Examining Land Use Change and Urbanization in Edmonton between 1966 and 1976

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Geography 479 Lab 1

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Executive Summary

This report explores how the historic urban expansion of greater Edmonton fragmented the landscape through urban development, while simultaneously homogenizing the landscape surrounding the urban core. This spatial analysis examines which types of land change accordingly with urban development, such as Outdoor recreation. Furthermore, the analysis gives insight on how the surrounding landscape experiences spatial homogenization, which is reflective of anthropogenic control and organization. Specific analysis of the change in land use devoted to Productive woodlands exemplifies this increase in control and how urban expansion favors specific types of land use beyond the urban core. As a consultant for timber companies, I argue expansive urban fragmentation of the landscape in the past has been especially beneficial for employing greater control over the surrounding environment.

Introduction

Between 1966 and 1976 Edmonton and its surrounding area underwent change that gives insight into how the process of urbanization affects the spatial organization of land use in the surrounding landscape. Although some metrics discussed appear to show only minor changes in land-use, distinct patterns of spatial reorganization begin to emerge in a theme of homogenization (i.e. less fragmentation). Map 1 shows an overview of the changes to land use. By 1976 greater Edmonton exhibited a landscape that appeared slightly more homogeneous than 1966, with more land-use devoted towards resource extraction, urban development, and human activity.

This report may prove useful to city planners and the Minister of Forestry to understand how a decade of urban expansion impacts the surrounding environment. More specifically, this report discusses which land-use types are most inclined to change accordingly with urban expansion. In order to work towards an efficient future, urban developers should reflect on the prior decades of urbanization to understand implications of further urban expansion. Furthermore, the Minister of Forestry can use this report to better understand the spatial relationship between urbanization and surrounding woodlands.

Data, Results and Discussion

The data for this spatial analysis of land use change comes from Canadian Land Use Monitoring datasets archived by GeoGratis. The original CLUMP files were converted to raster data sets using ArcGIS, then imported to FRAGSTATS (Version 4.2) where specific metrics of landscape and class metrics regarding spatial composition and fragmentation were calculated (See Appendix for metric explanations). Finally, these metrics were exported to Excel for further analysis and manipulation for visual purposes.

From 1966 to 1976 the changes in land use reveal a subtle trend of homogenization within the landscape of greater Edmonton. According to the landscape metrics in Table 2, the number of patches decreased by 199 and patch density decreased by 0.03 which indicates slightly less fragmentation in the landscape. Additionally, the percentage of like adjacencies increased by 1.06% and implies a slight increase in average likelihood that neighboring hectares (or 'cells' in the raster data set) of land are of the same land use type.

Digging deeper into class metrics (Table 1), the total of disjunct core areas from 1966 to 1976 dropped by 590 from a total of 6686 to 6096. Furthermore, the top six land use categories with the most disjunct core areas in 1966 (Cropland, Improved pasture and forage crops, Non-productive woodland, Productive woodland, Swampmarsh or bog, Unimproved pasture and range land) all experienced declines in their number of disjunct core areas, and a comparison in Figure 1 shows their respective and combined differences. Four out of these top six categories experienced a decline of at least 200 disjunct core areas. These declines in disjunct core areas support the trend of homogenization to the landscape because there are less patches with core areas spread amongst the landscape. However, the combined difference of disjunct core areas for the six classes is significantly higher at 1860 versus the total difference for all classes at 590 mentioned previously. Furthermore, these six classes originally made up 72.37% of the landscape in 1966 and declined 65.41% of the landscape in 1976. So, this difference in total decline of disjunct core areas and decline of 6.96% of the total landscape insights some uncertainty towards asserting that a trend of homogenization is sufficient to describe the overall change to the landscape between 1966 and 1976. So, other disjunct core areas within the landscape must have been converted and formed via other types of land use to explain a countering trend of fragmentation.

One of the clearest trends in land use change occurred via an increase to land classified as Urban built-up area. This coincides with the trends of rising population and "rise in the number of single-attached housing units since the 1960s," that John A.G. Hansen (1984) argues is a separate influence from increased population to the expansion of built-up areas (p. 64). First, according to the pivot table (Table 3) 99.96% of Urban-built up land remained from 1966 and 1976, while some percentage of every other land use category became Urban built-up area, barring 'Water Areas.' Map 2 displays two larger scaled maps of Edmonton's urban core and shows the purple area designated as 'Urban built-up area' in 1976 having clearly expanded from the original core in 1966. Furthermore, entirely new patches of urban built-up area that are especially visible at this scale sprouted west of the core and in the northeast and southwest corners of the inset maps by 1976.

Although the landscape became slightly more homogenized, urban expansion actually contributed towards fragmenting the landscape. Table 1 consists of various metrics that quantify this fragmented expansion. First, the number of patches and number of disjunct core areas for Urban built-up land rose from 133 to 1,718 and 88 to 1,290, respectively. So, just over 75% of new Urban built-up patches consisted of patches with core areas. Furthermore, the connectance index metric for Urban built-up land shows the largest decrease from 1966 and contains the third lowest measure for land use types in 1976. This implies that by 1976 greater Edmonton's urban expansion was exceptionally spread in the landscape as the proportion of functional joinings lowered significantly. This significant increase in disjunct core areas and decrease in connectance index suggests that urban expansion fragmented the landscape with relatively large patches in no specific direction from the original urban core of 1966.

A land use category that coincided with the type of urban expansion experienced in greater Edmonton was land used for Outdoor recreation. The 'Percentage of landscape' metric about tripled for land devoted to Urban built-up and Outdoor recreation, which were the highest proportional increases experienced in all land use categories. Also barring land devoted to Horticulture, the number of disjunct core areas only rose for Mines quarries sand and gravel pits, Urban built-up, and Outdoor recreation land use types. Lastly, the connectance index dropped 0.47, second largest drop behind Urban built-up area at 0.59. Thus, as urban expansion occurs rather sporadically around the core city of Edmonton, land devoted to Outdoor recreation follows

this development as people generally enjoy accompanying space for recreational activities. Some spaces we consider devoted to 'Outdoor recreation' today may also have been discounted in the original survey. According to an archived guide to the classification system, National Resources Canada (1968) included "parks and other open spaces within [Urban] built-up areas" as Urban built-up area (p.7). So, further research may be necessary to identify public green spaces in Urban built-up areas as Outdoor recreation land use.

Finally, another trend unique within the surrounding landscape of the urban core was the conversion of various land types to Productive woodland. Although 9.67% and 14.96% of Productive woodlands in 1966 became Urban-built up area and Croplands by 1976, respectively (Table 3), the percentage of landscape classified as Productive woodlands almost doubled and was 8.54% of the landscape in 1976 (Table 1). However, unlike urban expansion land devoted to Productive woodlands experienced one of the largest increases for the connectance index metric occurred by 0.18 while the number of disjunct core areas nearly halved. These metrics suggest the opposite of fragmentation. Furthermore, the perimeter area fractal dimension dropped, which entails the shape of Productive woodlands patches were less complex and suggests anthropogenic control and influence as humans generally organize land with less complex shapes. According to Table 3, Productive woodlands gained a large percentage of land from Unimproved pasture and range land and Non-productive woodland (also Unproductive landrock but there were only 36 ha in the landscape to begin with). Thus, land formerly deemed unproductive that also fragmented the landscape was converted for more efficient use. Map 3 shows a clear example of the homogenized growth in Productive woodlands coinciding with fragmented urban expansion in the western region of the study area.

The archived guide from National Resources Canada (1968) defines areas with "trees having over 25% canopy cover and being over 20 feet in height approximately," and "restocked areas, or plantations… regardless of age," and "cut-over [or] burned-over land" as Productive woodland (p.7). So, wildlife may persist in these regions, but Productive woodland is notably influenced by anthropogenic means of control, as mentioned by the decrease in the perimeter area fractal dimension class metric. As urban expansion occurred so did control over the surrounding landscape of Edmonton, and Productive woodland class metrics and Map 3 exemplify this phenomenon.

Recommendations

From the perspective of a consultant for timber companies, this historic example of urbanization shows urban expansion should be welcomed by the industry as more control, order, and efficient use of the land is achieved in the surrounding environment Urban built-up area. However, land used for outdoor recreation generally accompanies urban expansion, and more efforts should be made to identify areas of Outdoor recreation within Urban built-up area. Logging companies may then be able to justify to city planners that enough land is already devoted to Outdoor recreation within cities and towns and be able to push for more expansion into the land that surrounds Urban-built-up area. Lastly, land converted to Productive woodlands helped to homogenize the landscape, which could help preserve specific habitats for at least generation as wildlife often persists more successfully in a less fragmented landscape. So, the Minister of Forestry should collaborate with habitat preservation organizations to strategize common goals of further developing more cohesive patches of Productive woodlands within the Canadian landscape, provided these habitats are willing to shift internally around harvest times.

Works Cited

Jansen, J.A. G. (1984). Canadian small settlements and the uptake of agricultural land, 1966-1976. *Social Indicators Research, 15*(1), 61-84.

National Resources Canada, Government of Canada. "A guide to the classification of land use for the Canada inventory." 1968. https://uwaterloo.ca/library/geospatial/collections/canadian-geospatial-data-resources/canada/canada-land-use-monitoring-plan-clump

Table 1

Class Metric	Total Area (ha)		Percentage of Landscape		Number of Patches		Total Edge (100m)		Coefficient of Variation of Patch Area		Mean Shape Index		Area-weighted mean Shape Index		Perimeter Area Fractal Dimension		Total Core Area (ha)		Core Area Percent of Landscape		Number of Disjunct Core Areas		Connectance Index	
Landscape Type	1966	1976	1966	1976	1966	1976	1966	1976	1966	1976	1966	1976	1966	1976	1966	1976	1966	1976	1966	1976	1966	1976	1966	1976
Cropland	284,664	263,105	44.18%	40.86%	579	709	118,981	97,816	1498.20%	1121.91%	1.64	1.52	28.39	14.24	1.50	1.40	196,305	190,266	30.47%	29.55%	1349	928	0.73	0.59
Horticulture	23	750	0.00%	0.12%	5	44	42	782	89.74%	131.83%	1.03	1.14	1.07	1.27	N/A	1.19	0	255	0.00%	0.04%	0	22	No Data	1.37
Improved pasture and forage crops	46,750	44,358	7.26%	6.89%	2132	2170	55,214	53,454	186.34%	169.29%	1.36	1.34	1.92	1.83	1.44	1.41	11,720	10,710	1.82%	1.66%	1547	1489	0.15	0.15
Mines quarries sand and gravel pits	1,681	3,116	0.26%	0.48%	99	84	1,994	2,624	154.14%	342.12%	1.24	1.32	1.57	2.78	1.32	1.31	508	1,405	0.08%	0.22%	47	61	1.28	1.61
Non-productive woodland	19,086	7,316	2.96%	1.14%	517	403	18,693	9,095	339.77%	219.47%	1.52	1.37	2.90	1.85	1.48	1.37	7,816	2,236	1.21%	0.35%	413	203	0.43	0.39
Outdoor recreation	1,735	4,582	0.27%	0.71%	80	126	2,034	3,799	132.36%	249.26%	1.38	1.33	1.79	2.07	1.37	1.29	563	2,152	0.09%	0.33%	47	79	1.33	0.86
Productive woodland	28,450	54,995	4.42%	8.54%	843	417	28,759	23,739	263.17%	703.70%	1.49	1.48	2.57	3.82	1.46	1.33	10,701	38,268	1.66%	5.94%	670	384	0.29	0.47
Swampmarsh or bog	11,340	6,228	1.76%	0.97%	1144	551	18,726	9,312	218.23%	197.18%	1.28	1.26	1.72	1.72	1.44	1.37	1951	1,375	0.30%	0.21%	365	219	0.21	0.27
Unimproved pasture and range land	75,934	45,154	11.79%	7.01%	2597	1715	87,529	48,862	525.55%	281.50%	1.47	1.41	4.22	2.41	1.53	1.39	24,261	15,687	3.77%	2.44%	1922	1183	0.17	0.18
Unproductive landrock	36	18	0.01%	0.00%	16	6	110	50	83.89%	81.65%	1.11	1.17	1.24	1.33	1.52	N/A	0	0	0.00%	0.00%	0	0	9.17	13.33
Urban built-up area	19,596	59,439	3.04%	9.23%	133	1718	5,553	60,565	604.81%	414.54%	1.28	1.48	2.31	3.46	1.24	1.46	15,708	22,773	2.44%	3.54%	88	1290	0.82	0.23
Water Areas	19,861	19,875	3.08%	3.09%	337	340	11,189	11,366	599.70%	602.00%	1.32	1.32	4.06	4.06	1.34	1.34	13,003	13,003	2.02%f	2.02%	238	238	0.81	0.80

Table 2

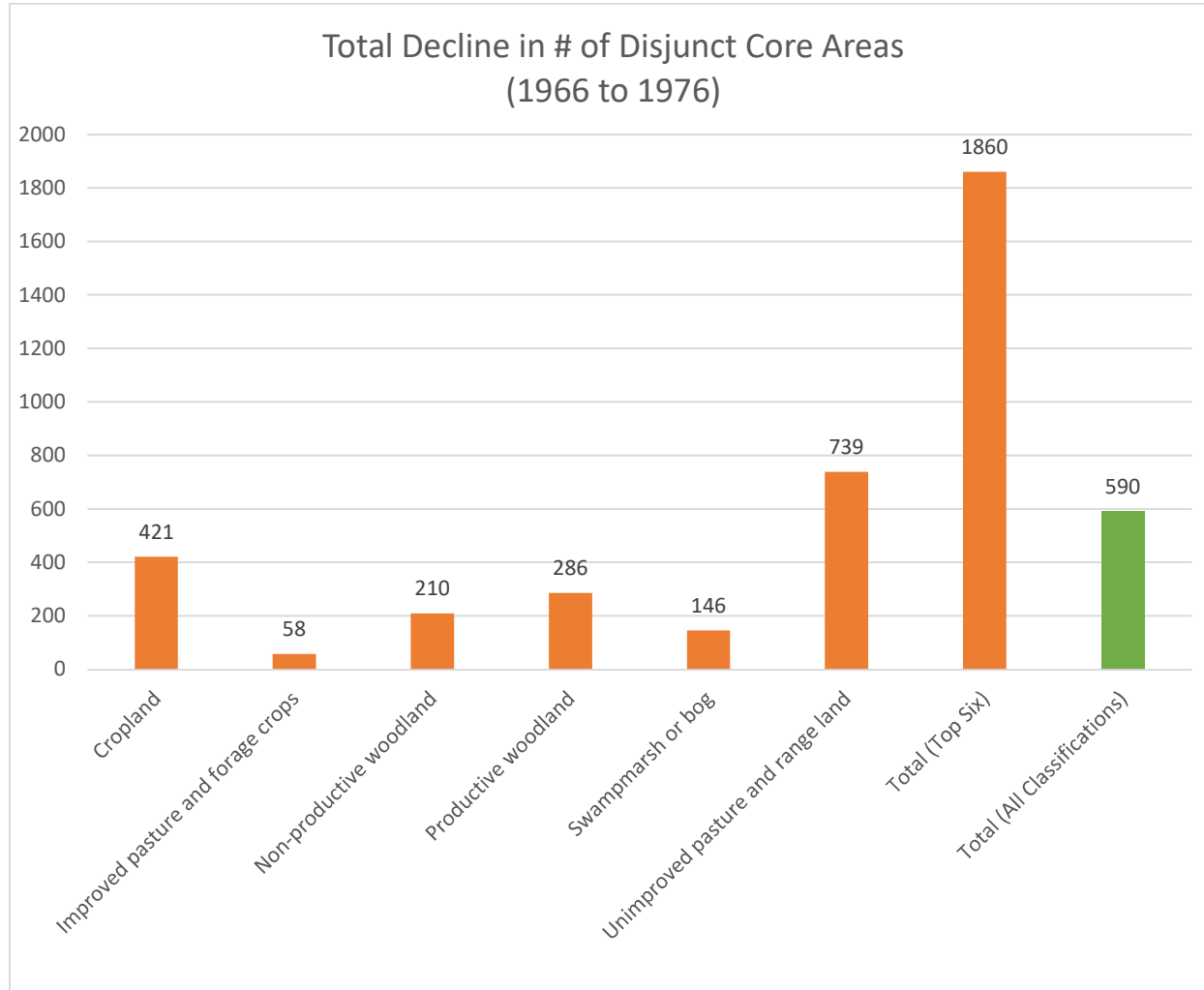| Landscape Metric	Number of Patches	Patch Density ($\frac{\# \ of \ patches}{1 \ ha}$)	Total Edge (100m)	Proportion of Like Adjacencies
1966	8,497	1.3188	175,917	86.18%
1976	8,298	1.2887	162,237	87.24%

Table 3

1966 \ 1976	Cropland	Horticulture	Improved pasture and forage crops	Mines quarries sand and gravel pits	Non-productive woodland	Outdoor recreation	Productive woodland	Swamp-marsh or bog	Un-improved pasture and range land	Un-productive landrock	Urban built-up area	Water areas	1966 Grand Total (ha)
Cropland	82.34%	0.22%	0.02%	0.70%	0.26%	0.22%	1.69%	0.38%	6.65%	0.00%	7.52%	0.00%	284,295
Horticulture	34.78%	52.17%	0.00%	0.00%	0.00%	4.35%	0.00%	0.00%	0.00%	0.00%	8.70%	0.00%	23
Improved pasture and forage crops	0.98%	0.01%	94.40%	0.13%	0.28%	0.09%	0.77%	0.16%	2.15%	0.00%	1.02%	0.00%	46,750
Mines quarries sand and gravel pits	4.34%	0.00%	0.12%	42.59%	3.81%	5.35%	9.10%	0.18%	13.44%	0.00%	21.06%	0.00%	1,681
Non-productive woodland	12.57%	0.05%	0.05%	0.27%	8.53%	2.30%	51.62%	0.46%	13.32%	0.00%	10.85%	0.00%	19,084
Outdoor recreation	0.17%	0.00%	0.00%	0.00%	0.00%	85.42%	0.00%	0.00%	0.29%	0.00%	14.12%	0.00%	1,735
Productive woodland	14.92%	0.04%	0.11%	0.39%	1.44%	2.07%	63.76%	0.27%	7.33%	0.00%	9.67%	0.00%	28,450
Swampmarsh or bog	17.67%	0.04%	0.12%	0.07%	7.82%	1.04%	12.86%	28.17%	26.08%	0.00%	6.06%	0.08%	11,336
Unimproved pasture and range land	26.08%	0.09%	0.14%	0.25%	4.55%	1.55%	32.34%	2.27%	22.95%	0.00%	9.78%	0.00%	75,896
Unproductive landrock	6.73%	0.00%	0.00%	0.00%	0.96%	12.50%	60.10%	0.00%	0.00%	14.90%	4.81%	0.00%	208
Urban built-up area	0.02%	0.00%	0.01%	0.01%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	99.96%	0.00%	195,96
Water areas	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	19,861
1976 Grand Total (ha)	263,100	750	44,358	3,116	7,316	4,581	59,431	6,224	45,150	31	54,983	19,875	508,915

Appendix

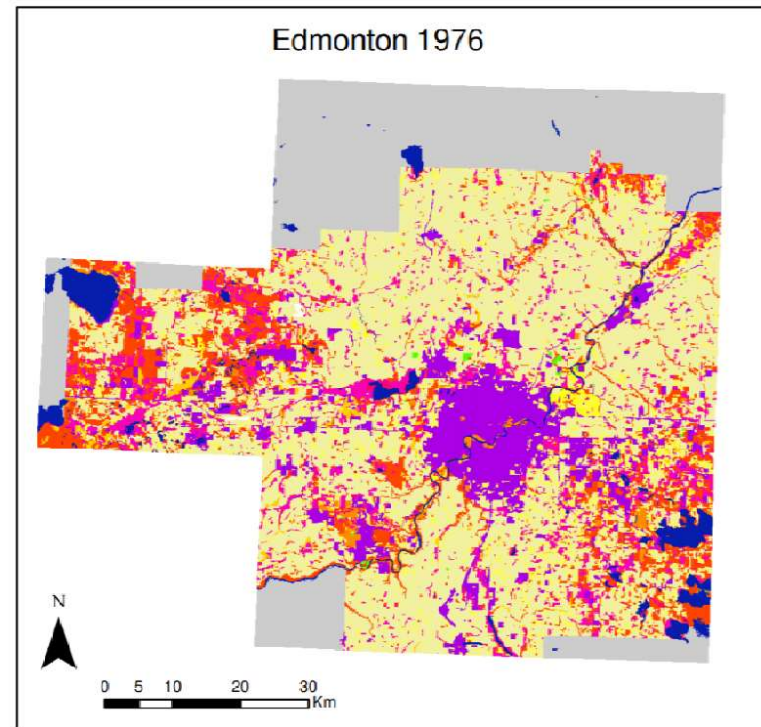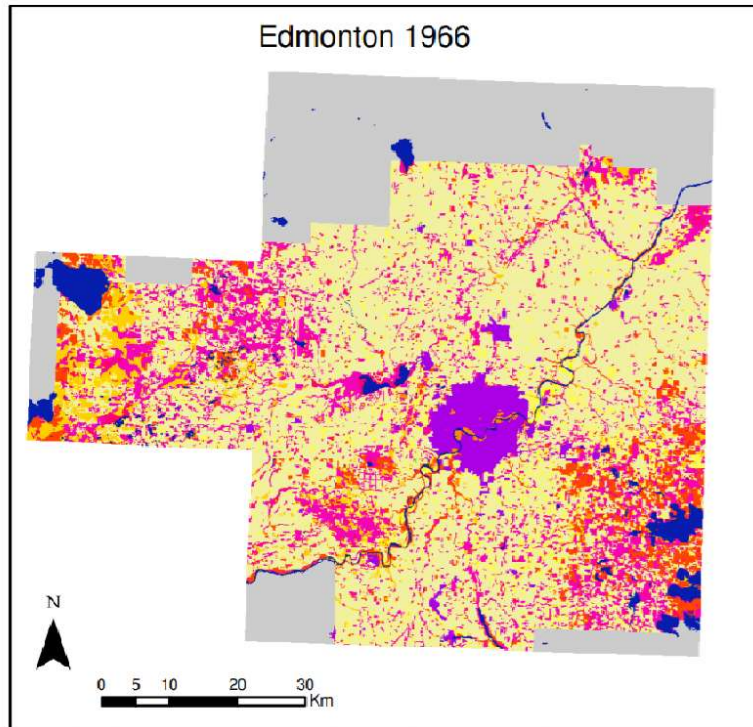| Class Metrics	
Total Area	The area represented by a specific class in hectares.
Percentage of Landscape	The total area of a specific class divided by the landscape area and converted to a percentage.
Number of Patches	The number of each patches devoted to a specific class within the landscape.
Total Edge	The combined length of edges (in meters) of each class' patch.
Coefficient of Variation of Patch Area	The standard deviation in patch size divided by the mean patch size of the corresponding patch type, then converted to percent.
Mean Shape Index	The sum of each patch's perimeter edges divided by the square root of the total patch area for each class. The higher the index value, the more complex the shape of the class type within the landscape.
Area-Weighted Mean Shape Index	Similar to the Mean Shape Index, but the equation is adjusted so the larger patches' edges influence the result more versus the smaller patches' edges.
Perimeter Area Fractal Dimension	Reflects shape complexity across a range of patch sizes. If enough patches are available, the measurement yields a result between 1 and 2. The further the result is from 1 for a class, the more complex the shape of that class is within the landscape.
Total Core Area	The total area of a class provided only the area 100m from the edge of class type's land is counted towards the sum.
Core Area Percent of Landscape	The total core area divided by the landscape area.
Number of Disjunct Core Areas	The number of core areas in each class. If a class has a high number of patches (that are large enough to contain a core area) spread throughout the landscape, then there will be more disjunct core areas for that class.
Connectance Index	The proportion of functional joinings for patches in a class. A functional joining occurs when patches are within 1 kilometer of each other.

Landscape Metrics	
Number of Patches	The total number of separate patches within the landscape.
Patch Density	The total number of patches divided by the landscape area and converted to a per unit basis of 100 hectares.
Total Edge	The sum of the length of edges from all patch types regardless of class.
Proportion of Like Adjacencies	The percentage of raster cells with cell adjacencies involving the corresponding patch type that are the same. A percentage below 50% would represent a highly fragmented landscape. A percentage of 100% would entail a landscape of one patch with a border of the same class type.

Figure 1

Total Decline in # of Disjunct Core Areas
(1966 to 1976)

Map 1

Edmonton's Land Use Change from 1966 to 1976

Land Use Classification

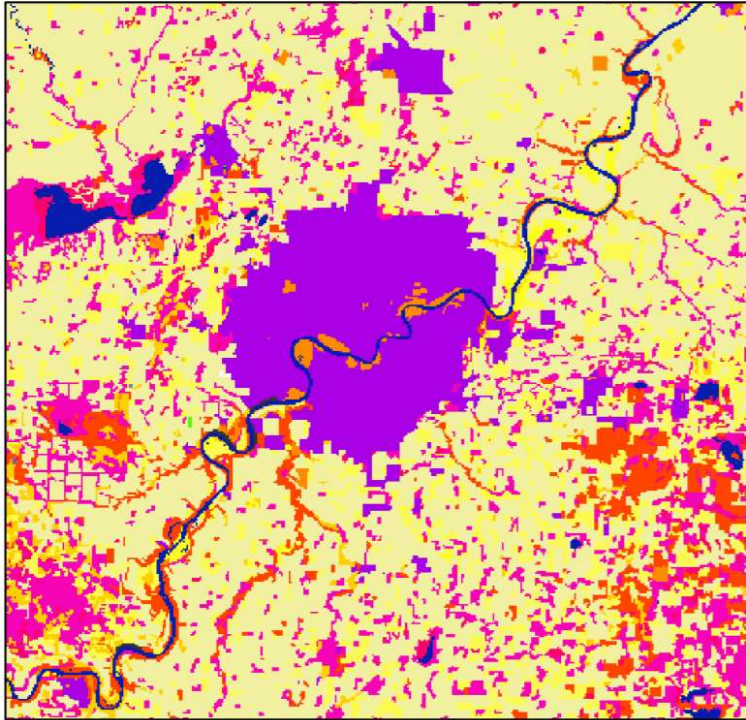|	
Cropland	Outdoor recreation
Horticulture	Productive woodland
Improved pasture and forage crops	Swampmarsh or bog
Mines quarries sand and gravel pits	Unimproved pasture and range land
Non-productive woodland	Unmapped areas

Unproductive landrock
Unproductive landsand
Urban built-up area
Water areas

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Data retrieved from Geogratis archive website
Map projection: UTM Zone 12N

Map 2

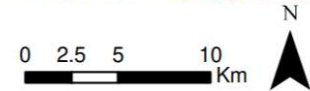# Urban Expansion from 1966 to 1976

Edmonton 1966   Edmonton 1976

Land Use Classification

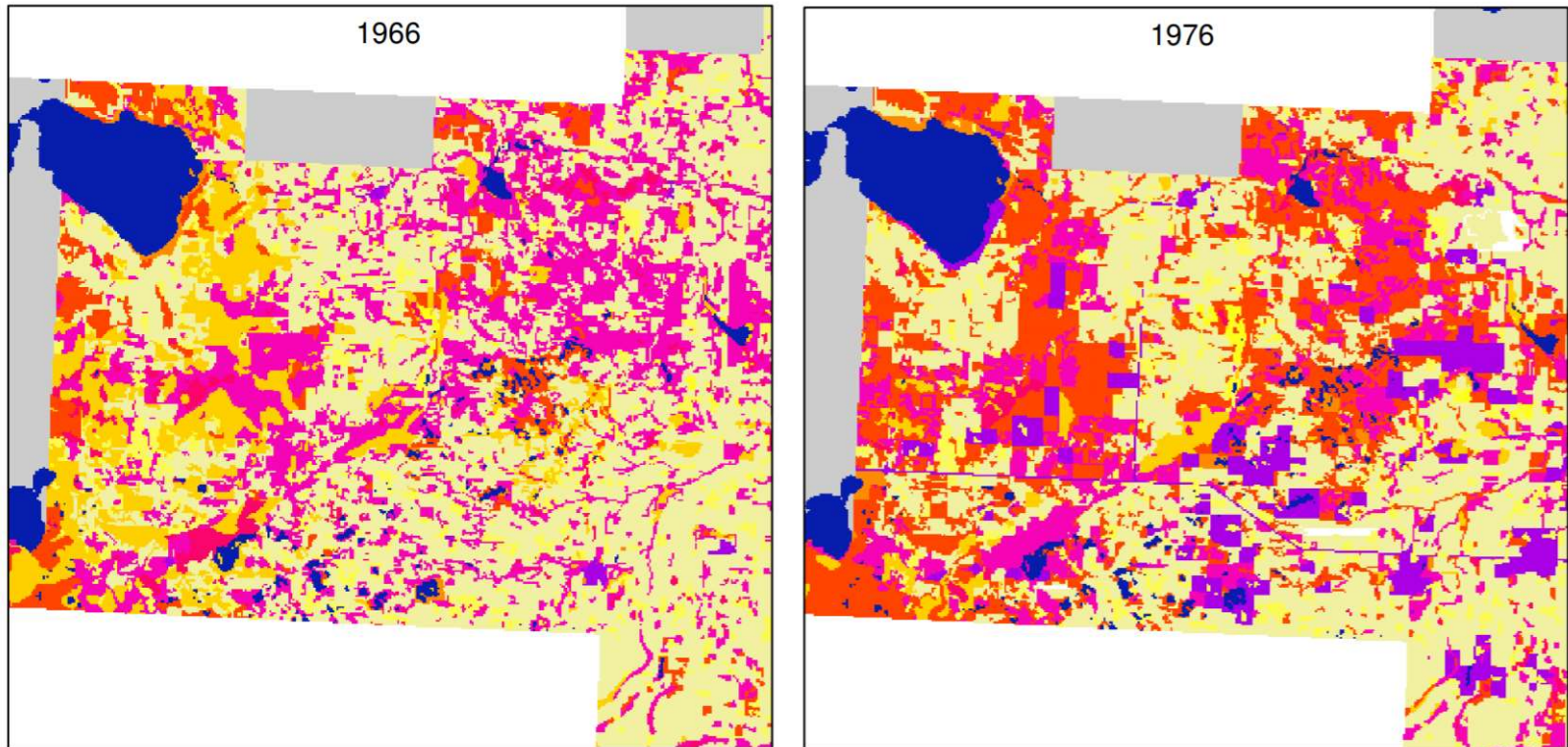|		
▢ Cropland	▢ Outdoor recreation	▢ Unproductive landrock
▢ Horticulture	▢ Productive woodland	▢ Unproductive landsand
▢ Improved pasture and forage crops	▢ Swampmarsh or bog	▢ Urban built-up area
▢ Mines quarries sand and gravel pits	▢ Unimproved pasture and range land	▢ Water areas
▢ Non-productive woodland	▢ Unmapped areas	

N

0   2.5   5   10
Km

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Data retrieved from Geogratis archive website
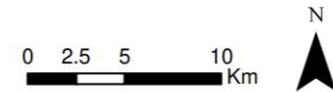Map projection: UTM Zone 12N

Map 3

Transitioning to Productive Woodlands from 1966 to 1976

1966

1976

Land Use Classification

Cropland	Outdoor recreation	Unproductive landrock
Horticulture	Productive woodland	Unproductive landsand
Improved pasture and forage crops	Swampmarsh or bog	Urban built-up area
Mines quarries sand and gravel pits	Unimproved pasture and range land	Water areas
Non-productive woodland	Unmapped areas	

N

0 2.5 5   10
Km

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Data retrieved from Geogratis archive website
Map projection: UTM Zone 12N