Looking Ahead

An Assessment of Potential Land Use Trends in Strathcona County

Prepared for
Planning and Development Services
Strathcona County

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Disclaimer

This report is intended to demonstrate a land use assessment and modeling approach that may be helpful to citizens, stakeholders and planners. The information used to describe the historical and current land use conditions in Strathcona County is derived from diverse sources. In some cases, calculations have been made with incomplete knowledge, and are therefore approximations. When reviewing simulation model results, it is appropriate to focus on the relative direction of projected trends, not precise numbers at any future year in the simulation interval. The simulations are intended to provide strategic-level insights, and are not expected to be highly accurate in a given year.

The views, statements and conclusions expressed and the recommendations made in this report are entirely those of the authors and should not be construed as statements or conclusions of, or as expressing the opinions of the Strathcona County, its employees or agents.

Introduction

Strathcona County is a unique municipality located northeast of Edmonton in Alberta's Capital Region (Figure 1). The juxtaposition of urban and rural areas governed by a single municipality has created an economically and culturally diverse community. It includes the hamlet of Sherwood Park, plus eight smaller hamlets, 900 farms and numerous country residential developments. Historically an agricultural-dominated area, the economic base of the region has evolved to include oil refineries, manufacturing and other heavy industry, and diverse retail and commercial operations. The County is strongly influenced by its proximity to the City of Edmonton, which is the commercial and transportation hub of northern Alberta. Edmonton provides numerous economic opportunities for Strathcona County businesses, and County residents frequently travel to and from Edmonton for work, recreation, health care, and a wide range of other metropolitan services. In turn, the County is also a destination for many Edmonton residents seeking a range of recreational and other activities.

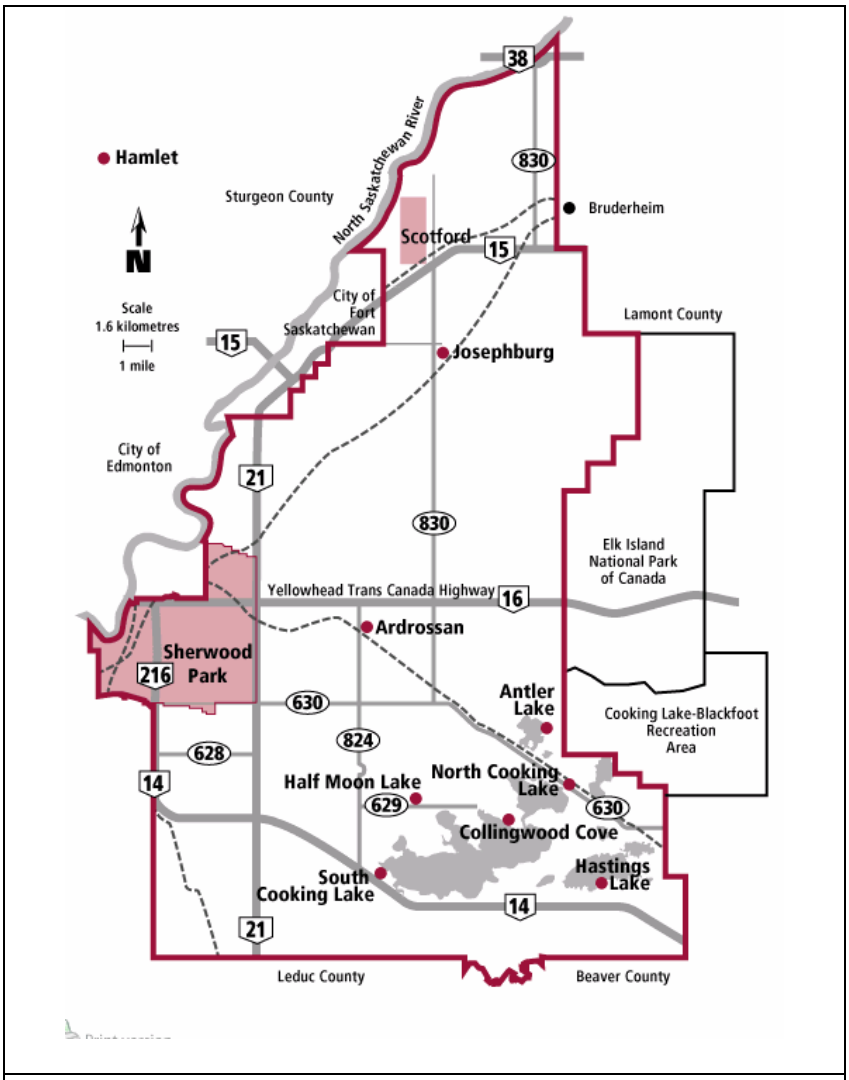


Figure 1. Map of Strathcona County.

Steady growth in the urban and rural population, and a desire to grow and diversify the economy while maintaining traditional land uses such as agriculture, make it challenging to plan future land use development. A key element of the County planning process is the Municipal Development Plan (MDP). The most recent (1998) Municipal Development Plan sets out "guidelines for orderly growth and development over the next 20 years and beyond". It also provides "a comprehensive long term land use policy framework within which present and projected growth and development may take place" (see www.strathcona.ab.ca/Strathcona/Departments/Planning+and+Development+Services). The objectives of the MDP are:

- To maintain and enhance the quality of life of Strathcona's citizens through opportunities for realization of individual and community needs and aspirations.

- To enhance the environmental management of the County.
- To provide for planned, efficient, economical and beneficial development which provides for a diversity of choice and lifestyle.

Unprecedented growth in Strathcona County over the last several years has prompted a review of the 1998 Municipal Development Plan to ensure policies and guidelines are still relevant. For example, the population grew by over 14 per cent from 1998 to 2003 (Figure 2), resulting in unprecedented demand for housing, business and commercial services, and other infrastructure. The 2005 population was approximately 80,000 people, of which just over two-thirds live in Sherwood Park.

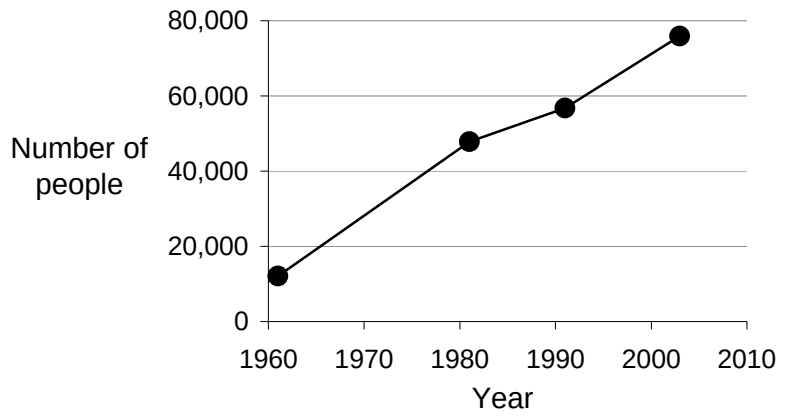


Figure 2. Growth of the population of Strathcona County, 1961 to 2003. Source: Strathcona County Municipal Census Report 2003.

Among the many elements of the MDP review is an assessment of the long-term sustainability of land use and landscape conditions over the next several decades (this study). The results of an initial assessment and an illustration of a modeling approach are summarized in this report. Further analysis may be conducted pending a review of its utility to the County.

The purpose of this study is to assess competing land uses and the cumulative effects of land use planning decisions in and around Strathcona County. A modeling approach is used to forecast future environmental, social and economic conditions under alternative "what if" scenarios. Additional information about the study and the modeling approach used is available in the project terms of reference (Stelfox and Farr 2005).

Strathcona County landscape and land use

Landscape

The topography and natural vegetation patterns of the Strathcona County landscape are strongly influenced by historical patterns of glaciation and deposition. Much of the southern part of the County is situated on the Beaver Hills - Cooking Lake Moraine, a 1,500 km^2 complex of hummocky knob and kettle terrain elevated above the surrounding area. Mixedwood forests interspersed with wetland depressions on this moraine add considerable topographic and ecological variety to a part of the province dominated mostly by parkland vegetation. The high levels of biodiversity (plants, invertebrates, vertebrates) known to inhabit the Cooking Lake Moraine reflect this considerable variation in landform. To the north and west of the moraine complex, lands undulate towards the North Saskatchewan River valley, part of which was,

during glacial times, a shallow glacial lake in which fine materials eroded from southeastern parts of the County were deposited.

The County can be divided into several relatively distinct areas based on a combination of topography and soil parent materials (Soil Inventory Working Group 1998). In southern and eastern parts, at elevations of 730 -770 m a.s.l, the mostly hummocky terrain contains numerous wet depressions. Native vegetation is predominantly mixedwood (aspen, spruce) forest, and, south of Sherwood Park, parkland vegetation consisting of groves of poplar trees interspersed with open areas of grass and shrubs. Northwest of the moraine complex, from Sherwood Park to Josephburg and Bruderheim, gently undulating terrain at elevations of 650 – 710 m was historically dominated by parkland vegetation. Soils in this part of the County have excellent agricultural capability, with some soil-landscapes ranking in the top 5% in the province (Toma and Bouma/ Stantec Consulting 2003). In the extreme north of the County, at elevations of 620 – 650 m, the undulating terrain historically dominated by grassland vegetation is generally less suitable for agricultural uses without supplementary irrigation of its often sandy soils.

Agricultural, residential, and industrial developments over the past several decades have transformed much of the natural landscape of Strathcona County. Most of the forest (Figure 3) and wetlands have been converted to, or modified by, some form of land use. Approximately 18,000 hectares of forest and 2,000 hectares of wetlands remain in the Agriculture land base. Because this estimate is based on interpretation of aerial photographs taken in the year 2000 (Rogeau 2003), the current area of natural habitat is probably lower due to forest clearing since that time. Also, it is difficult to determine the extent to which natural habitat is altered by grazing, brush clearing, off-road vehicle use, and other activities.

Concerns over the loss of natural habitat to development range from practical considerations related to natural capital and the ecological services it provides, to ethical considerations related to the intrinsic value of nature in its own right. Surveys have indicated that numerous families have moved to Strathcona County because of its high aesthetic values, and there is a general desire to ensure that municipal planning protects these values. Maintaining natural habitat would promote the conservation of biodiversity by providing homes for native species. It would also promote the conservation of soil resources: soils perform ecologically important roles in filtering and moderating the flow of surface and ground water, cycling nutrients, carbon pool dynamics, and supporting plant life. Natural habitats also remove air pollutants, moderate local weather patterns, and sequester atmospheric carbon (greenhouse gases). Wetlands and aquatic environments also provide habitat for many species not found elsewhere, including those that are truly aquatic (e.g., fish, loons) and those that require aquatic habitat for part of their life history (e.g., frogs, beavers).

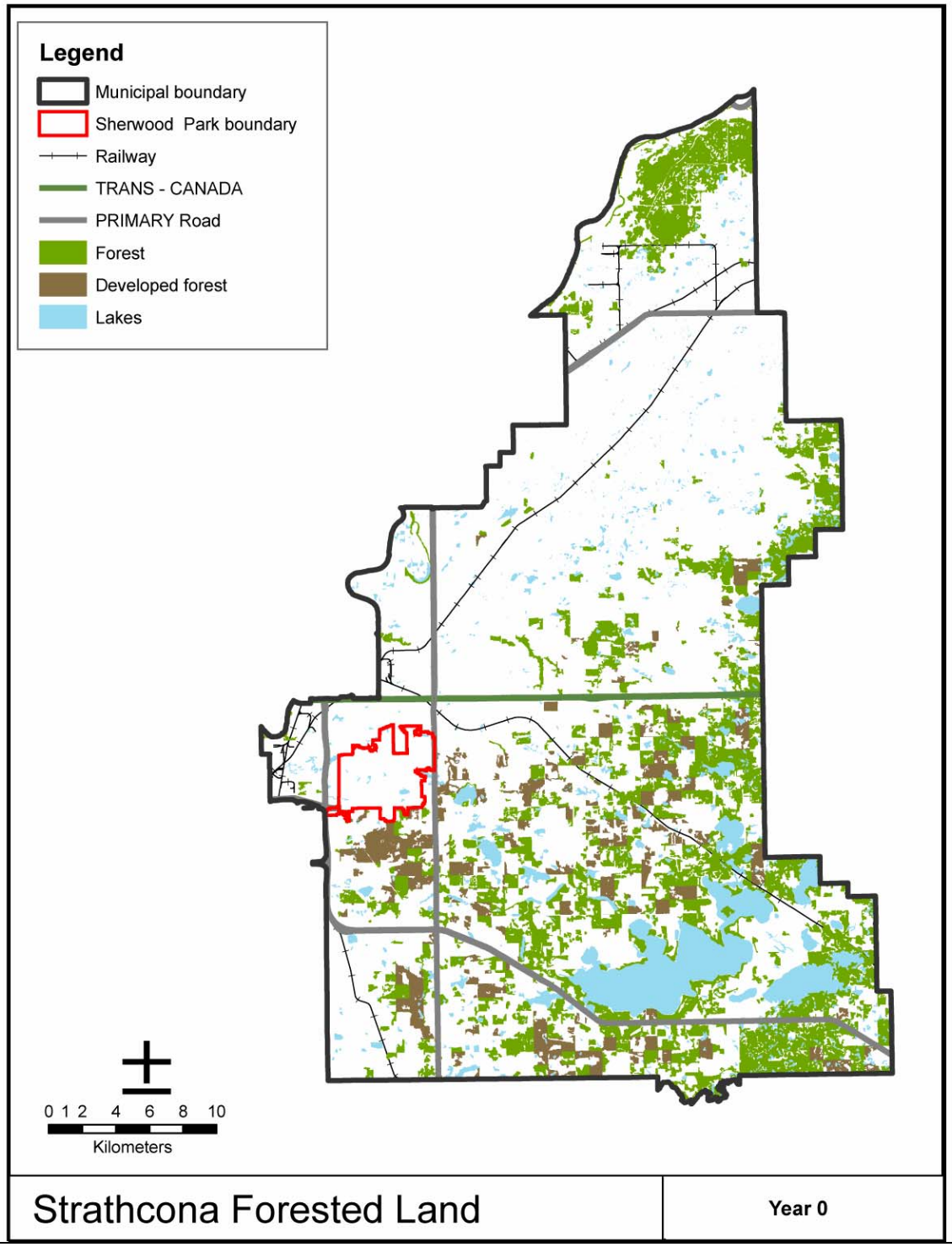


Figure 3. Area of forested land in Strathcona County. "Forest" is within the Agricultural land base, while "Developed forest" is within the Country Residential and Rural Residential land use areas. Source: Prepared from digital files from Rogeau (2003).

Based on interpretation of aerial photography obtained in 1996, about two-thirds of the terrestrial natural habitat in the County outside of lakes consisted of upland vegetation communities, including poplar, mixedwood and conifer forest stands (Table 1). The remainder consisted of wetland complexes, including marsh, bog, slough and swamp habitats.

Table 1. Summary of wildlife habitat in Strathcona County in 1986.

	Area (ha)	%
Upland restoration	3,600	9
Upland wildlife habitat	23,580	60
Wetland restoration	1,836	5
Wetland wildlife habitat	10,195	26
Total	39,211	100
Lake restoration	16	0.2
Lake wildlife habitat	7,808	99.8
Total	7,824	100.0

Source: Geowest 1997; summarized from *habitat_priority_units.dbf*

Major creek systems in the County include Astotin, Ross, Point-Aux Pins, Oldman and Irvine, all of which flow directly or indirectly into the North Saskatchewan River (Figure 4). The total length of rivers and streams in the County is approximately 2,200 km. This value is significantly less than stream lengths that would have occurred prior to the arrival of the agricultural era because of the extensive amount of streams that have been lost to cultivation and channelization.

Numerous lakes and ponds are distributed throughout the County (Figure 4), with the largest lakes located in the Cooking Lake area in the southeastern part of the County. These include North Cooking Lake, South Cooking Lake, and Hastings Lake.

Additional information on the ecological setting and biophysical conditions in Strathcona County may be found in the following documents:

- Wildfire threat analysis and fire risk zoning (Rogeau 2003)
- Prioritized Landscape Ecology Assessment of Strathcona County (Geowest 1997)
- Strathcona County Southeast Watershed Ecosystem Assessment (Griffiths 1992)
- Environmentally Sensitive Areas: County of Strathcona and M.D. of Sturgeon (Infotech 1989)
- A Survey of Wetland Wildlife Resources in Strathcona County (Griffiths 1987)
- Outdoor Master Plan (Strathcona County Recreation and Parks 1987)
- Significant Natural Features and Landscapes of Strathcona County (Westworth and Knapik 1987)
- Ducks Unlimited List of Significant Wetland Habitat with Management Potential in Strathcona County (1986)

Land use

General overview

In this assessment, the diverse array of land uses in Strathcona County was consolidated into broad categories: Urban, Country Residential, Rural Residential, Industrial, Conservation / Parks, Recreation, Utilities, Transportation (roads), and Oil and Gas (production and exploration), and Agriculture. The current spatial arrangement of these land uses is illustrated in Figure 5.

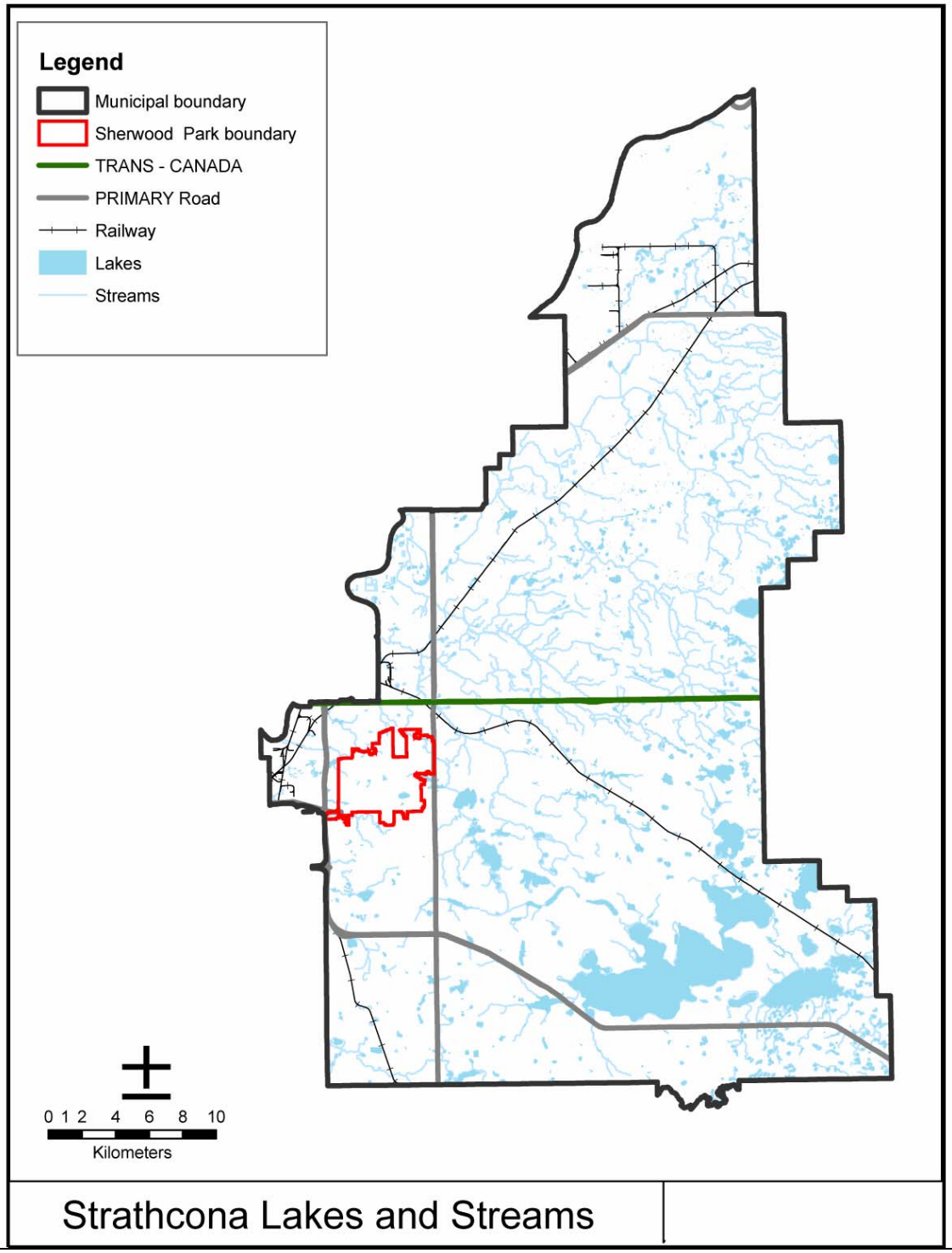


Figure 4. Rivers, streams, lakes and ponds in Strathcona County. Source: County GIS: lake 1996.shp, streams.shp.

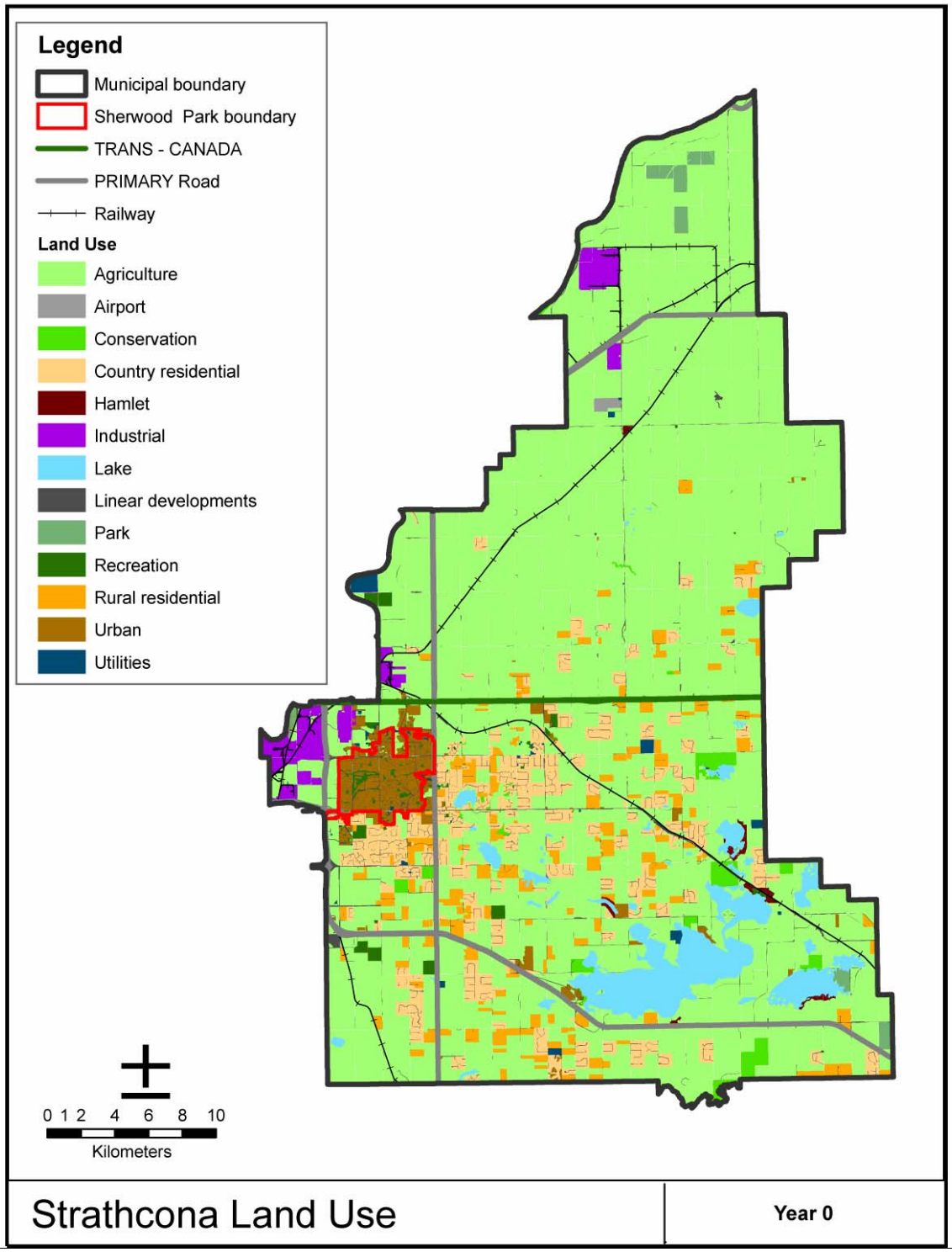


Figure 5. Map of current land use in Strathcona County. Source: County GIS (land use.shp).

Urban

The urban land use occupies approximately 2,700 hectares in the County. While Sherwood Park and the other eight hamlets share the 'hamlet' designation, the smaller size (Figure 6) and rural

character of the other hamlets sets them apart from Sherwood Park. Some hamlets such as Josephburg and Ardrossan are located in a primarily agricultural setting, while others such as Collingwood Cove and South Cooking Lake are surrounded by a mosaic of agricultural land and natural habitats. Population density in these hamlets is variable, ranging from approximately 1 person per hectare in the larger hamlets (Josephburg, Collingwood Cove, South Cooking Lake, Ardrossan) to about 6 people per hectare in Antler Lake and Half Moon Lake (Source: Strathcona County GIS Services: urban service areas.dbf).

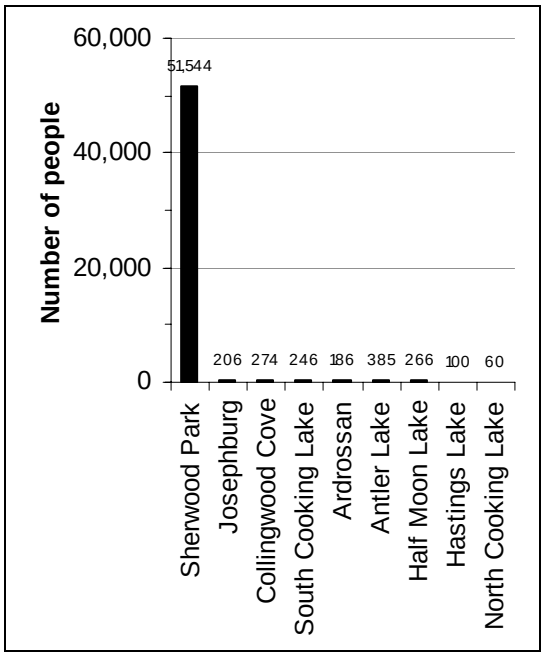


Figure 6. Population of Sherwood Park and the eight other hamlets in Strathcona County. Source: Strathcona County 2003 Municipal Census Report.

Country Residential

The Country Residential land use class is concentrated in the southern half of Strathcona County (Figure 5), with a total area of approximately 9,000 hectares. Approximately 5,900 Country Residential dwellings were reported in the 2003 Municipal Census, indicating an average lot size of 1.5 hectares per dwelling. Typical lot sizes in recent developments are between 2 and 5 acres (0.8 to 2 hectares). The Country Residential population is approximately 17,500 people (2003 Municipal Census), a density of approximately 2 people per hectare.

The average "footprint" occupied by a country residential dwelling, its driveway, and its share of the subdivision road, consists of approximately 0.2 hectares, or approximately 20% of this land use class. The land cover of the remaining 80% of the class varies among different parts of the County. For example, subdivisions in the agriculture-dominated part of the County are located on lands previously cleared for agricultural production. Others, such as those in the Cooking Lake area, are located on lands still dominated by natural habitats such as forest and wetlands. Some landowners try to preserve or restore natural habitats on their property, while others develop their land for aesthetic, recreational, or other purposes.

Rural Residential

Large acreages in the Rural Residential land use class are distributed throughout Strathcona County (Figure 5), with a total area of approximately 5,100 hectares. There are approximately 1,600 farm dwellings in the County and a farm population of approximately 4,600 people (2003 Municipal Census). Unlike the country residential land use class in which the area surrounding the dwelling may include natural habitat and developed yards, many large acreages and farm homes are surrounded by agricultural land.

Industrial Land

The industrial land use class occupies approximately 2,200 hectares. Most of this area consists of four heavy industrial developments in the north part of the County: Scotford, Strathcona, Astotin and Sandhills (Figure 5, Figure 7). The remaining industrial areas are located on the western and northern parts of Sherwood Park.

Figure 7. Scotford plant in northern Strathcona County. Source: http://www.industcards.com/cc-canada.htm

Roads

The transportation network in Strathcona County (outside of Sherwood Park) consists of highways maintained by the Province, a largely complete one-by-two mile grid of county roads, and roads within country residential subdivisions (Figure 8). The total length of these rural roads is approximately 1,500 km. The area of land occupied by linear developments, most of which are roads and the accompanying rights-of-way, is approximately 6,400 hectares. These values are conservative, however, and do not include wellsite access roads, driveways to acreages, or roads found within the hamlets.

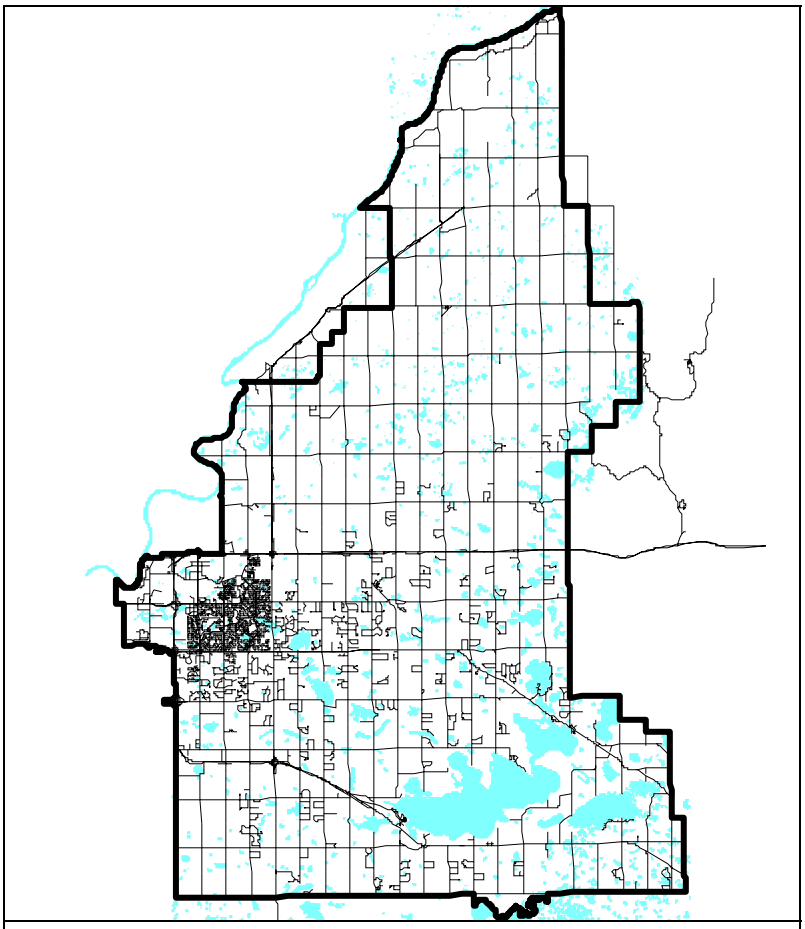


Figure 8. Road network in Strathcona County. Source: street network.shp

Oil and Gas

For the purpose of this assessment, the oil and gas land use class consists of well sites, their accompanying infrastructure (pipelines, well site roads) and the seismic lines required to locate hydrocarbon reserves. There are approximately 500 well sites in the County, of which about 200 are active, and 300 are abandoned (Figure 9). The highest concentration of well sites is in the far northern part of the County, but there are numerous wells dispersed throughout the County (Figure 9). Oil and gas developments are sometimes a source of concern for residents in terms of groundwater supplies (e.g., Griffiths and Woynillowicz. 2003), air quality, emergency preparedness and emergency response systems.

The total area of the oil and gas land use class is estimated to be approximately 1,500 hectares, based on the following metrics (based partly on those given by Schneider et al. (2003):

- average well site area: 1 hectare
- average length of pipeline per active well site: 1 km
- average pipeline right of way width: 25 m
- average length of seismic line per active well site: 5 km
- average seismic line width: 5 m

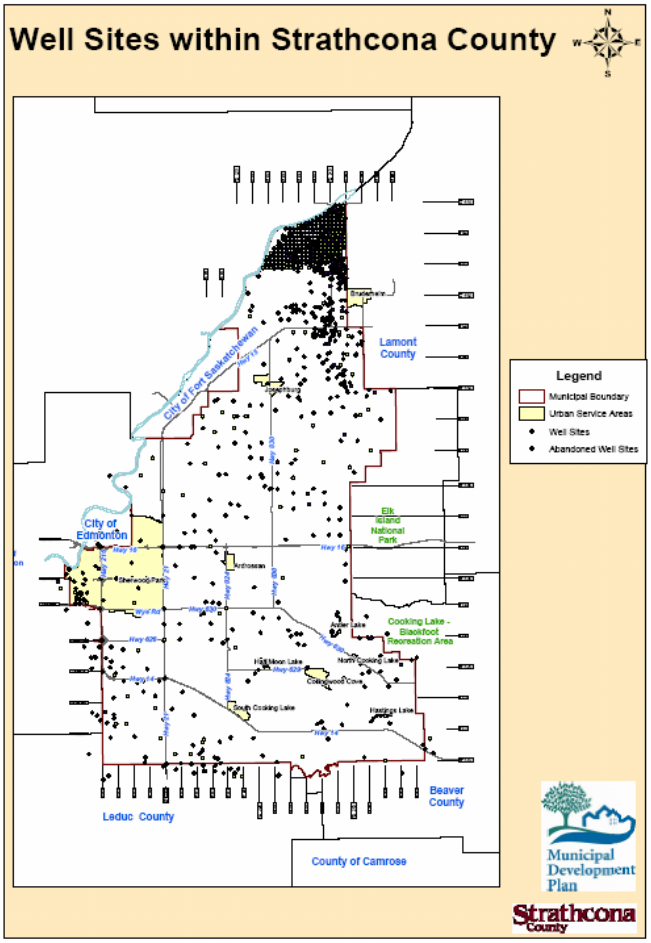


Figure 9. Well sites in Strathcona County. Source: http://www.strathcona.ab.ca

Agricultural Land

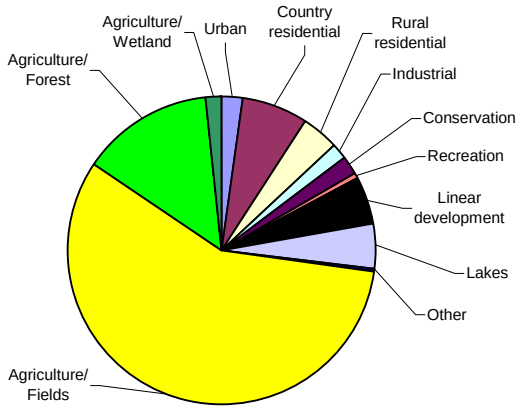
The area of the agricultural land base (Figure 5) is estimated to be approximately 92,000 hectares. Of this area, approximately 72,000 hectares consist of cropland and pasture, with the remaining area consisting of forest and wetland habitat.

Compared to the average for Alberta, farms in Strathcona County are relatively small, averaging about one-third the size of the average farm in Alberta. Only a third of the 900 farms in the County in 2001 were larger than 100 hectares (240 acres). Wheat, other grains and oilseeds and livestock form the bulk of farm incomes in the County, with gross receipts for most (72%) farms less than 50,000 in 2001 (Toma and Bouma/ Stantec Consulting 2003).

Example of an agricultural landscape in Alberta.

Comparisons among land use sectors

It is important to recognize that the area occupied by a sector (Figure 10) does not provide a complete picture of its potential ecological impact. Area in different land uses can vary significantly in terms of water consumption, waste production, electricity demands, and atmospheric emissions. For example, agricultural lands, particularly pasture, provide considerably more ecological services (e.g., water filtration, carbon sequestration, wildlife habitat) than industrial lands. Lands used for industrial purposes may also have negative impacts on water quality and air quality, and do not provide significant areas for wildlife habitat. Some landuses, such as the energy sector and the transportation network, may not comprise much area because their features (seismic lines, roads) are narrow. The extent of their effects may be felt over much larger areas, though, as is the case when invasive plant species establish along linear features and progressively invade natural habitat or agricultural crops.



	Area (ha)	%
Urban	2,686	2
Country Residential	8,750	7
Rural Residential	5,095	4
Industrial	2,237	2
Conservation	2,182	2
Recreation	744	1
Linear Development	6,379	5
Lakes	5,841	5
Other	657	1
Agriculture/ Fields	72,121	57
Agriculture/ Forest	17,581	14
Agriculture/ Wetland	2,228	2
Total	126,500	100

Figure 10. Area of various landscape and land use classes in Strathcona County.

The economic and social contributions of various land uses within a region such as Strathcona County are also complicated to measure and compare. Some observations are possible from a breakdown of employment by sector within the County (Table 2). In some cases there is only partial correspondence between the sectors as defined here and the industry divisions in Table 2, but some general observations are possible:

Table 2. Strathcona County labour force by industry division.

	Number	%
Business & Community Services	18,005	42
Retail and Wholesale	6,335	15
Manufacturing	4,310	10
Construction	3,595	8
Public Administration	2,805	7
Finance	2,675	6
Transportation and Utilities	2,555	6
Agriculture	1,145	3
Mining	1,030	2
Total All Industries	42,455	100

Source: Statistics Canada (2001)

- The agriculture sector, which occupies over half of the County (Figure 10) accounts for 3% of its labour force.
- The oil and gas sector, with its relatively small footprint (less than 1% of the County area) also employs relatively few people (2% of the labor force in the mining industry – this includes oil and gas).
- The relative size of other industry's footprint (2%) is much smaller than the proportion of the labour force employed in the manufacturing sector (10%).
- 78% of the labour force (business and community services, retail and wholesale, construction, public administration, and finance) is primarily "urban", centered in Sherwood Park. Sherwood Park covers approximately 2% of the County area.

Another measure of a sector's economic contribution to a region is the estimated municipal regular property tax (Table 3).

Less straightforward are the non-economic contributions of various land uses, such as lifestyle and cultural aspects. For example, agriculture contributes to the rural character of Strathcona County that is valued by many urban and rural residents.

Table 3. Estimated municipal regular property tax revenues in Strathcona County (2005).

	$ (million)	%
Residential	34.8	45
Farmland	0.2	< 1
Industrial machinery and equipment	29.8	38
Linear (power and pipe)	3.4	4
Commercial, other industrial and other	9.6	12
Total	77.7	100

Source: Strathcona County

It has long been recognized that classical economic metrics (e.g., GDP, wages, royalties) do not measure the true economic value of natural and anthropogenic lands to society. A more progressive approach attempts to capture the full suite of ecological goods and services provided by the landscape and inform society about how natural capital can change under different management regimes.

Land use challenges in Strathcona County

Table 4. Challenges facing the rural community in Strathcona County. Source: Strathcona County "Facts, Trends, Issues" handout (www.strathcona.ab.ca).

Trends	Issues
Population • Between 1997 – 2003, the overall population within the rural areas increased by 6.3% (1528 people). Rural population is projected to be 28,190 by the end of 2009. (Source: Strathcona County Population Forecast, 2004).	• Will the growing population in the rural area diminish the rural experience or lifestyle for those residing there? • Can we continue to grow in the rural areas, maintaining a rural standard of development (i.e. wastewater disposal?)
Demographics • The percentage of the population over 65 will continue to increase over the next 10 to 15 years as the baby boomer segment ages. • By 2020 the percentage of those over 65 living in the rural service area could be over 14%. (Source: Strathcona County Population Projections 2001-20)	• As the population ages it is likely that many over the age of 65, who own larger homes or large acreages will consider downsizing and search for housing that is more easily maintained and close to major amenities. • Where will seniors want to live in the future considering that this age group will likely be healthier and more active than in the past?
Agriculture • The recent trend has been towards less mid-sized "traditional farms" and more large scale farms as well as more small scale, intensified agricultural operations. (Source: Future of Agriculture Study, 2003)	• With larger, commercial farming operations, will the stewardship of the land be affected? • If smaller, intensive farming applications are permitted, will this have an impact on not only the quality of life, but also the environment due to increased activity? • Many County residents have stated that they want to protect agricultural land. (Source: Community Consultation 2002). • Can diversification occur in the rural areas (farm size, residential uses, tourism), while still maintaining a viable agricultural base?
Transportation • As the population grows, so too will the number of vehicles traveling on rural roads. Some roads are already exceeding traffic levels that were projected for 2016. (Source: Strathcona County Traffic Impact Study, 2001)	• Increased traffic on rural roads leads to congestion and increased road maintenance costs.
Recreation • Between 1981and 2001 the number of horses within Strathcona County increased by 41%. Strathcona County is now home to approximately 7500 horses. • Strathcona County residents on average earn more than most Albertans, and therefore have more disposable income. There is evidence in rural residential areas, that disposable income is spent on items such as ATV's, motorbikes, snowmobiles, pets, etc.	• Overgrazing is becoming more of an issue. It occurs when the land base is not large enough to support the horse population that is grazing on the land. • The County has received complaints from the farming community about trespassing, damage to property, and noise. • The question has been raised whether keeping a few horses for personal, recreational use, constitutes an agricultural operation with associated tax rates?
Environment • Based on recent demand for small and large acreage lots, it is expected that there will be continued pressure to develop lands in the rural areas well into the future. • Currently, a large portion of the Cooking Lake Moraine is situated on lands that could potentially be developed for agricultural and/or residential uses.	• The County may lose significant habitat unless control measures are put in place. • Provincial legislation permits a municipality to take only a certain percentage of gross developable land for parks, recreation and schools. The lands that have been identified as "environmentally significant" make up more than the permitted maximum. How do we preserve these lands? Should we continue to try to preserve these lands?
The Hamlets • Antler Lake saw its population decrease by 49 people between 2000 and 2003. • Of the 8 hamlets, Ardrossan, Josephburg and Hastings Lake had the largest population increases. (Source: Strathcona County Census 2003)	• Should future hamlet growth be focussed on Ardrossan and Josephburg because they have the ability to service more land, therefore support a larger population? • Should rural hamlets function more like small towns with more diverse range of land uses i.e. commercial, industrial, and recreational?

Table 5. Challenges facing the environment in Strathcona County. Source: Strathcona County "Facts, Trends, Issues" handout (www.strathcona.ab.ca).

Trends	Issues
Wetlands • Wetlands continue to be lost each year to urban development, rural development and agriculture. • Due to encroachments from agriculture and transportation corridors, our natural creek systems are being degraded.	• How can Strathcona County ensure that wetlands are protected? • How can Strathcona County ensure that creeks are protected?
Conservation easements • As more landowners decide to conserve wildlife habitat over the long term, the need for Environmental Protection Agreements increases.	• How can Strathcona County effectively manage the high number of Conservation Easements registered within the County?
Municipal reserve (Rural) • Municipal Reserve in the rural area is not developed, rather the lands are dedicated to conserve wildlife habitat.	• How can Strathcona County effectively manage the Municipal Reserve parcels in the best interest of the public and the environment?
Biological diversity • The number of rare and endangered species of plants and animals is on the increase. • Increasing development in the rural area, typically resulting in loss of habitat, decreases the diversity of wildlife in Strathcona County.	• How can Strathcona County protect biodiversity when development pressures are increasing?
Biological diversity • The ecological significance of the Cooking Lake Moraine has resulted in a regional partnership (Beaver Hills Initiative) with surrounding municipalities and the National Park. The intent of the partnership is to coordinate land uses to conserve natural resources and quality of life.	• How can Strathcona County incorporate the outcome of the regional partnership in long term planning?
Urban tree retention • As remnant urban tree stands become smaller, hazards increase and habitat values decrease.	• Should Strathcona County continue to include in their annual budget, maintenance funds to address hazards and protect wildlife habitat in remnant tree stands?
Rural tree retention • Municipal Reserve dedication is used to protect forests from residential development.	• How can Strathcona County protect more forested areas from residential development?
Sustainable development • As energy exploration, agriculture, residential development and recreational uses compete for the landscape, the natural environment is lost.	• How can Strathcona County balance economic, environment and social aspects to maintain quality of life?

Looking ahead: Potential land use trends in Strathcona County

The ALCES model

Potential land use trends in Strathcona County were projected for this study using ALCES (A Landscape Cumulative Effects Simulator; www.foremtech.com), a simulation model initialized with a set of rules defining the rates at which the area of each landscape or land use class, including the length of each linear feature, may change in the future. Since the total area of the study area remains constant throughout a simulation, an increase in the area of one cover class requires an equivalent decrease in the area of one or more other cover classes. Land uses may expand into other cover types in proportion to their area within the study area, or they may be directed to expand into a subset of cover types according to defined proportions.

The model thus tracks potential changes in the composition of the study area and calculates associated outputs. The model also simulates reclamation by defining the rates at which industrial disturbances recover and are reclaimed to natural vegetation or other cover (e.g., seismic lines, well sites).

When reviewing simulation model results, it is appropriate to focus on the relative direction of projected trends, not precise numbers at any future year in the simulation interval. The simulations are intended to provide strategic-level insights, and are not expected to be highly

accurate in a given year or in a given place. A more detailed description of the ALCES simulation model is available at http://www.foremtech.com.

Simulations in this study were run for a 50-year period. There is no "correct" simulation period, but the strategic level at which ALCES operates make very short intervals (e.g., less than 10 years) impractical. Periods of 20, 50, 100, and 200 years have been used in previous regional assessments. A 50 year period represents two full generations of County inhabitants and is an appropriate amount of time to discuss issues dealing with strategic level planning.

It is important to understand that ALCES does not use a spatially explicit modeling approach. The model neither receives maps directly from a GIS as input, nor does it produce maps directly as output. (It is possible, however, to generate maps that illustrate certain model outputs.) ALCES uses a spatially stratified modeling approach, in which changes over time in the area, length, and numerous other metrics associated with distinct categories of landscape and land use classes are calculated and reported in the form of tables and charts.

Scenarios

A scenario is a set of statements describing how conditions could change in the future (Peterson et al. 2003). They may range from highly probable to completely hypothetical, depending on their intended purpose. Purposes may range from the accurate prediction of future conditions for detailed land use planning to a hypothetical 'what-if' exercise intended to explore the system, learn more about the major issues, and discover surprises. The ALCES modeling approach applied in this assessment is more suited to scenarios that have the latter ('what-if') purpose (Hudson 2002).

In the context of this initial assessment, scenarios have been defined in terms of the growth rates of major land use sectors and human population. They could also be defined to include statements about incentives or regulatory constraints that could affect the intensity of development, management practices, and where development could occur. They could also include statements about additional factors that could influence future conditions such as climate change, water supply, and development outside the study area.

Back-casting

An understanding of historical trends is a useful complement to analyses of potential future scenarios (Figure 11). Ideally, historical information would be available for each indicator used to evaluate the modeled outcome of a scenario. However, the availability, accuracy, and timeframe associated with historical information may vary widely. For the purpose of this assessment, changes from pre-settlement conditions in many indicators were simulated by gradually adding land use footprints such that by the end of the simulation, the study area had the same characteristics as today. In some cases the historical growth rate is based on the provincial average as estimated by Stelfox (unpubl. data) and may not match actual trends in Strathcona County.

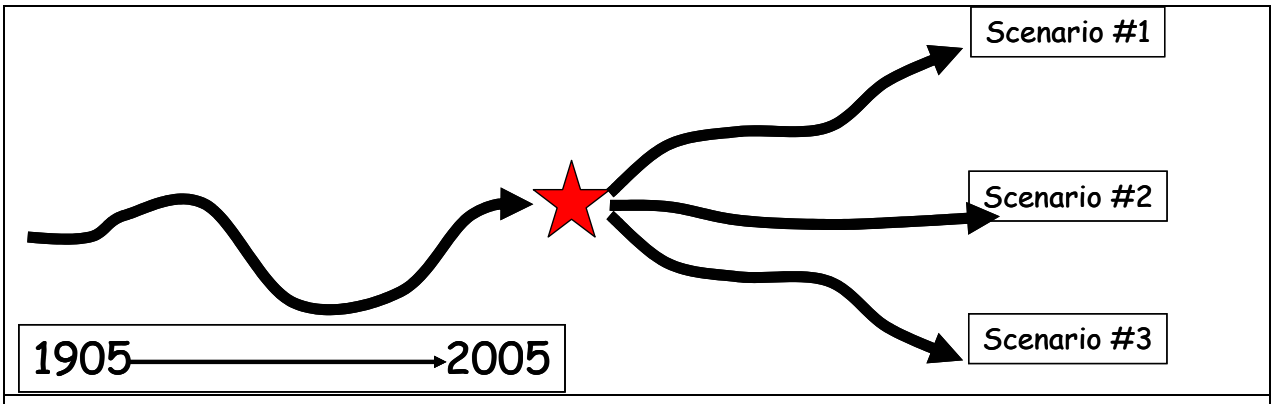


Figure 11. Illustration of backcasting of historical trends and forecasting of alternative scenarios.

Base Case scenario

In the Base Case scenario, each of the land use sectors was given a growth trajectory that is believed to be "reasonable" given current knowledge of the sector. "Reasonable" means as likely or more likely to occur than an alternative scenario. The Base Case scenario could be expected to unfold if the factors currently influencing land use in the area continue to behave as they do today, or "business as usual".

The Base Case scenario for this assessment specifies that the land uses that have historically expanded their footprint in the County will continue to do so for the next several decades. The rate of expansion has been set to 2% per year for the following land uses: urban, country residential, industrial, oil and gas (Table 6). The transportation network was set to grow at 1% per year, based on the assumption that the County road grid has been completed, and new roads (to wellsites and acreages) to be built will occur at a rate lower than what has been observed in the past 3-4 decades. These are relatively "blunt" scenarios in that the growth rate of several land use sectors is equal; additional scenarios could specify unique growth rates for each sector.

Land uses were directed to expand into agricultural lands and natural habitat in proportion to the area of agricultural lands and natural habitat in the County at any given year of the simulation. For example, if 100 hectares of country residences are built in the County during a given year, and if 60% of the available land is agricultural and 40% is natural habitat in that year, then country residences would replace 60 hectares of agricultural land and 40 hectares of natural habitat. This rule set could be changed in a further simulation exercise.

Table 6. Growth rate for each land use sector in the Base Case scenario.

Land use	Growth rate (%)	Limit to growth?
Country Residential	2 % per year	Yes (14,189 ha)
Rural Residential	2 % per year	Yes (28,764 ha)
Urban	2 % per year	Yes (6,736 ha)
Industrial	2 % per year	Yes (11,752 ha)
Utilities	2 % per year	No
Recreation	2 % per year	No
Conservation, Parks	2 % per year	No
Agricultural lands	None	No

Alternative scenarios

Modified rates of growth in multiple land use sectors

In these scenarios, each land use sector that grows under the Base Case scenario is specified to grow faster or slower: 1% per year or 3% per year, compared to 2% per year in the Base Case scenario.

Examples of factors that could influence the growth rates of land use sectors include:

- The economic environment (e.g., supply and demand) at local, provincial, national and international scales.
- Changes in tax structure, economic instruments, regulatory incentives or constraints.
- The availability of services such as water, sewer, transportation and utilities.

Decline in vehicle usage

Traffic congestion, vehicle emissions and safety concerns are all expected to increase with the growing population of Strathcona County. This scenario explores the question: "What if the number of people and the required transportation network continue to grow, but vehicle usage rates were reduced?" Factors responsible for a reduction in vehicle usage rates (expressed in kilometers driven per vehicle per year) could include:

- Increase in the number of people per vehicle, e.g., increased car pooling.
- Shifts from use of private vehicles for commuting to transit.
- Decrease in the use of vehicles, e.g., due to increased fuel cost.
- Increased in amount of telecommuting (home-based businesses)

In the Base Case, vehicle usage rates remain unchanged throughout the simulation period. Vehicle counts from a 2001 study (Stantec Consulting 2001) (36,290 vehicles/ day on highways, 500 vehicles/ day on County roads) were used to derive estimates of the distance driven by all vehicles each year, assuming traffic counts per km of road remain constant. In the alternative scenario, vehicle usage rates decline by 1% each year to 50% of current rates by the year 2055. Both scenarios assume that the transportation network (highways and county roads) grows at 1% per year, and that the average trip distance covers 25% of the transportation network.

Indicators

Evaluating a scenario in the context of sustainability requires a means by which the forecasted results can be quantified and understood (Bell and Morse 1999). While a wide range of environmental, economic, and social conditions can potentially be estimated, practical considerations require the identification of a limited suite of indicators. The indicators used in this assessment are an initial set of indicators that are thought to be of interest to municipal planners and stakeholders, and that are relatively straightforward to calculate and interpret. The variables relate mainly to the area of various landscape types and land use footprints. Additional indicators can be derived to reveal associated trends in other environmental conditions such as water demand, water quality, nutrient and sediment runoff, air quality, greenhouse gas emissions,

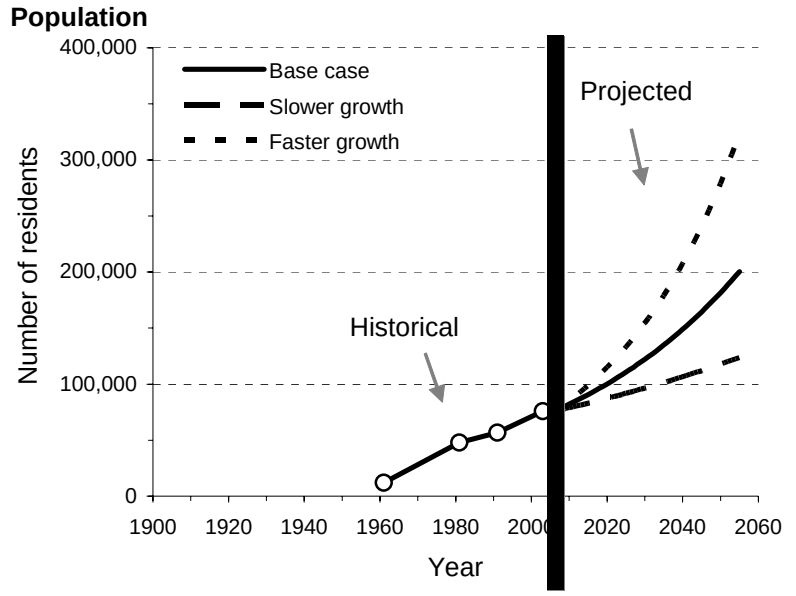
and wildlife habitat. The inclusion of any indicator in an assessment is contingent upon the availability of information needed to initialize the simulation model.

The indicators in this assessment are:

- Human population
- Area of each landscape type and land use footprint type
- Vehicle mileage

Simulation results

1. Modified rates of growth in multiple land use sectors



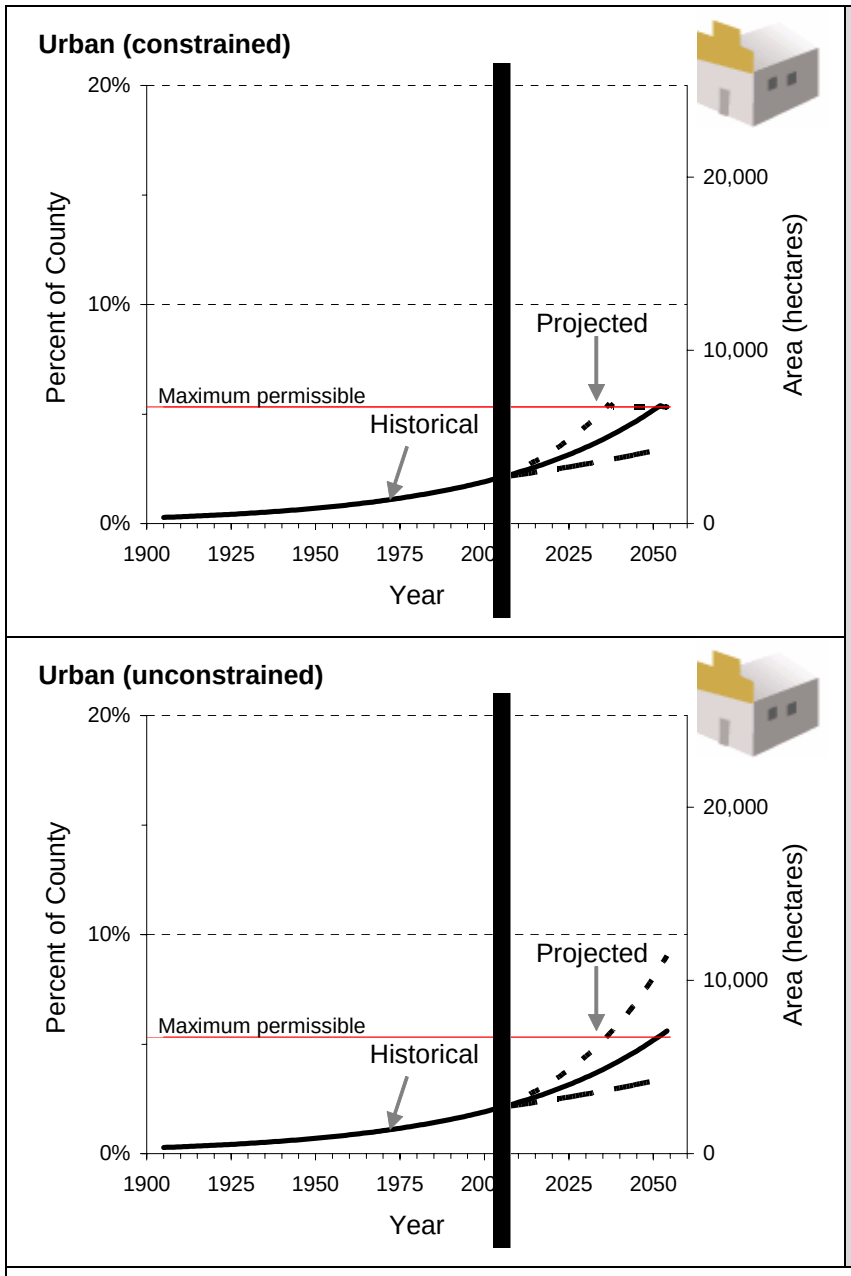
Key points

The number of County residents has increased steadily over the past several decades. Today there are approximately 80,000 people living in the County. Over two-thirds live in Sherwood Park, one-quarter live in country residences, and about six percent on farms or large acreages.

If the population grows at 2% per year, it would almost triple to 200,000 people within 50 years.

Increased population means greater pressure on municipal services and intensification of potential conflicts between residents and land use sectors such as agriculture and oil and gas.

Figure 12. Historical and potential future trends in the population of Strathcona County. Historical trends are from the Strathcona County Municipal Census Report (2003). Projected scenarios are as follows:
Base Case = 2% population growth per year
Slower growth = 1% population growth per year
Faster growth = 3% population growth per year



Key points

The urban footprint has grown to 2% of the County area.

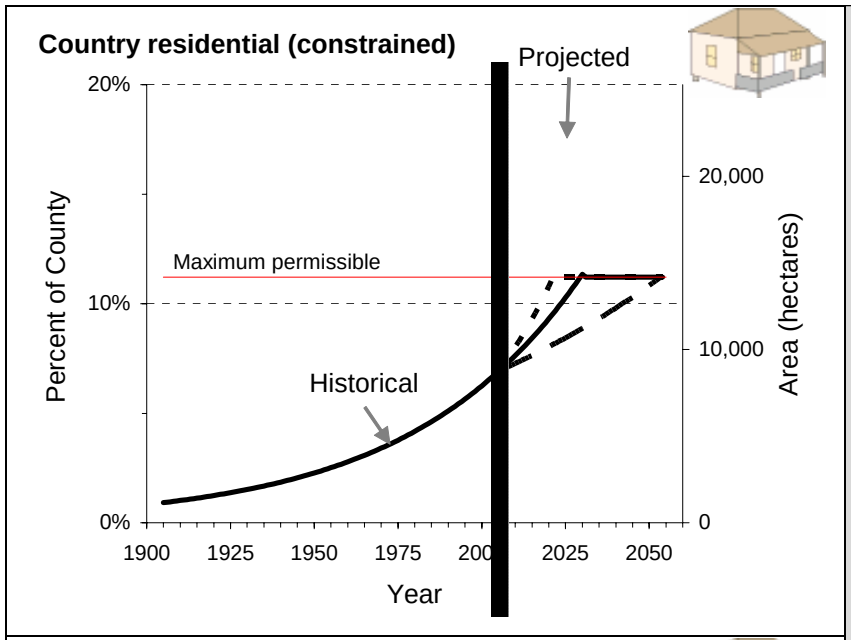
Today there are over 2,700 hectares of urban land in the County.

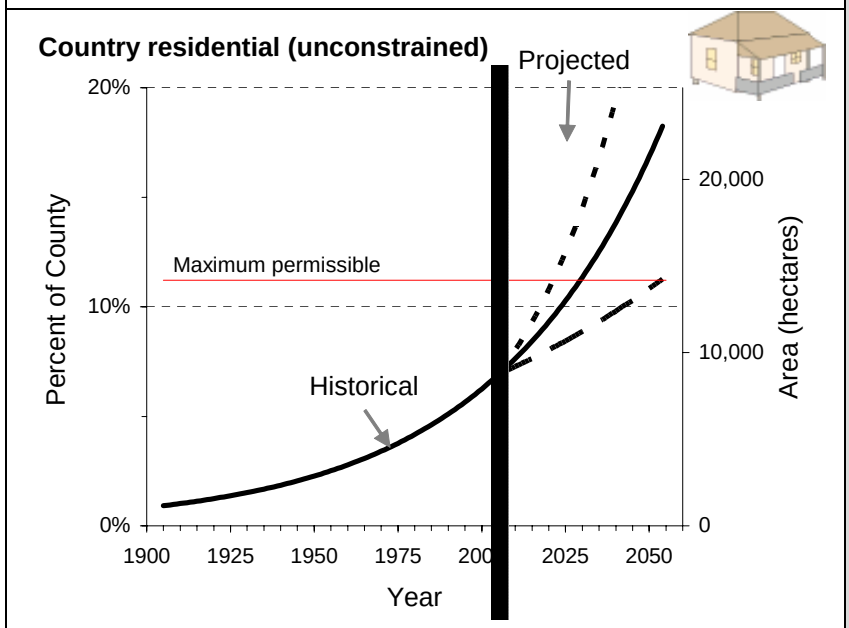
If the area of urban land grows at 2% per year, it would reach the 7,000 hectare limit imposed by current MDP policy designations within 50 years. At 3% growth per year, this limit would be reached in 25 years.

Growth of urban areas in Strathcona County occurs at the expense of agricultural lands and natural habitat. It also intensifies the potential conflicts between residents and the oil and gas sector around the perimeter of the urban area of Sherwood Park.

Because of its high population density relative to other land uses, urban growth places heavy demands on transportation infrastructure and other services.

Figure 13. Historical and potential future trends in the urban footprint in Strathcona County. Projected scenarios are as follows:
<u>Base Case</u> = 2% growth per year in the area of the urban, country residential, industrial, and oil and gas land use sectors, 1% growth of the transportation sector, and no growth in the area of the agriculture sector
<u>Slower growth</u> = 50% slower growth in all land use sectors (compared to the Base Case)
<u>Faster growth</u> = 50% faster growth in all land use sectors (compared to the Base Case)





Key points

The area of this land use has grown to 7% of the County area.

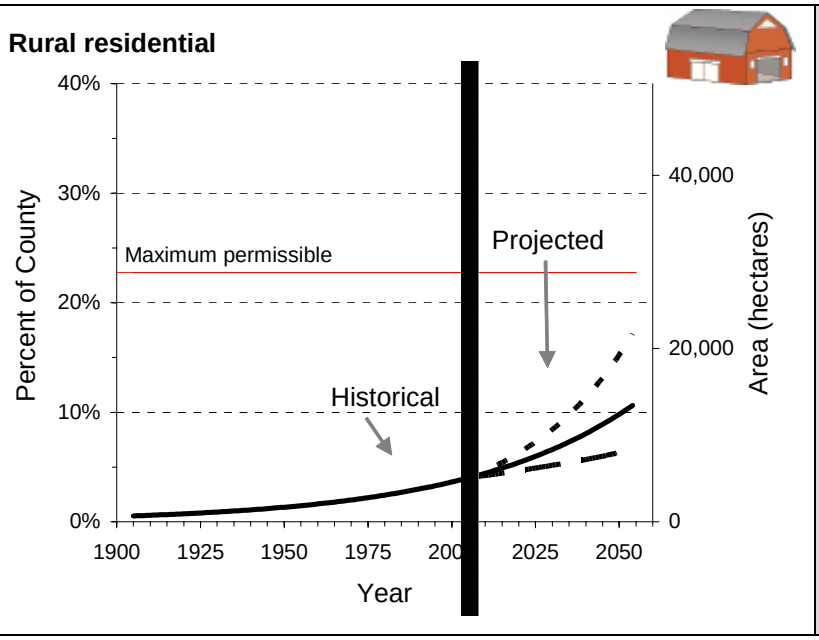
Today almost 9,000 hectares have been developed for Country Residential purposes.

If Country Residential developments grow at 2% per year, they would occupy 14,000 hectares within 20 years. This is the maximum permissible area of this land use under the current MDP policy designation.

If growth of this land use was unconstrained by MDP policy designations, it would occupy almost 20% of the County (24,000 hectares) within 50 years.

Expansion of Country Residential developments occurs at the expense of agricultural lands and natural habitat. It would also intensify existing land use conflicts between residents and the oil and gas sector around country residential developments. It would also accelerate groundwater withdrawals, potentially leading to water shortages and wastewater disposal problems. (This issue is currently being addressed by requiring new Country Residential developments to hook-up to municipal water and sewer systems).

Figure 14. Historical and potential future trends in the Country Residential footprint in Strathcona County. Projected scenarios are as in Figure 13.



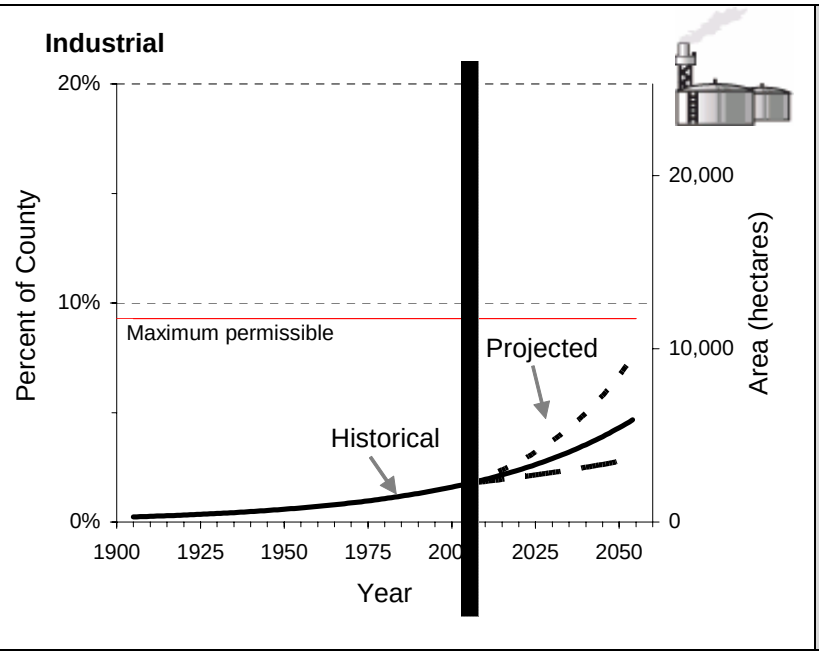
Key points

The area of the Rural Residential land use has grown to 4% (5,000 hectares) of the County.

If this land use grows at 2% per year, it would occupy almost 14,000 hectares within 50 years.

Because Rural Residential properties are large, this land use makes a relatively minor contribution to the housing stock of the County. However, by maintaining agricultural land uses, it contributes to the rural character of the County.

Figure 15. Historical and potential future trends in the Rural Residential footprint in Strathcona County. Projected scenarios are as in Figure 13.



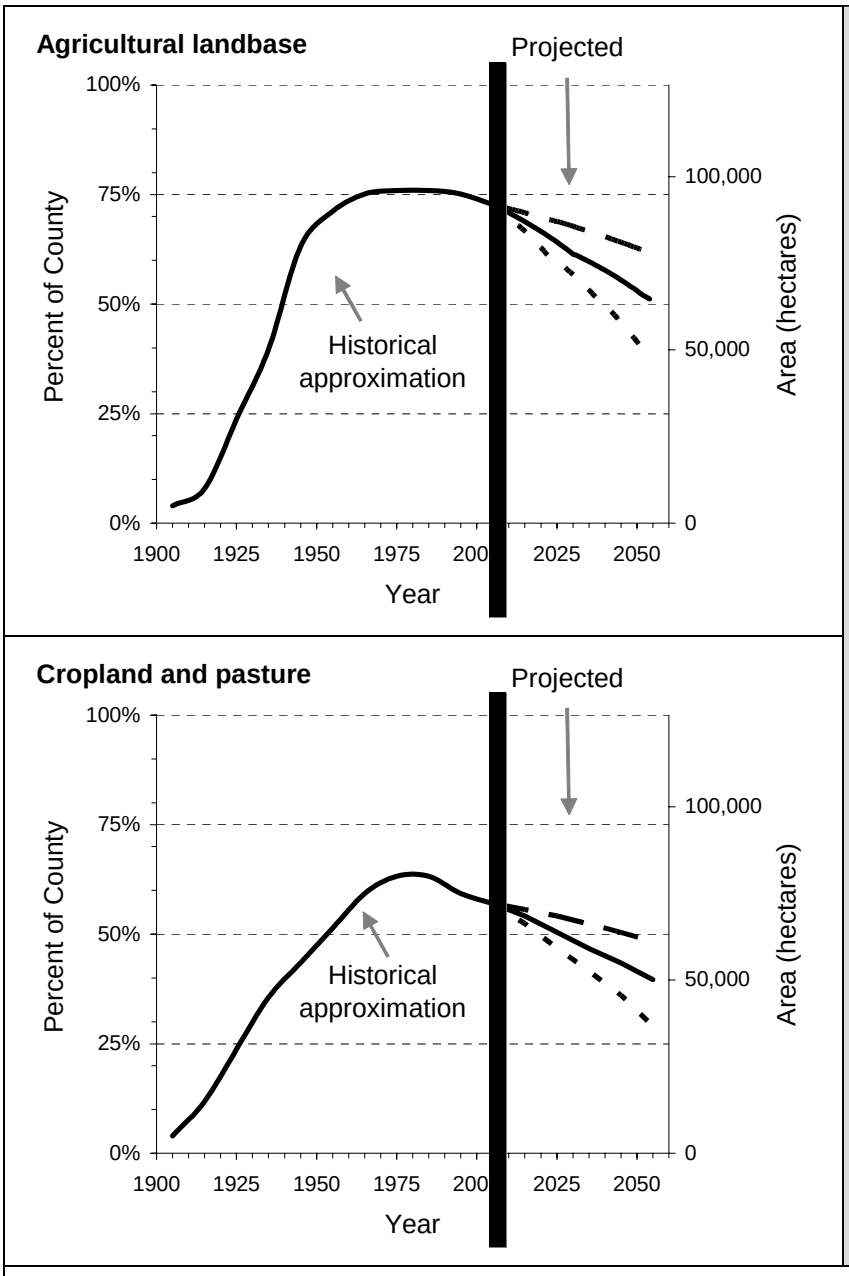
Key points

The area of industrial land has grown to 2% of the County area, approximately 2,200 hectares.

If the area of industrial land grows at 2% per year, it would almost triple to almost 6,000 hectares within 50 years.

Further increases in industrial lands would occur mostly within forested areas in the north of the County. A larger industrial infrastructure would increase pressure on water supply and wastewater treatment systems, and may exacerbate existing concerns over air quality in some parts of the County.

Figure 16. Historical and potential future trends in the industrial footprint in Strathcona County. Projected scenarios are as in Figure 13.



Key points

Historical growth in the agricultural land base has slowed considerably over the last few decades. In all likelihood, agricultural lands are likely declining as their landbase is consumed by acreages, urban sprawl, and roads.

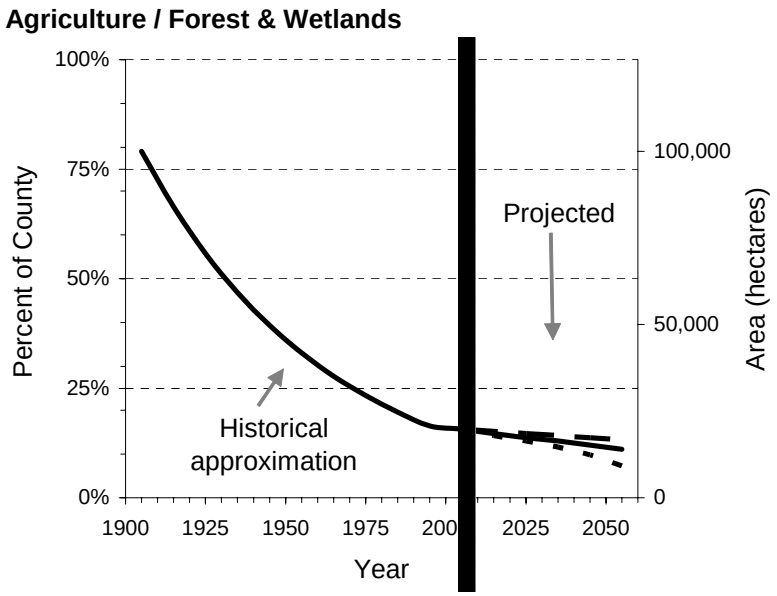
Today, the agricultural land base covers 70% of the County, around 92,000 hectares.

Of this area, 72,000 hectares are estimated to be under some form of agricultural production (cropland and pasture), with the remaining 20,000 hectares covered by forest and wetlands).

Continued expansion of urban areas, country and rural residences, and the industrial sector would erode the agricultural land base even further.

Reversal of this trend would require that one or more land use sectors be reclaimed to agriculture. Alternatively, additional natural habitat could be converted to agriculture (although natural habitats suitable for conversion to agriculture would be scarce).

Figure 17. Historical and potential future trends in the area of lands used for agriculture in Strathcona County. Historical trend is based on provincial trends estimated by Stelfox (unpubl. data) and may not match actual trends in Strathcona County. Projected scenarios are as in Figure 13.



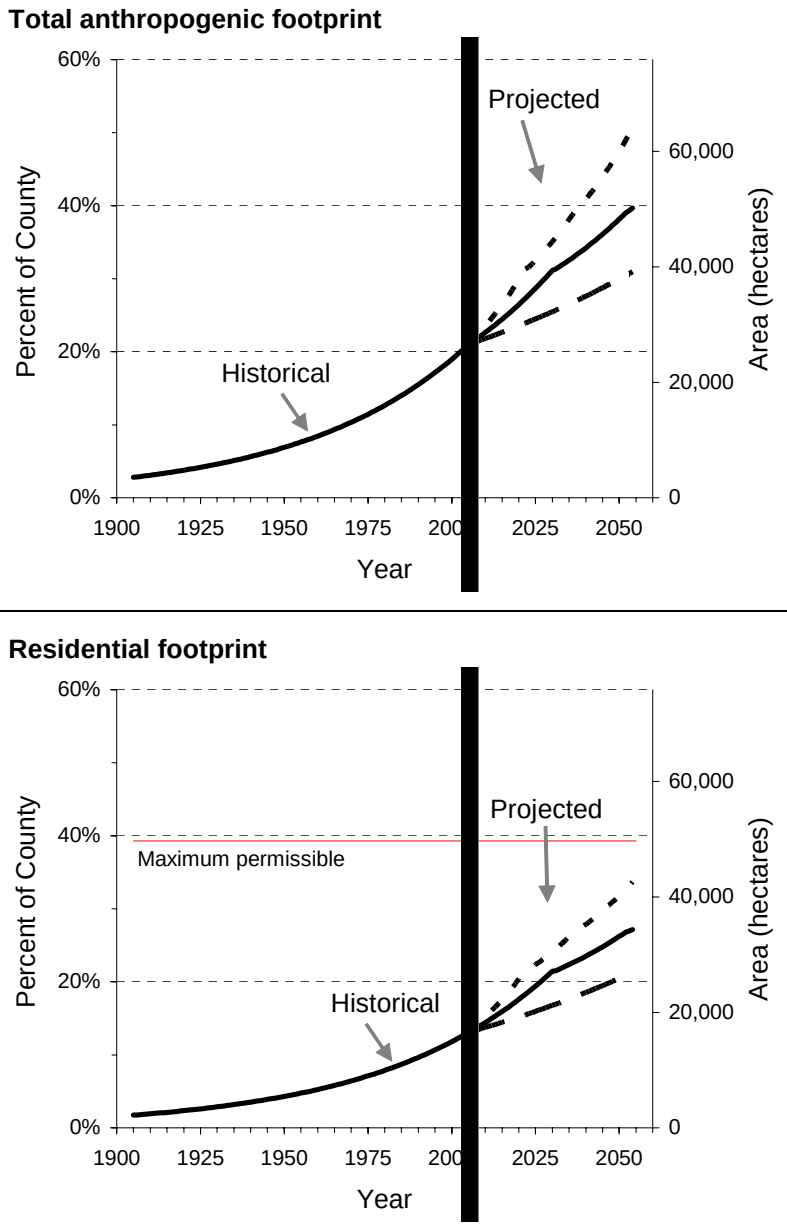
Key points

Historically, most of the loss in natural habitat in Strathcona County has been due primarily to the expansion of agriculture and secondly to other land uses.

Today, there is relatively little natural habitat left in the County. It occupies approximately 15%, or 20,000 hectares of the agricultural land base within the County. (This does not include additional natural habitat in protected areas and intact habitats in subdivisions)

In the future, continued expansion of residential development and industrial land use would further fragment and reduce natural habitat area.

Figure 18. Historical and potential future trends in forest and wetland habitats on the agricultural land base of Strathcona County. Historical declines are based on the provincial average growth of agriculture and other land uses estimated by Stelfox (unpubl. data) and may not match actual trends in Strathcona County. Projected scenarios are as in Figure 13.



Key points

The combined area occupied by anthropogenic (man-made) developments has grown to 21% of the County, or 27,000 hectares.

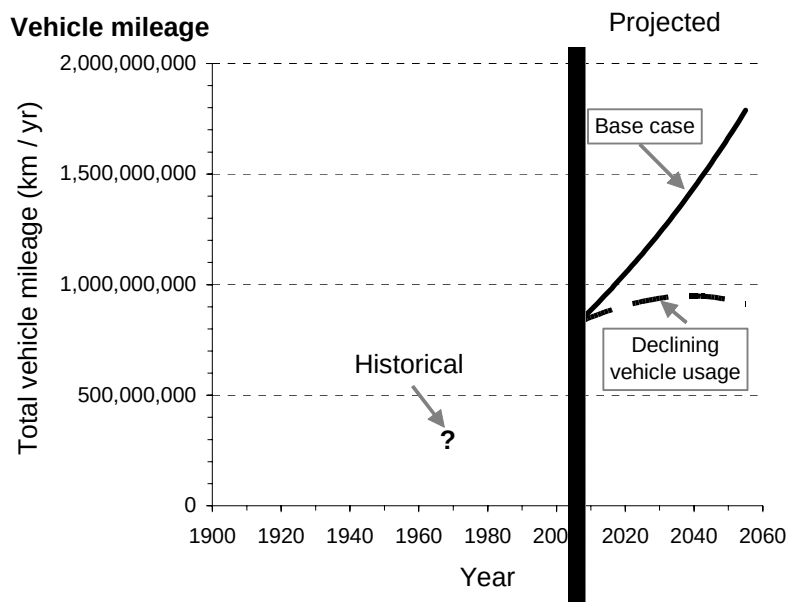
If all land use sectors were to grow by 2% per year for the next several decades (or until they reach the maximum permissible area as defined by current MDP policy designation boundaries), the anthropogenic footprint would almost double to 50,000 hectares by the year 2055. If growth were unconstrained by zoning, non-agricultural land use would cover an even larger area.

Residential developments (urban country residential and rural residential) have the greatest contribution to the anthropogenic footprint.

Figure 19. Historical and potential future trends in the total anthropogenic footprint (top) and the residential footprint only (bottom) in Strathcona County. Projected scenarios are as in Figure 13.

2. Decline in vehicle usage

The total mileage driven by all vehicles in Strathcona County is expected to increase along with the expanding population (Figure 20). Vehicle usage rates (km/ vehicle/ year) could be reduced through strategies such as increased car pooling, greater transit use, or by people simply driving less. If vehicle usage rates declined by 1% per year over the next 50 years (i.e., to 50% of current rates by the year 2055), the total mileage driven by all vehicles in the County would also decline (Figure 20). This trend would occur in spite of a growing population and transportation network.



Key points

The total mileage driven by all vehicles in Strathcona County is expected to increase along with the expanding population.
Vehicle usage rates (km/ vehicle/ year) could be reduced through various strategies.

If vehicle usage rates declined by 1% per year over the next 50 years, the total mileage driven by all vehicles in the County would also decline. This trend would occur in spite of a growing population.

Figure 20. Projections of the total mileage driven by all vehicles in Strathcona County under alternative vehicle usage patterns. Historical trends are unavailable. Projected scenarios are as follows:
Base Case = Current vehicle usage rates remain unchanged.
Declining vehicle usage = Vehicle usage rates decline by 1% each year.

Next steps

As outlined in the project terms of reference (Stelfox and Farr 2005), this report describes an initial landscape and land use assessment and modeling exercise for Strathcona County. It is anticipated that further modeling to explore additional and more detailed scenarios may proceed pending review of this project. The following scenarios and indicators are suggested as next steps due to their potential importance to County planners and their suitability for analysis using the ALCES model initialized for this project. The inclusion of any indicator in the assessment is contingent upon the availability of information needed to initialize the simulation model.

- Comparison of performance of social, economic, and ecological indicators under a scenario where explicit protection of the Beaver Hills portion of the County becomes a priority.
- Benefits and costs of alternative septic treatment technologies that could be adopted by rural County residents. Relevant indicators include volumes of effluent released into surface and subsurface water, and related water quality measures.
- Effects of alternative growth rates and spatial arrangement of linear features (e.g., pipelines, transmission lines, seismic lines, roads, including driveways) on invasive plants (e.g., Forman and Alexander 1998), on the quality of habitat for selected wildlife species (e.g., Fleming 2001, Marklevitz 2003), and on biodiversity in general (e.g., Trombulak and Frissell 2000, Federal-Provincial-Territorial Biodiversity Working Group 2003).
- Effects of alternative land use trends on levels of biotic carbon in the County as a means of estimating County contributions to the carbon budget and greenhouse gases.
- Vehicle emissions resulting from alternative population growth rates and alternative transportation strategies.
- Potential landscape conversions associated with various climate change scenarios.
- Potential impacts of the expansion of the city of Edmonton east into Strathcona County.
- Detailed exploration of the social, economic and environmental consequences of different (smart growth) scenarios, including cost of infrastructure development, maintenance and reclamation. This could include the development of a comprehensive set of indicators of sustainability for Strathcona County (e.g., Bell and Morse 1999, NRTEE 2003).
- Other scenarios and indicators as requested by municipal planners and stakeholders.

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Appendix 1. The role of historical land use information

As discussed in the main body of this report, the Base Case scenario consists of growth trajectories that are believed to be reasonable for several land use sectors. Historical information for land use sectors and their associated footprints are a potentially useful source of information to evaluate the "reasonableness" of such a scenario. Summaries of historical information can also help stakeholders better understand issues that are important to an assessment of competing land uses and cumulative effects. The following is a partial list of potentially useful historical information for several land uses in Strathcona County. Note that not all of this information would be required to initialize and run the ALCES model. While much of it could be useful in that regard, it would be also useful in its own right to help stakeholders understand issues.

Agricultural

- Trends in the area cleared for agriculture over time
- Livestock populations over time
- Production of agricultural products over time
- Other agricultural trends

Residential (Hamlet / town / city, agricultural residence, country residential)

- Historical changes in the area of settlements and the number of residences, by category
- Historical population trends
- e.g., census results, including Strathcona County 2003 Municipal Census Report
- Trends in water use and sewage

Oil and gas (Well site, pipeline, seismic line)

- Historical trends in the area, length, and number of oil and gas footprints (e.g., well sites, pipelines, seismic lines)
- Historical production information, including information on the locations and size of known reserves (pools)

Other industrial (Industrial land)

- Trends in the area of lands directly and indirectly impacted by industrial development
- Economic trends such as production, taxation, employment

Transportation (Major road, minor road)

- Growth of the transportation network over time
- Trends in vehicle traffic and related issues such as collisions

Appendix 2. ALCES inputs

The ALCES model has the capacity to receive several hundred input values related to a range of landscapes, footprints, land use sectors, and indicators. It is important at the start of a modeling and assessment project to identify the initial subset of inputs needed to run the model and calculate the required indicators. Our experience suggests that during the early stage it is best to be conservative, and identify the minimum number of inputs required to simulate a relatively simple scenario and calculate a relatively small number of indicators. As a project progresses and users become more familiar with the model's capabilities and input requirements, the list of inputs may grow.

It is important to understand that inputs related to initial conditions are relatively "hard" numbers, in that levels of uncertainty over accuracy and confidence are generally known or can be estimated. Other inputs, particularly those related to future conditions, are "soft". These soft variables usually represent the majority of simulation model inputs. Because model variables related to future conditions describe events that have not yet occurred, it is not possible to estimate, in advance, levels of accuracy.

Inputs relating to future conditions in a Base Case scenario tend to require more effort to obtain than those needed for other scenarios, because they are generally intended to represent "reasonable" predictions of future events (based on current knowledge). Inputs needed to simulate alternative scenarios generally require less effort because they are generally modifications of the Base Case scenario. Alternative scenarios are often intended to help project participants understand the sensitivity of one or more indicators to a land use activity or natural process, or to help them develop options to mitigate undesirable outcomes.

The ALCES model is organized into modules (also called panels), which contain input devices (tables, graphs, switches), model output (tables, charts), and supporting information (text, illustrations, photographs). Table A1 lists the modules that receive input information, and indicates which ones would require inputs given the preliminary scope for this project outlined earlier in this document. Indicators that would require inputs from each module are also identified.

Exclusion of a module from this initial list is not intended to mean that the issue represented by the module is unimportant. Rather, it means that initializing and running the ALCES model to forecast the suggested scenarios and indicators would not require inputs contained in that module. Provided the necessary input information is available, the list of initialized modules could expand to allow simulations involving additional indicators and scenarios.

Table A1. List of input modules in the ALCES model. Modules containing one or more inputs considered to be necessary for this project are identified with an asterisk (*****). Indicators that would require inputs from the corresponding module are identified with a check mark (√).

			Indicator			
Module (=Panel)		Inputs required for this project?	Area of each landscape type	Area of each land use footprint type	Length of linear footprints	Human population
4	Initializing the land base	*	√	√	√	
5	Meteorology, aquatics and industrial use of water					
5.2	Future climate change scenarios					
5.3	River inputs from surface runoff and glacial meltwater					
5.4	Water crossings, sediment, and hanging culverts					
6	Natural disturbance regimes					
7	Plant community and carbon structure and dynamics					
7.2	Rangeland community structure and dynamics					
8.1.2	Forest harvest goals and constraints					
8.2	Energy and mining sector	*	√	√	√	
8.2.1	Future trajectory of well drilling and surface mines	*	√	√	√	
8.2.2	Seismic line trajectories	*	√	√	√	
8.2.3	Wellsite and wellsite access road information	*	√	√	√	
8.2.4	Information on pipelines and surface mines	*	√	√	√	
8.2.5	New discoveries of hydrocarbon and mine reserves					
8.3	Agricultural and livestock sector					
8.3.1	User-defined agricultural temporal trends					
8.4	Transportation sector	*			√	
8.4.2	User-defined transportation and utilities temporal trends	*			√	
8.5	Human populations and settlements	*	√	√		√
8.8	Protected areas					
8.10	Tourism, recreation, hunting and fishing					
8.11	Spatial origin and reclamation of land use footprints	*	√	√	√	

Table A1. List of input modules in the ALCES model. Modules containing one or more inputs considered to be necessary for this project are identified with an asterisk (*****). Indicators that would require inputs from the corresponding module are identified with a check mark (√).

			Indicator			
Module (=Panel)		Inputs required for this project?	Area of each landscape type	Area of each land use footprint type	Length of linear footprints	Human population
8.12	Conversions of landscape types					
8.12.1	Climate change induced landscape type conversions					
8.13	Land use input and output rates and flows					
8.13.1	Temporal changes in land use flow rates					
8.14	Economic and employment metrics					
9.1	Habitat Suitability Index (HSI) for Species 1					
9.1.1	Species 1 response curves for habitat relationships					
9.1.2	Species 1 buffer response					
9.3	Woodland caribou					
9.4	RSF and logistic regression (LR) models					
9.5	Old growth bird community richness					
9.6	Biota sensitive to stream crossings					

Issues that could be addressed by initializing other modules include:

Water quantity and quantity

- This would require initialization of Module 5 “Meteorology, aquatics and industrial use of water” and related modules

Air quality

- Not modeled directly in ALCES, but indirect assessments are possible by establishing assumed relationships between air quality and land use footprints that may affect air quality such as roads (and, indirectly, vehicles) and industrial plants

Tourism and recreation

- This would require initialization of Module 8.10 “Tourism, recreation, hunting and fishing”

Wildlife habitat

- Depending on the habitat or species concerned, this could require more detailed stratification of landscape types, potentially including different forest types and multiple categories of non-forest vegetation
- This would also require initialization of one or more wildlife habitat modules.

Other

- ALCES could potentially support an assessment of additional issues deemed important by project managers and participants, provided the input information needed to initialize the model is available.