poor' does not display the characteristic well, if at all, and is thus assigned a zero. The overall rankings for accessibility are presented in Table 5.5 and Table 5.6 for 50km and 100km rankings, respectively.

Table 5.5 50 km Road Analysis Summary

	Highway Density	Arrangement	Total Road Density	Roadless	Average	Rank
Amherst	4	5	5	1	3.75	5
Bridgetown	9	5	7	1	5.5	6
Eastern Passage	1	1	1	1	1	1
Port Hawkesbury	7	5	8	6	6.5	8
Stellarton	5	1	4	1	2.75	3
Sydney	5	5	6	8	6	7
Truro	3	1	2	1	1.75	2
Windsor	2	1	3	6	3	4
Yarmouth	8	9	9	8	8.5	9

Table 5.6 100 km Road Analysis Summary

	Highway Density	Arrangement	Total Road Density	Roadless	Average	Rank
Amherst	1	4	4	7	4	5
Bridgetown	8	4	7	3	5.5	6
Eastern Passage	1	1	1	3	1.5	1
Port Hawkesbury	6	4	6	7	5.75	7
Stellarton	5	1	5	3	3.5	3
Sydney	7	8	8	7	7.5	9
Truro	3	3	3	1	2.5	2
Windsor	4	8	2	1	3.75	4
Yarmouth	9	4	9	3	6.25	8

5.4 Comparative Rankings

In the following comparative rankings, agriculture is weighted at 25%, forestry at 55%, and roads at 20% with the land area reserved as a tiebreaker. It was felt that forestry is most critical, as it is will be the largest feedstock by far, and will continue to be the major feedstock for an extended time. Agriculture was also considered important as it indicates both the current and future potential for agricultural biomass. Roads were included as trucking is a major cost and inaccessible biomass is an important constraint, at least in the near future.

5.4.1 50km Assessment

The results of combining the 50km agriculture, forestry, and accessibility information are presented in Table 5.7. The five ‘best’ sites are Truro, Windsor, Stellarton, Sydney, and Bridgetown.

Table 5.7 50km Rankings.

	Area (ha)	Area Rank	Derived Rankings			Average Ranking	Rank
			Agriculture	Forestry	Roads		
Amherst	369,087	8	5	9	5	7.2	8
Bridgetown	449,488	5	4	6	6	5.5	5
Eastern Passage	378,765	6	7	7	1	5.8	7
Port Hawkesbury	483,310	4	6	5	7	5.65	6
Stellarton	565,506	3	3	3	3	3	3
Sydney	377,142	7	8	3	9	5.45	4
Truro	732,172	1	2	1	2	1.45	1
Windsor	620,992	2	1	2	4	2.15	2
Yarmouth	286,180	9	9	8	8	8.25	9

5.4.2 100km Assessment

The results of combining the 100km agriculture, forestry, and accessibility information are presented in Table 5.8. The five ‘best’ sites are Windsor, Truro, Bridgetown, Stellarton, and Eastern Passage.

Table 5.8 100km Rankings.

	Area (ha)	Area Rank	Derived Rankings			Average Ranking	Rank
			Agriculture	Forestry	Roads		
Amherst	1,037,263	7	3	8	5	6.15	7
Bridgetown	1,547,050	4	6	1	6	3.25	3
Eastern Passage	1,447,745	5	5	6	1	4.75	5
Port Hawkesbury	1,362,283	6	7	5	7	5.9	6
Stellarton	1,730,238	3	4	4	3	3.8	4
Sydney	1,017,834	8	8	7	9	7.65	8
Truro	2,083,034	2	1	3	2	2.3	2
Windsor	2,100,391	1	1	2	4	2.15	1
Yarmouth	880,300	9	9	9	8	8.8	9

5.5 Site Selection

Based on the 50km and 100km rankings of the nine sites, Windsor, Truro, Stellarton, and Bridgetown are the most promising sites in terms of providing biomass feedstock for the

ethanol plant. The proximity of Windsor, Truro, and Stellarton results in large overlapping areas within the 50 and 100km radii of these sites. Choosing these sites as prospective locations of the envisaged three bio-ethanol plants will not be appropriate with respect to the biomass feedstock supply. Therefore, Bridgetown has been included to substitute Truro, which happens to be situated approximately halfway from Windsor and Stellarton. Port Hawkesbury is also recommended for further study due to its proximity to large quantities of hardwood, both in 50km and 100km buffer, with no major competition.

6. Recommendations and Observations

- Further research into biomass crops needs to be conducted to encourage the adoption of a biomass industry for the province. This would include testing new biomass plant species, modifying cultivation techniques for existing crops, and improving the agricultural technologies associated with biomass production and harvesting. Important potential species include, but are not limited to: hemp, switchgrass, and reed canary grass.
- NSDNR should develop a procedure manual for measuring the quantity of residue and waste left after logging operations. This would help the province identify underutilized biomass resources.
- Further research and incentives need to be created in order to effectively use harvest residues. Areas of study could include better use of tops and branches, brushwood bale systems, full-tree debarking and chipping, and site nutrient management.
- Determining the amount of ‘derelict’ land is questionable. This is presently based on census information as well as on qualitative reports from agricultural agents. In many cases, it would appear uneconomic to redevelop land for expensive feedstocks when the land has already been demonstrated to be of questionable quality.
- SRF appears to have substantial potential in the longterm for supplying biomass in the province. Further research and incentive programs are needed to encourage experimentation with windrow and full field SRF (see section 3.4.4).

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