Fragmentation and Conversion of Agricultural Land in Alberta

**Land Use Framework Reporting:
Background and Methodology**

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Introduction

The agricultural industry is a key component of Alberta's history, culture, and economy. To be successful, agriculture requires a land base on which to operate, and it often competes with other land uses such as energy development, recreation, or urban growth. These competing developments often result in the **fragmentation** and **conversion** of agricultural land to non-agricultural uses, which in many cases results in a permanent loss of agricultural land.

Reducing the fragmentation and conversion of agricultural land was identified as an area needing additional clarity in provincial policy under Alberta's 2008 Land-use Framework (LUF). Prior to 1996, Alberta Agriculture and Rural Development (ARD) had tracked conversion; however no data has been collected since 1996. With the development of regional plans, Alberta Agriculture and Forestry (AF) has committed to monitoring and reporting on the fragmentation and conversion of agricultural land to non-agricultural uses. This information is intended to provide municipalities with information regarding the loss of agricultural land in their jurisdiction and to assist municipal planners and decision makers in meeting provincial expectations identified in LUF regional plans.

The Government of Alberta has also heard public concerns regarding the conversion of high quality agricultural land to other uses. Of particular concern is the Highway 2 corridor between Edmonton and Calgary, where much of current development occurs on Class 2 land, as defined by the **Land Suitability Rating System (LSRS)**. In response, AF is also monitoring and reporting on the conversion of agricultural land by LSRS class.

While the most direct and accurate method of determining agricultural land use change in Alberta would be through municipal land use data stored within the Assessment Shared Services Environment (ASSET) system maintained by Alberta Municipal Affairs, Alberta's "*milenet* Master Agreement" precludes the sharing of this land use data with AF due to the sensitive nature of the data (e.g., tax assessment data). These data access constraints prevent a completely accurate identification of the actual land use of a given parcel of land in Alberta without some form of ground-truthing or visual review. Therefore it was necessary to establish a method of determining land use change using readily available data. The land titles database from Service Alberta provides parcel size data for all titled parcels in the province, which allows for the evaluation of potential land use based on parcel size and then to assign each titled parcel to a particular land use class based on that size. This necessitated the creation of a rule set to determine the potential land use of a parcel based on its size.

Fragmentation: Occurs when once contiguous agricultural areas become divided into separate fragments isolated from each other by other, non-agricultural land uses. Fragmentation can also occur within a given agricultural parcel of land by access roads, oil and gas developments and/or linear infrastructure.

Conversion: An actual, observable land-use change from an agricultural use to a non-agricultural use (or vice versa), such as residential housing. Conversion can be temporary (e.g., upstream oil and gas development) or permanent (e.g., rural residential development). Conversion may be positive or negative (i.e., a gain or loss of agricultural land, respectively).

Land Suitability Rating System (LSRS): Developed in 1995, the LSRS is a comprehensive approach to integrating and modeling soil, landscape and climate factors. Universally, LSRS 1, 2 and 3 lands are considered suitable for crop production, and LSRS 4 lands are considered marginal for crop production. Alberta does not have any LSRS 1 lands, mainly due to climate factors.

Land Use

This document outlines the methodology being utilized to calculate the fragmentation and conversion of agricultural land in Alberta, which determines the agricultural land area (and the annual change in land area) provincially, by Land-use Framework (LUF) region, by municipality, and by Land Suitability Rating. This document also provides an explanation of the rationale behind choosing this methodology over other options (e.g., remote sensing) being employed by different organizations.

Land Use Classes

For the purposes of the analysis, AF created four general land use classes into which all land in Alberta (other than excluded lands, discussed below) was classified. These classes are:

- **Urban** – any land under the jurisdiction of a city, urban service area, town, village, or summer village.
- **Rural Residential** – any parcel of land that does not qualify as Urban, but is privately owned and has an area of approximately 10 acres (4 hectares) or less.
- **Agricultural** – any parcel of land that does not qualify as Urban, is outside the Green Area and privately owned, and has an area between 10 acres (4 hectares) and 240 acres (97 hectares); or any public land parcel (either within or outside of the Green Area) under an agricultural disposition (e.g., grazing lease).
- **Other** – any parcel of land that doesn't qualify as Urban, Rural Residential, or Agricultural. This includes all non-urban parcels that privately owned (outside the Green Area) and are larger than 240 acres (97 hectares), and all publicly owned parcels (inside the Green Area) provided they are not under an agricultural disposition. This class also includes National Parks, Provincial Parks and protected areas.

Acres vs. Hectares
Since Alberta's grid network and parcel system was created by the Alberta Township System (which utilized acres are the primary unit of measurement), this document and the methodology described within it use acres as the primary unit of measurement for area.

Parcel Size in Alberta:
Most parcels in Alberta (outside of urban boundaries) are 160 acres (i.e., a quarter section) due to the Alberta Township System, which divided the entire province into townships, sections, and quarter sections. However, there are larger agricultural parcels that must be included in the agricultural land use class, which led to an upper limit of 240 acres.

Establishing the Land Use Classes

In order to determine the set of land use categories and their respective rule sets, an analysis of parcel size distribution was completed. This analysis examined all titled parcels outside Alberta's Green Area (outside of urban boundaries) and graphed them based on the number of parcels within a given size class (Figure 1). The graph displayed clear spikes around 10 acres and 160 acres, with a small spike around 80 acres. Further detailed analysis was conducted on a cross-section of rural municipalities across the province; this analysis indicated clear spikes in parcel size distribution at both the 5 acre and 160 acre sizes. This indicated that parcels smaller than 10 acres are common – however these parcels are likely to be rural residential in use, as the 2011 Census of Agriculture indicates that less that 5 percent of the total number of farms in Alberta are smaller than 10 acres in size. Agricultural parcels smaller than 10 acres are commonly used for small-scale farming operations such as sheep, goats, horses or

vegetables (e.g., U-Pick operations) – while these types of operations are important to rural communities and the agricultural industry, the impact of their exclusion from the Agricultural land use class is likely offset by the inclusion of non-agricultural parcels in that class (see discussion in the Potential Sources of Error section). Therefore, the rural residential category has been set to include parcels between 0 and 10 acres.

Figure 1: Frequency of Titled Parcels Outside Alberta's Green Area between 10 and 640 acres (Data: 2011).
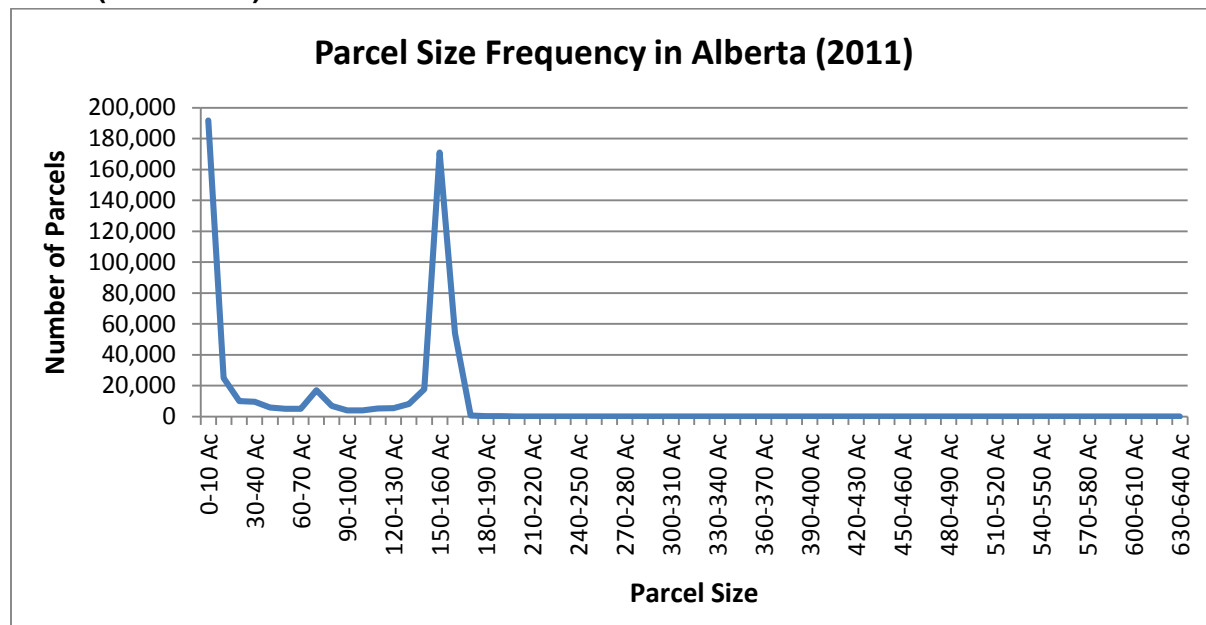
Spikes in the data at both 80 and 160 acres indicate that large parcels that have not been subdivided (i.e., half-quarter and quarter sections) are common throughout rural Alberta, which is likely due to the fact that historically, most properties were initially titled according to the quarter section under the Alberta Township Survey system. While the frequency histogram above indicates that most of Alberta's titled parcels are between 150 and 170 acres (i.e., a 160 acre quarter section), it is likely that there are still a number of parcels over 160 acres that are agricultural in nature. As such, it was determined that the threshold for the agricultural land class should be set at a larger value than 160 acres in order to capture those parcels in the Agricultural category.

To determine the cut-off value, the distribution of the number of properties above and below six different cut-off points was analyzed (Figure 2). A ground-truthing exercise (through the analysis of aerial imagery) established that of the number of titled parcels outside the Green Area that were larger than 640 acres (i.e., 17 parcels), a small number of them are used for agriculture while the remaining parcels are non-agricultural (e.g., reservoirs, airports, etc.). This established that the upper limit of the Agricultural land use class should be less than 640 acres to avoid the inclusion of parcels that are primarily non-agricultural in use.

Figure 2: Options for cut-off values for the Agricultural land use class (Data: 2011).

Cut-off at 160 acres (quarter section)	
Area between 10 and 160 acres	36,479,131 acres (299,665 properties)
Area between 160 and 640 acres	9,095,701 acres (55,902 properties)
Cut-off at 240 acres (1½ quarter sections)	
Area between 10 and 240 acres	45,427,930 acres (355,127 properties) (adds 55,462 properties)
Area between 240 and 640 acres	146,901 acres (440 properties)
Cut-off at 320 acres (2 quarter sections)	
Area between 10 and 320 acres	45,506,841 acres (355,413 properties) (adds 286 properties)
Area between 320 and 640 acres	67,991 acres (154 properties)
Cut-off at 400 acres (2½ quarter sections)	
Area between 10 and 400 acres	45,529,469 acres (355,477 properties) (adds 64 properties)
Area between 400 and 640 acres	45,363 acres (90 properties)
Cut-off at 480 acres (3 quarter sections)	
Area between 10 and 480 acres	45,550,199 acres (355,524 properties) (adds 47 properties)
Area between 480 and 640 acres	24,633 acres (43 properties)
Cut-off at 560 acres (3½ quarter sections)	
Area between 10 and 560 acres	45,560,099 acres (355,543 properties) (adds 19 properties)
Area between 560 and 640 acres	14,732 acres (24 properties)
Cut-off at 640 acres (full section)	
Area between 10 and 640 acres	45,574,832 acres (355,567 properties)

Further analysis of the various options for cut-off points indicated that parcels under 240 acres are typically agricultural, while those over 240 acres in size are typically non-agricultural. In addition, setting the limit at 240 acres (as opposed to 160) added over 55,000 parcels; setting the limit higher than 240 acres would have yielded minor additions, as there are only 440 parcels between 240 and 640 acres. As a result, the agricultural category has been set to include parcels between 10 and 240 acres in size. The analysis established that setting the upper limit of the agricultural category at 240 acres (i.e., a quarter section plus half a quarter section, or the largest single parcel out possible) excluded only 440 parcels with a total area of 146,901 acres. These parcels were generally found to be non-agricultural in use – most are reservoirs, airports, waste facilities, and/or used for other industrial purposes, such as oil sands operations. Therefore, the Other category has been set to include privately owned parcels larger than 240 acres (as well as public parcels not under an agricultural disposition, National Parks, and Provincial Parks and protected areas).

Exclusion of Certain Lands

The methodology excludes certain land uses and classifications based on the assumption that they do not contain notable areas of agricultural land and/or that their land use and/or size are unlikely to change significantly in the future. Excluded land uses/classes are:

- First Nations Reserves;
- Lands owned or managed by the Department of National Defence (DND);
- Permanent hydrography (e.g., lakes, rivers, and reservoirs) large enough to appear with distinct boundary lines (i.e., not a single line for rivers) at a 1:20,000 mapping scale; and
- Road allowances according to the Alberta Township Survey grid.

Although First Nation and DND lands do contain some agricultural land, it accounts for relatively little when compared to the remaining Alberta land base. In addition, as these lands are outside provincial jurisdiction, their presence in the Agricultural category could indicate changes to the agricultural land base that are outside the province's control, which would reduce the usefulness of the data in the future in assessing the need for provincial policy. Therefore these lands were excluded from the analysis.

Road allowances are excluded due to variability in whether or not they appeared in the public land dispositions database for a given year (i.e., road allowances in a given area appeared in the data and on a map in some years but not in others, specifically within the Green Area). For example, when road allowances were included in the Other category, the Lower Athabasca Region saw a large fluctuation in that category from year to year due to the inconsistent nature of the source data. This necessitated the exclusion of road allowances from the calculations.

Method to Calculate Agricultural Land Conversion

Using Geographic Information Systems (GIS), every parcel of land in Alberta is assigned to a land-use class according to the defined rule set. Then the total area of each land use class, in each LUF region, is calculated (Table 1a). Using those totals, the area of each land use class is subtracted from the area in the next year to determine the change in area from year to year (Table 1b).

Part of AF's commitment includes reporting on the total area of agricultural land within each LSRS class on an annual basis. This allows for the calculation of the annual change in agricultural land area for each LSRS class, and indicates the quality of the agricultural land converted to other uses (or converted from other uses to agriculture). This is only done for the Agricultural land use class since the LSRS rating is related to crop production and is not directly applicable to non-agricultural land.

In order to perform the calculation, each parcel of land is assigned an LSRS class based on its dominant class (e.g., if 50% or more of the parcel is LSRS Class 2, the entire parcel is classified as LSRS Class 2). This is used to calculate the total area of agricultural land within each LSRS class for each LUF region (Table 2a), and subsequently calculate the annual change of agricultural land within each class (Table 2b).

Method to Calculate Agricultural Land Fragmentation

The methodology employed for fragmentation utilizes only land classified as Agricultural by the conversion methodology. These parcels are then sorted into discrete categories based on their size:

- Greater than 240 acres
- 160-240 acres
- 80-160 acres
- 60-80 acres
- 40-60 acres
- 20-40 acres
- Less than 20 acres

The number of parcels in a given class provides an indication of the level of fragmentation with respect to subdivisions (Table 3a). Using this data, the annual change in the number of parcels in each category is calculated (Table 3b). If the number of larger parcels (e.g., 80-160 acres, 160-240 acres, greater than 240 acres) declines and the number of smaller parcels (e.g., parcels smaller than 80 acres) increases, the landscape is said to be increasingly fragmented (by smaller properties) due to the creation of additional properties and/or fence lines. The likelihood of a parcel being used for extensive agricultural purposes, such as the production of grain and oil seeds or cattle grazing, tends to decrease as parcel size decreases; particularly as the parcel size approaches the 10 acre rural residential cut-off value. While smaller operations are important to rural communities and the agricultural industry, the fragmentation of larger parcels into smaller parcels typically indicates a shift towards the conversion of those parcels into non-agricultural uses.

Potential Sources of Error

The Green Area boundary has not been substantively updated since 1999 (minor updates were done in 2012) – this means that generally, any land in the Green Area that has become privately owned/titled as a result of a public land sale since 1999 is not considered as being added to the agricultural land base. This is because the current methodology excludes all land (including new agricultural land) within the Green Area boundary with the exceptions of public land under an agricultural disposition. In practice, if an individual has a grazing lease on public land within the Green Area and then proceeds to buy the land from the province, this newly acquired private land becomes masked from the analysis since it is no longer publicly owned land under disposition but is still within the dated Green Area boundary (as per the 1999 boundary).

In addition, any public land in the Green Area that is in the process of being sold to a private owner may be classified into the Agricultural land use class for unknown technical reasons. For example, public land recently sold to expand the Fort McMurray airport is classified as agricultural by the analysis.

Similarly, any agricultural land within urban boundaries resulting from annexed land that has yet to be developed is not captured in the analysis, thus leading to under-estimations of total

agricultural land; however, agricultural land within urban boundaries is generally considered to represent a relatively small percentage of the total agricultural land in Alberta.

The Agricultural land use classification may include cultivated agriculture, grazing/pasture lands, private forests and woodlots, wetlands on private land, golf courses and other private recreation facilities, and areas set aside as private conservation trusts – these latter uses are not generally agricultural in nature. This may impact the results, however it is anticipated that this will be offset by agricultural parcels included in the Other category.

The Other category tends to fluctuate, likely due to the occurrence of sliver polygons within the dataset that are added and deleted year over year. Sliver polygons are an artifact in the analysis resulting from the Geographic Information System (GIS) overlay process when boundaries which should be coincidental are, in fact, slightly offset. This is related to the precision at which the data is captured and reported in the base data sets.

While the nature of the methodology allows for the possible classification of agricultural land into the other categories (and vice versa), it is anticipated that any such misclassifications will be balanced by similar misclassification within the other categories. For instance, there are some rural residential properties and industrial properties that fall within the limits of the Agricultural land use class (10 to 240 acres). The same may be said for agricultural lands falling within the Rural Residential and Other land use classes; there may be some properties (e.g., ranch land in southern Alberta on parcels over 240 acres) that fall within those categories but are actually agricultural in nature. These are known sources of potential error in the analysis that cannot easily be corrected without significant ground-truthing of all provincial data.

With respect to assigning LSRS classes to parcels, each parcel was assigned a class based on the dominant (i.e., 50% or greater) LSRS class of that parcel. This may lead to an exaggeration or underestimation of the quantity of land for a given LSRS class.

The overall validity of the methodology can be verified by comparing the calculated data with established values – the 2006 Census of Agriculture (and many others preceding it) indicates that Alberta regularly reports approximately 52 million acres (21 million hectares) of agricultural land (as total farm area), which coincides with the values provided in this report. In addition, the change in the Urban land use class generally aligns with reported annexations, which provides further verification of the methodology. In total, the methodology classifies approximately 162 million acres (65.6 million hectares) of land into the four land use classes – this represents approximately 99 per cent of the total Alberta land base of approximately 164 million acres (66.3 million hectares).

The fragmentation methodology provides only an indication of fragmentation due to parcel subdivision – it does not account for other fragmenting factors such as natural features (e.g., wetlands, forests), energy developments such as well pads associated with up-stream oil and gas, or utility corridors. In addition, in the event that large parcels are added to the land base

(e.g., sales of public land) the fragmentation index will go down, whereas the actual level of fragmentation remains the same (i.e., the same number of smaller parcels still exists).

Additionally, the potential exists for the fragmentation method to be slightly exaggerated, as any subdivision of an agricultural parcel will result in a higher fragmentation index, regardless of whether the subdivided parcel's land use actually changes. For example, a quarter section could be subdivided but remain intact from a land use perspective until the owner decides to sell one of the parcels.

Benefits of the Methodology Outlined in this Report

This methodology is beneficial in that:
- it is a repeatable calculation that is based on readily available data;
- it is likely that the source data will be available in perpetuity;
- the data has predictable sources of error that remain constant throughout LUF regions and across the province, and
- it will not change quickly in response to economic signals (e.g., crop prices, cattle prices).

Other Possible Methodologies

Remote Sensing

Remote sensing imagery (aerial and/or satellite) is another means of determining land use change, as it classifies the aerial imagery into discrete land-use categories using classification algorithms. Agriculture and Agri-Food Canada's Annual Crop Inventory (ACI) provides this data for Alberta, and its use was explored by AF. As the methodology evolved, however, it became clear that annual variation in the data led to unreliable results, particularly for annual reporting purposes as committed to by the Government of Alberta. These inconsistencies included:
- The ACI is a mosaic of images captured during the growing season of a given year, and not necessarily taken at the same point and time from year to year. This may result in classification errors as a result of land changing classifications based on the time of year of the photo capture. For example, due to the nature of the algorithm employed by AF, exposed land (e.g., a cultivated field in early May) adjacent to urban area was misclassified as being developed or developing urban land, whereas imagery acquired at the same location in July clearly indicated full crop growth.
- There was a great deal of fluctuation in the land classified as forest – this led to the analysis showing annual change in agricultural land and forested land when it is unlikely these changes were actually occurring.
- In some cases, water bodies grew and shrank despite the unlikelihood that these changes were actually occurring (e.g., Lake Newell appeared and disappeared from year to year).

These changes are likely due to a combination of the annual difference in the timing of image capture and error in the classification algorithm.

The images below (Figures 3, 4, and 5) provide an example of the annual variation and inaccuracy of remote sensing data. Figure 3 is an aerial image of an area northwest of Devon, AB (Graminia) taken between 2010 and 2013 (exact year unknown). It depicts developed land (Edmonton – in the northeast corner of the image) and a large number of country residential lots. Maps of the same area developed from the Annual Crop Inventory indicate an increase in developed land in that area between 2009 and 2013 (Figures 4 and 5, respectively); however, the aerial image taken at roughly the same time (and confirmed through ground-truthing of the area) illustrates that the increase was less extensive than that suggested in the remote sensing data.

Figure 3: Aerial image of area northwest of Devon, AB (Google Earth, 2010-2013).
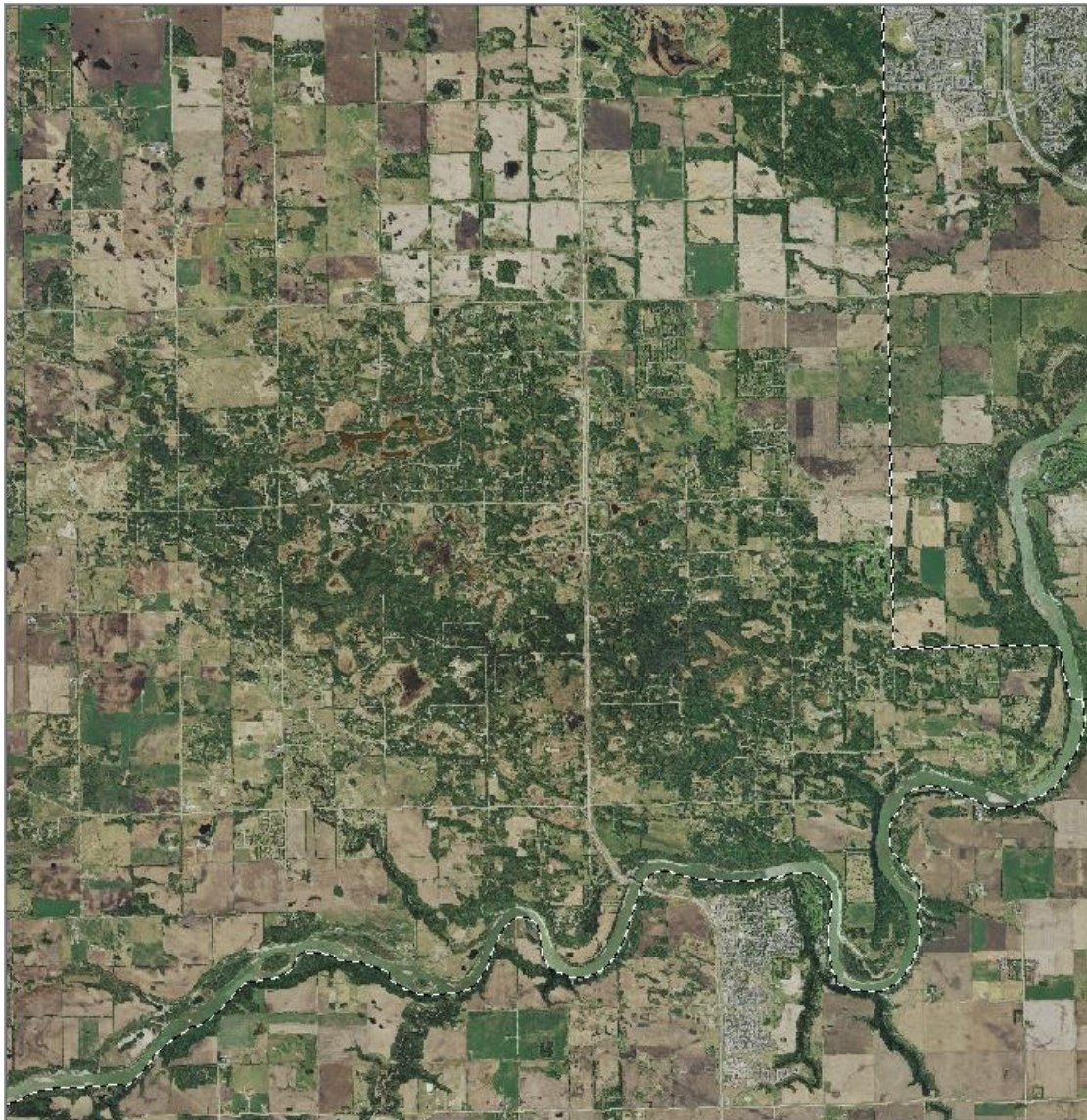
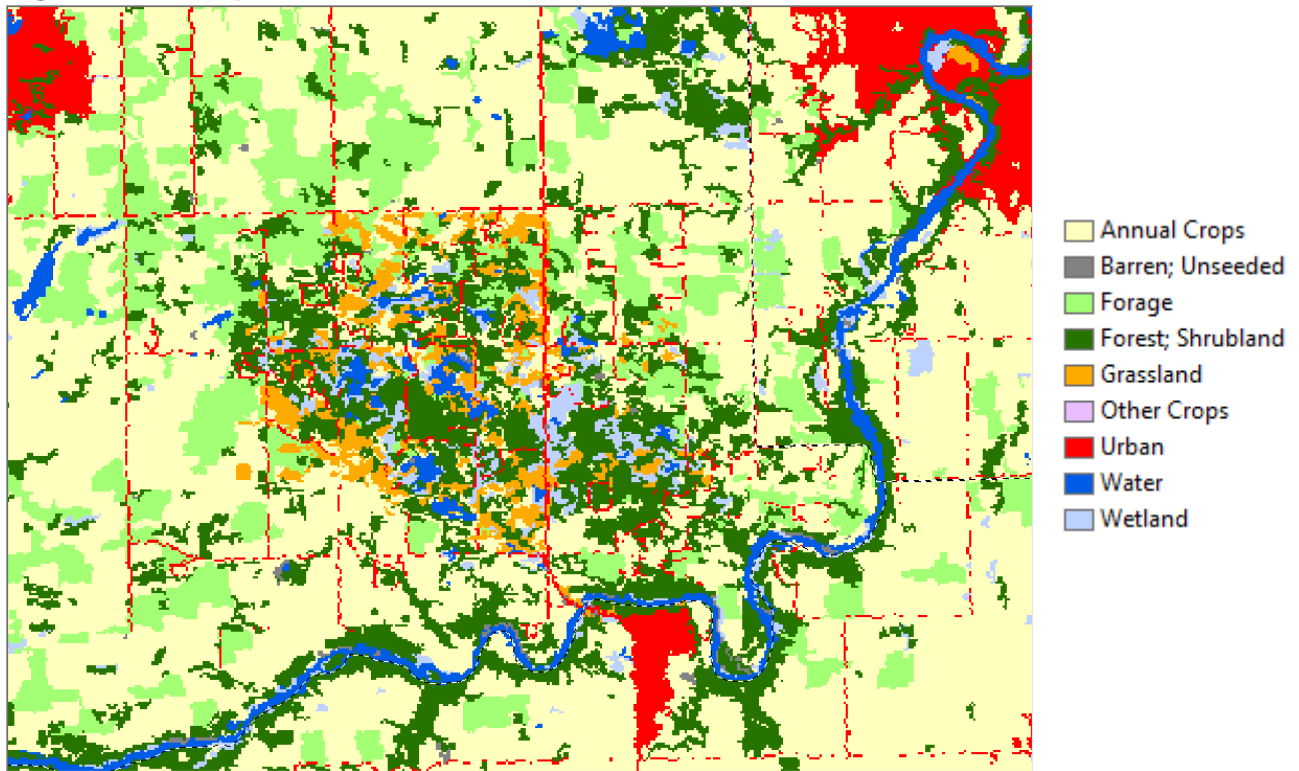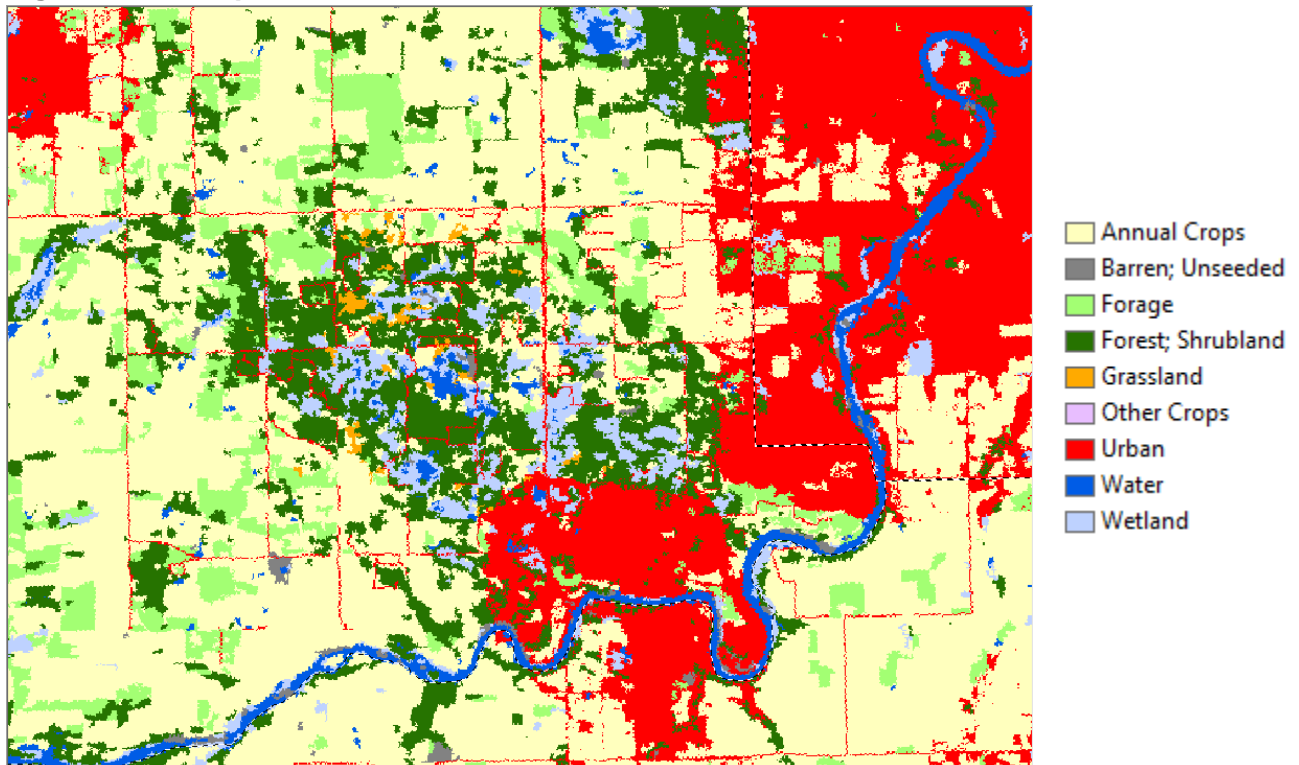**Figure 4: Developed land northwest of Devon, AB in 2009.**

Figure 5: Developed land northwest of Devon, AB in 2013.

Employing this data as part of the land conversion calculations leads to an erroneous assumption that significant development has occurred, when in fact this is not substantiated by on-the-ground analysis of the region.

AF decided that the annual variation in remote sensing imagery would be balanced over time, thus providing improved results for images captured between discrete, relatively distant time periods; however, the variation precluded the use of this technology for accurate annual reporting for the province and by LUF region, municipality, and Land Suitability Rating System classes.

Agricultural Census

Another potential method of calculating agricultural land conversion is through comparisons of the Census of Agriculture, which is collected by Statistics Canada on a five year basis. In order to determine agricultural land conversion, the **total farm area** of a given census year (e.g., 2011) could be subtracted from the total farm area of a previous census year (i.e., 2006), with the difference indicating the net change in total farm area for the province.

There are a number of potential sources of error with this methodology. As the census employs self-reporting by agricultural land owners, total farm area reported in the agricultural census may be skewed by farmers reporting (or not reporting):

- rented land,
- community pastures,
- actively farmed land inclusive or exclusive of the homestead, or
- inclusion of non-farmed areas (sloughs, bush, irrigation pivot corners, etc.)

> **Total Farm Area:**
> The measure of the total land area of Alberta farms, which is equal to the sum of the following (Census of Agriculture) land use categories:
> - Total Land in Crops
> - Summerfallow
> - Tame or Seeded Pasture
> - Natural Land for Pasture
> - Christmas Trees, Woodlands and Wetlands
> - All other land

In addition to this, there may be differences in how the census is collected and analyzed over time – AF is aware of such differences between the 2006 and 2011 census period. Due to the potential for error when using this methodology, and the fact that data is only collected every five years, it was decided that the agricultural census was not a viable data source for AF's purposes (i.e., annual reporting).

Conclusion

Upon evaluating all possible methodologies, AF determined that the inability to access actual land use data and the unreliability of alternative data sources necessitated the development of a proprietary method of calculating the amount of agricultural land in Alberta. While this methodology comes with its own set of limitations and potential errors, it provides a reliable, repeatable means of determining the annual change in agricultural land at a provincial scale, as well as by LUF region and Land Suitability Rating.

Land Use

The differences in the results calculated by these methodologies support a need to be open and transparent by reporting on all assumptions and sources of potential error that can be attributed to both the data acquisition and calculation processes. Failure to provide this information with published calculated values makes their true interpretation unfeasible. This may lead to incorrect assumptions regarding the extent of changes to the agricultural land base, which in turn may poorly inform policy development.