


Environmental Scan For Agriculture in Alberta

Prepared by the Environmental Scan Team

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AGRICULTURE, FOOD AND
RURAL DEVELOPMENT
Resource Management and Irrigation Division
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Environmental Scan for Agriculture in Alberta

Background

Alberta and Canada have agreed, under section 25.4 of the Agriculture Policy Framework (APF), to jointly conduct a scan of environmental issues facing agriculture in Alberta. The scan is a geographical assessment of the location, extent and severity of environmental issues associated with the primary production sector of agriculture in Alberta. It describes areal extent of concerns affecting air, water, soil and biodiversity at scales appropriate to targeting priority areas for implementing Environmental Farm Planning (EFP), Equivalent to Environmental Farm Planning (EEFP) and Beneficial Management Practice (BMP) incentive funding. This environmental scan will be used to target and structure APF and related programming. The scan will also contribute to national level assessment, and in conjunction with established APF targets and Agri -Environmental Indicators, will serve as a baseline statement of conditions.

The Alberta Environmental Scan Committee was established in February 2003, to define the regional environmental scan process for Alberta. A technical team was identified by the Committee, and developed the first draft of the environmental scan product by June 11, 2003. This first draft did not include a biodiversity component. The technical team met again on September 23, 2003 to initiate a second draft, incorporating the biodiversity component. This version of the environmental scan was completed in December 2003.

Environmental Scan Technical Team Membership

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Objective

To develop a single map of Alberta that identifies areas within the province to target EFP, EEFP, related APF programs, and the implementation of BMPs.

Methodology

Five components were initially identified as factors to be considered in the environmental scan:

1. Surface water quality,
2. Ground water quality,
3. Soil risk,
4. Air quality, and
5. Biodiversity.

The vulnerability of each component to impacts from agriculture was considered to be a function of:

1. The spatial distribution of relevant physical characteristics of the component, and
2. The spatial distribution of relevant agricultural activities.

The following approach was then used to select and integrate appropriate, available geographic information:

1. Identify which physical characteristics and agricultural activities are relevant to each of the five components.
2. Select geographic data sets which represent the identified characteristics and activities.
3. Combine the characteristics and activities to form a single component risk factor for each of the five components, for each land location. The range of values for each component risk factor is a continuous range of real numbers, from 0 to 1.
4. Combine the five component risk factors together, using appropriate weightings, to form a single environmental scan rating, for each land location.
5. The 25% of the land with the highest ranking is identified as *high priority area*, the next 25% of the land is *medium priority*, and the remaining ranked 50% is *low priority*.

Physical characteristics, agricultural activities and datasets

The physical geographical characteristics which were identified as relevant to water, soil, air and biodiversity risk, and the agricultural activities which may impact these, are listed in Table 1. The physical characteristics listed in Table 1 are *inherent vulnerabilities*, in the case of soil and water quality risk, while they are *qualities* or *aspects* of air quality and biodiversity. The measures listed under agricultural activities are surrogates for estimating agricultural intensity with respect to the specific resource vulnerability, aspect or quality. In particular, the measure of *total economic activity* is not intended as an economic measure, but as a surrogate for agricultural intensity as it affects biodiversity.

These characteristics and activities were identified with consideration of the availability of suitable data. To be useful to the environmental scan process, a geographical dataset must be complete for the agricultural region of Alberta, and of a scale of spatial specificity appropriate to the regional scan process. The environmental scan map is intended for use at a scale of 1:3,000,000. Geographical datasets used in the scan process were typically of a 1:1,000,000 scale or larger. All agricultural activities were identified from the 2001 Census of Agriculture, custom-processed by Soil Landscape of Canada polygons. Many of the physical characteristic datasets used in this process are also based on the Soil Landscape of Canada polygons.

Table 1: Environmental Scan Components, and the relevant physical characteristics and agricultural activities.

Component	Physical characteristics	Agricultural activities
Surface Water Quality	Not applicable, at this scale	Agriculture Intensity: <ul style="list-style-type: none"> • Manure production (livestock) • Fertilizer use (cropping) • Use of other agrochemicals (pesticides)
Ground Water Quality	<ul style="list-style-type: none"> • Aquifer vulnerability • Precipitation minus potential evapo-transpiration 	Agriculture Intensity: <ul style="list-style-type: none"> • Manure production (livestock) • Fertilizer use (cropping) • Use of other agrochemicals (pesticides)
Soil Risk	Erosion vulnerability: <ul style="list-style-type: none"> • Wind erosion potential • Water erosion potential 	Cultivation intensity (soil residue cover)
Air Quality	<ul style="list-style-type: none"> • Not applicable, at this scale 	<ul style="list-style-type: none"> • Manure production (odour) • Cultivation intensity (particulate matter)
Biodiversity	<ul style="list-style-type: none"> • Upland habitat • Riparian areas • Wetlands • Species at risk 	Total economic activity: <ul style="list-style-type: none"> • Capital value • Gross sales • Total expenses

Surface Water Quality Risk Factor

The physical characteristics, which make some surface waters more susceptible than others to pollution from agricultural activities, are at a site-specific scale not addressed in this regional environmental scan. Therefore no regional physical characteristics were identified for use in determining surface water quality risk.

The Agricultural Intensity Index, as developed through the Alberta Environmentally Sustainable Agriculture (AESAs) Water Quality Program, has been identified as a good indicator of agricultural impacts on surface water (Johnson and Kirtz 1998, Anderson *et al* 1999). The Agricultural Intensity Index is the relative ranking (a real number factor between 0 to 1) of the sum of the rankings (from 0 to 1) of watersheds by each of manure production, fertilizer use and agrochemical use, per unit area, based on Census of Agriculture data. This index correlated well with measured water quality from monitoring sites on small streams. For the environmental scan, this ranking methodology was applied to the Soil Landscape of Canada (SLC) polygons, using the 2001 Census of Agriculture data. The resultant rankings, shown in Figure 1, are the Surface Water Quality Risk Factor.

Groundwater Quality Risk Factor

The agricultural activities which impact groundwater quality are the same ones identified for surface water quality. The Agricultural Intensity Index by SLC polygon, from the 2001 Census of Agriculture data, was used again as the indicator.

Ground water aquifer sensitivity varies from location to location in the province. The Aquifer Vulnerability Index (AVI) prepared by PFRA and AAFRD (Dash and Rodvang 1999, Cowen and

Dash, 2003), ranks aquifer vulnerability in four classes, based on surficial geology and depth to the aquifer. This map is shown in Figure 2.

Aquifers in areas with a higher *mean annual precipitation minus potential evapo-transpiration* (P-PE) value are more susceptible to contaminants through leaching to the groundwater. A P-PE rating map was prepared by classifying the ecodistricts of Alberta into three groups, with P-PE of -240 mm per year or greater, between -510 and -240 mm per year, and less than minus 510 mm per year, based on 30-year normal precipitation data (1971 – 2000) prepared by the AESA Soil Quality Program. This map is shown in Figure 3.

Aquifer vulnerability classes were combined with P-PE ratings, as shown in Table 2, to create the groundwater physical sensitivity factor. In general, the AVI ranking is decreased by 1 in the brown soil zone, and increased by one in the black, dark grey and grey soil zones of the province, while it is left unaltered in the dark brown and thin black soil zones.

Table 2: The groundwater physical sensitivity factor is derived from aquifer vulnerability rating and rainfall availability.

P-PE	Aquifer vulnerability rating			
	Negligible	Low	moderate	High
-240 or greater	3	4	5	6
-510 to -240	2	3	4	5
Less than -510	1	2	3	4

The Agricultural Intensity Index rating was multiplied by the groundwater physical sensitivity factor, and the resultant values were ranked from 0 to 1, to form the Groundwater Quality Risk Factor, shown in Figure 4.

Soil Risk Factor

The agricultural activity with the most impact on soil quality in Alberta is cultivation. This impact can be represented quantitatively through a cultivation rating based on frequency of cultivation. The cultivation rating for each SLC polygon was based on the 2001 Census of Agriculture, as follows:

$$\begin{aligned} \text{Cultivation Rating} = & (\% \text{ of area in no till}) \times 1 + \\ & (\% \text{ of area in conservation tillage}) \times 2 + \\ & (\% \text{ of area in conventional tillage}) \times 3 + \\ & (\% \text{ of area in summer fallow}) \times 4. \end{aligned}$$

This implies a rating of zero for uncultivated areas. The cultivation intensity rating map is shown in Figure 5.

The associated physical characteristics of soil landscapes, which affect the sensitivity of soils to cultivation, are identified by wind erosion and water erosion potential ratings, which are available for the SLC polygons. Risk classes were assigned integer values from 1 to 5, as shown in Table 3. The erosion risk value assigned to each polygon was the average of the wind risk value and water risk value for that polygon. Soil erosion risk is shown in Figure 6.

Table 3: Water and wind erosion risk ratings and assigned values.

Risk Rating	Assigned Value
Negligible	1
Low	2
Moderate	3
High	4
Severe	5

The Cultivation rating was multiplied by the soil erosion risk value, and the result was ranked from 0 to 1, to form the Soil Risk Factor, shown in Figure 7.

Air Quality Risk Factor

Two aspects of air quality were considered in this environmental scan. Odour was considered to be directly correlated to manure production, and particulates were considered to be directly correlated to cultivation intensity. The airsheds of the agricultural region of Alberta were considered to be uniform in their physical susceptibility to risk from agricultural activities.

The SLC polygon ratings for manure production, described in the development of the Agricultural Intensity Index, were used as an indicator of odour. The manure production index map is shown in Figure 8.

The cultivation rating assigned to SLC polygons in the Soil Risk step described above, was used as an indicator of particulates.

The manure rating and the cultivation rating were added, and the result was ranked from 0 to 1, to form the Air Quality Risk Factor, shown in Figure 9.

Biodiversity Risk Factor

Addressing biodiversity presented a challenge. The overall goal of maintaining biodiversity in agricultural landscapes may be more readily attained through prevention of further losses in areas less impacted by agriculture than through efforts to restore biodiversity in more heavily impacted areas. To the degree the EFP and EEFP programs have a restorative focus in areas of greatest agricultural impact, they may not be suited to preservation activities in regions of minimal historical impact. Therefore, the targets for biodiversity under the APF may be accomplished by ensuring biodiversity objectives are also pursued in those areas that are presently least impacted by agricultural activity.

After extensive deliberation on the challenges involved in identifying what is meant by biodiversity in the context of this environmental scan, four databases were identified as acceptable surrogates for a physical description of biodiversity in Alberta.

1. The density of upland habitat was estimated from the landuse / landcover map prepared by PFRA for the Western Grain Transition Payments Program. The percentage of the land in each Soil Landscape of Canada polygon that was classified as trees, shrubs or grasslands is considered to be "upland habitat". The upland habitat density map is shown in Figure 10.
2. The density of wetland habitat was estimated from the Ducks Unlimited Canada (DUC)

wetland database. The percentage of the land area in each Soil Landscape of Canada polygon that was identified as wetlands in the DUC database was considered to be "wetland habitat". The wetland habitat density map is shown in Figure 11.

3. The density of waterways, in linear kilometers per square kilometer of land, in each Soil Landscape of Canada polygon, was used as a surrogate for riparian area density. Linear waterways were identified from the Government of Alberta's Base Features Single Line Network map (1:20,000 scale). The waterways density map is shown in Figure 12.
4. The number of natural habitat areas of species at risk, which overlap at any given location in the landscape, was used as a surrogate for density of Species at Risk. Species at Risk habitat area maps are available from web site of the Committee on the status of endangered wildlife in Canada (COSEWIC, <http://www.cosewic.gc.ca>.) The number of species at risk habitats map is shown in Figure 13.

These four maps were each converted to a 0 to 1 ranking, and spatially added together, with the wetland density index given a double-weighting. The result was a spatial range of values from 0 to 5. A value of one was added to this result, to give a biodiversity physical factor map with a range of values from 1 to 6. This results in a range of values in this physical factor map that is similar to the range of values used in the physical component of the groundwater and soil maps.

All human activity impacts biodiversity. The more we do as humans, and the more geographically concentrated our activities, the more we impact biodiversity. The total economic activity, by region, is more likely to be highly correlated with impact on biodiversity, than is any single subset of economic activities. This is not to say that all activities have equal impact on biodiversity: there is room for beneficial management practices to reduce or minimize the impact of each economic activity. In the same way one avoids thinking of a single species or group of species when thinking about biodiversity, one must avoid thinking of a specific agricultural practice, such as cultivation, when thinking of agriculture's effect on biodiversity.

An Economic Activity Index was calculated from the Census of Agriculture data, as the sum of the total capital value, gross sales, and total expenses for all farms in the Soil Landscape of Canada polygon, normalized to a per-area basis, and ranked from 0 to 1. The Economic Activity Index map is shown in Figure 14.

The Economic Activity Index was multiplied by the biodiversity physical factors map. The result was ranked from 0 to 1, to create the Biodiversity Risk Factor, shown in Figure 15.

The Combined Environmental Scan Rating

Each of the risk factors described above results in a ranking from 0 to 1 for each land location. These rankings can be combined with equal weighting by simply adding them, or other weightings can be identified depending on the precedence to be assigned each factor. After considering several weightings, the team settled on an equal weighting of all components except air quality, which is given a half-weighting. Air quality is given a lower rating because we generally have less data on air quality, and we have less confidence in the use of manure and cultivation measures as a surrogate for the effects of agricultural intensity on air quality.

The final environmental scan rating is then created by spatially adding the surface water, groundwater, soil, and biodiversity risk values, plus $\frac{1}{2}$ the air quality risk value. These sums were then ranked from 0 to 1. These results were then classified into three percentile groups, as follows:

High Priority: 75 to 100th percentile range
 Medium priority: 50 to 75th percentile range
 Low priority: 0 to 50th percentile range

Results

A map was produced to display the final combined environmental scan rating. Landscapes associated with the highest 25 percentile were ranked as high priority, and the lowest 50 percentile ranked low priority. The 50 to 75th percentile range is ranked as medium priority. Results of these rankings, in terms of land area and number of farms, are shown in Table 4. Figure 16 shows the final map of the Environmental Scan for Agriculture in Alberta.

Table 4: Number of farms and land area identified in each of the three classes.

Priority Level	# of Farms	% of total farms	Area farmed (km ²)	% of farmed area
Low	11950	28	71000	37
Medium	26240	53	94640	49
High	9160	19	26070	14

The precise delineation of three priority classes, from continuous variables, is necessarily arbitrary, dependent on the percentile value selected. Medium priority areas immediately adjacent to high priority areas may be quite similar. While the tiny islands of high priority are informative in helping understand the system, some generalization of the high priority boundary will be required, when targeting programs and accounting success measures.

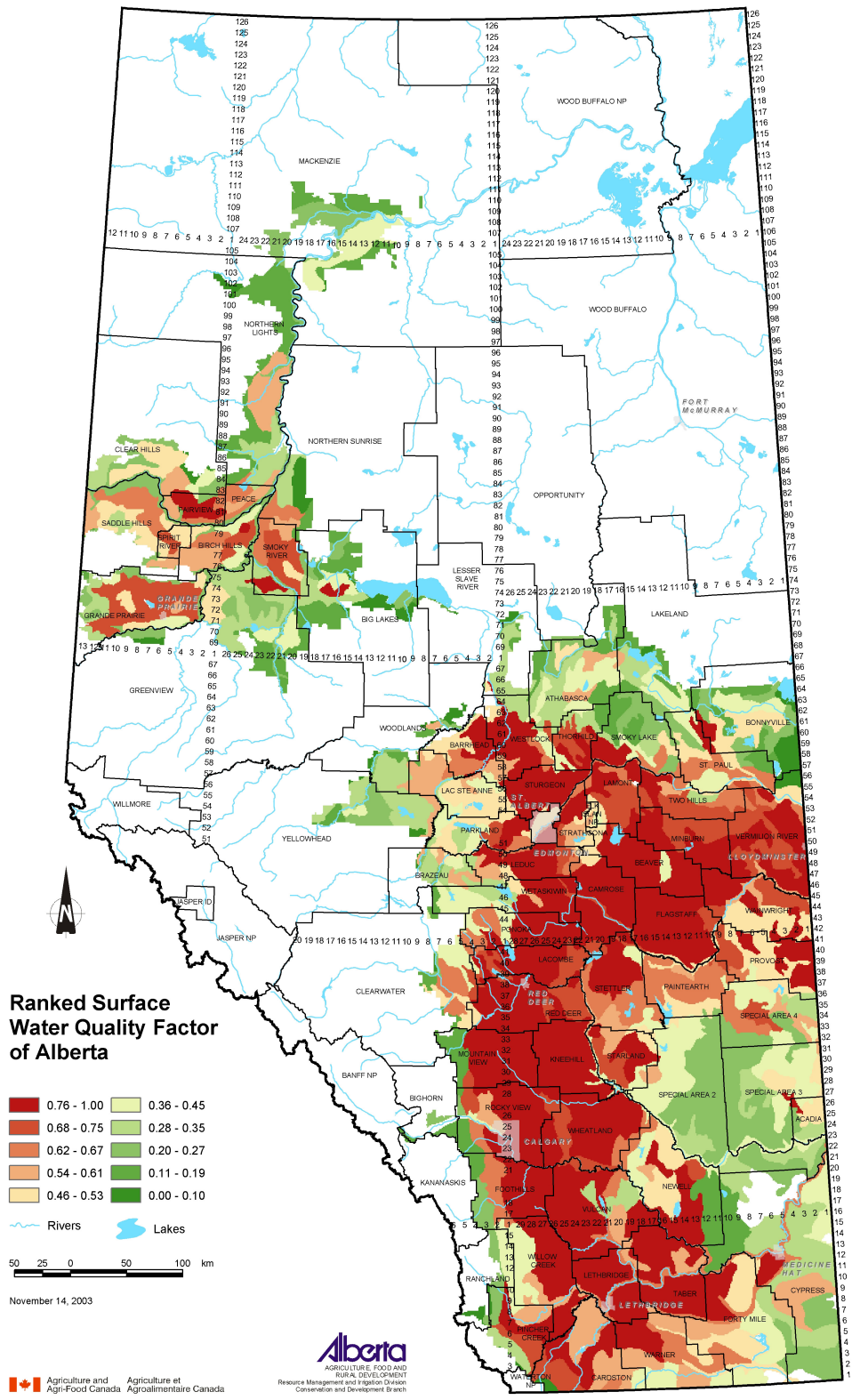


Figure 1. Map of Surface Water Quality Risk.

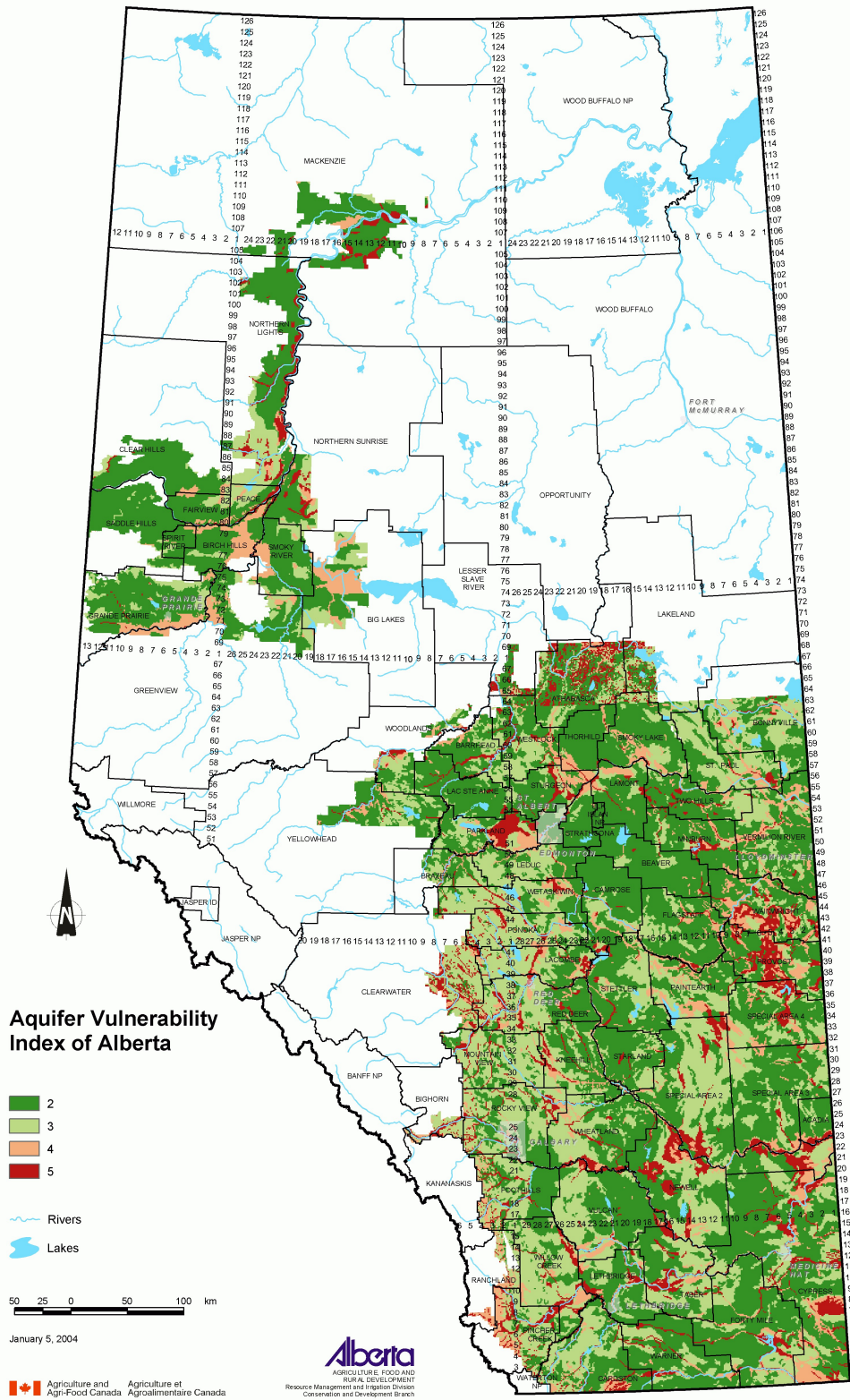


Figure 2. Aquifer Vulnerability Index Map.

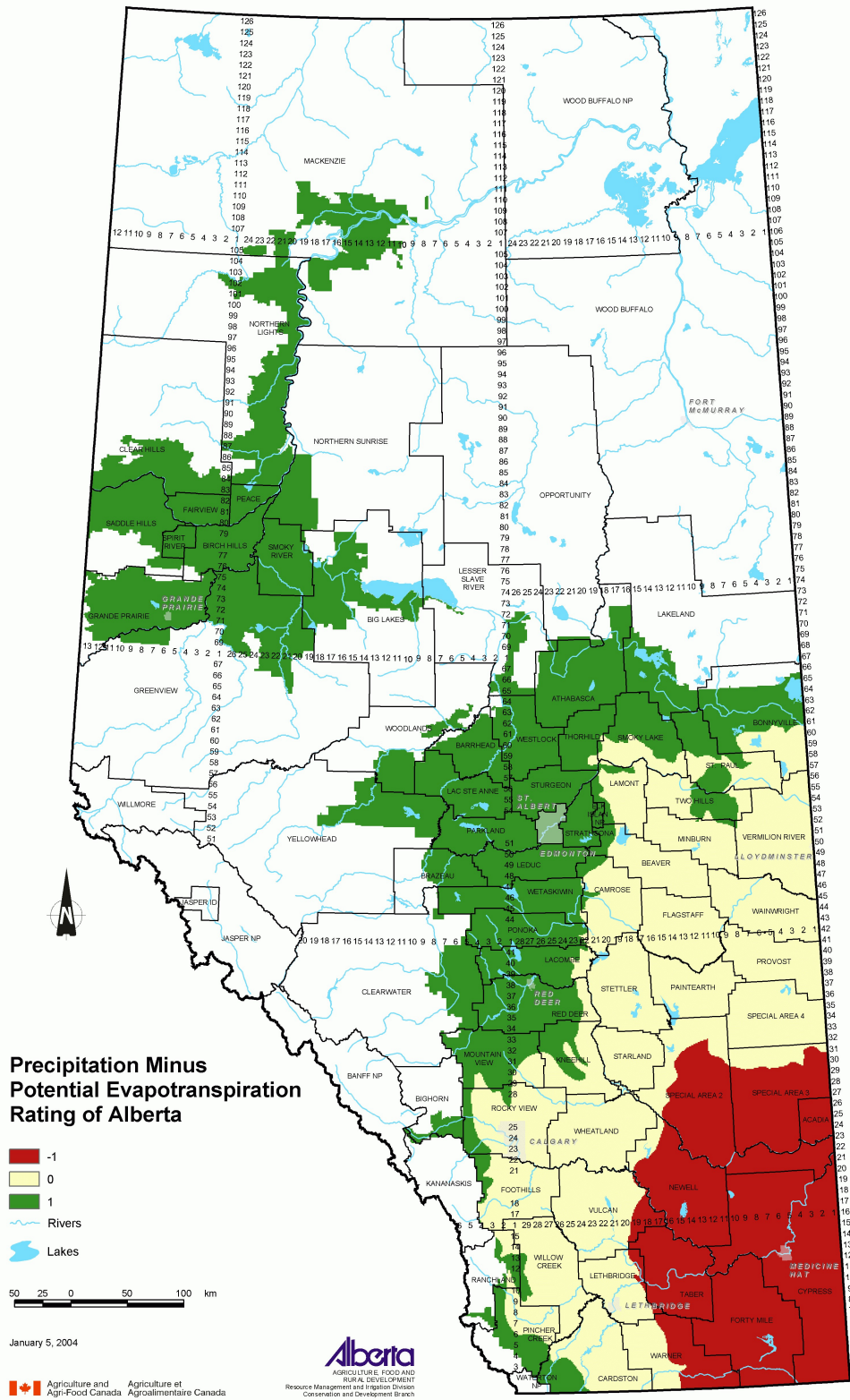


Figure 3. Map of precipitation minus potential evapotranspiration rating.

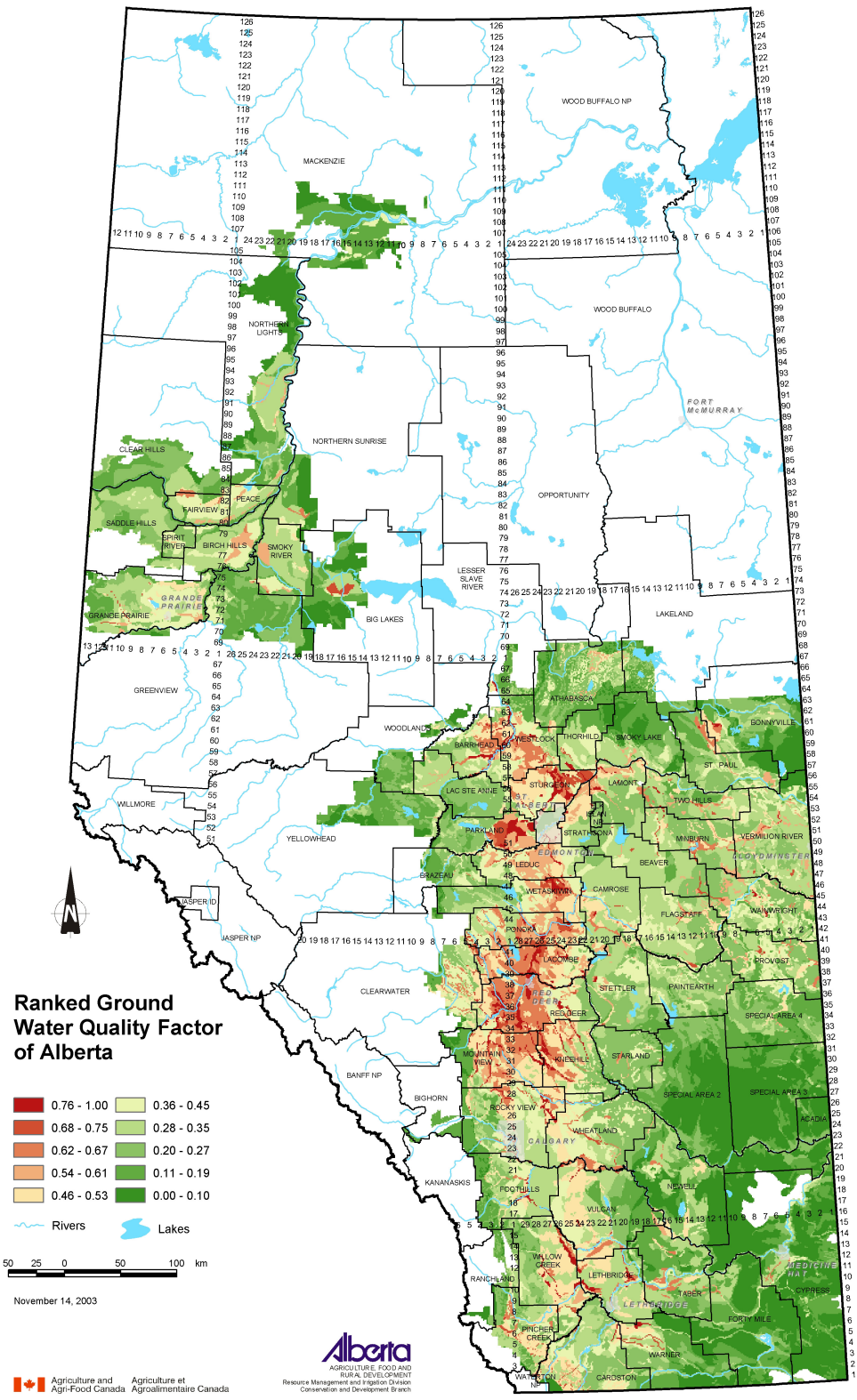


Figure 4. Map of Groundwater Quality Risk.

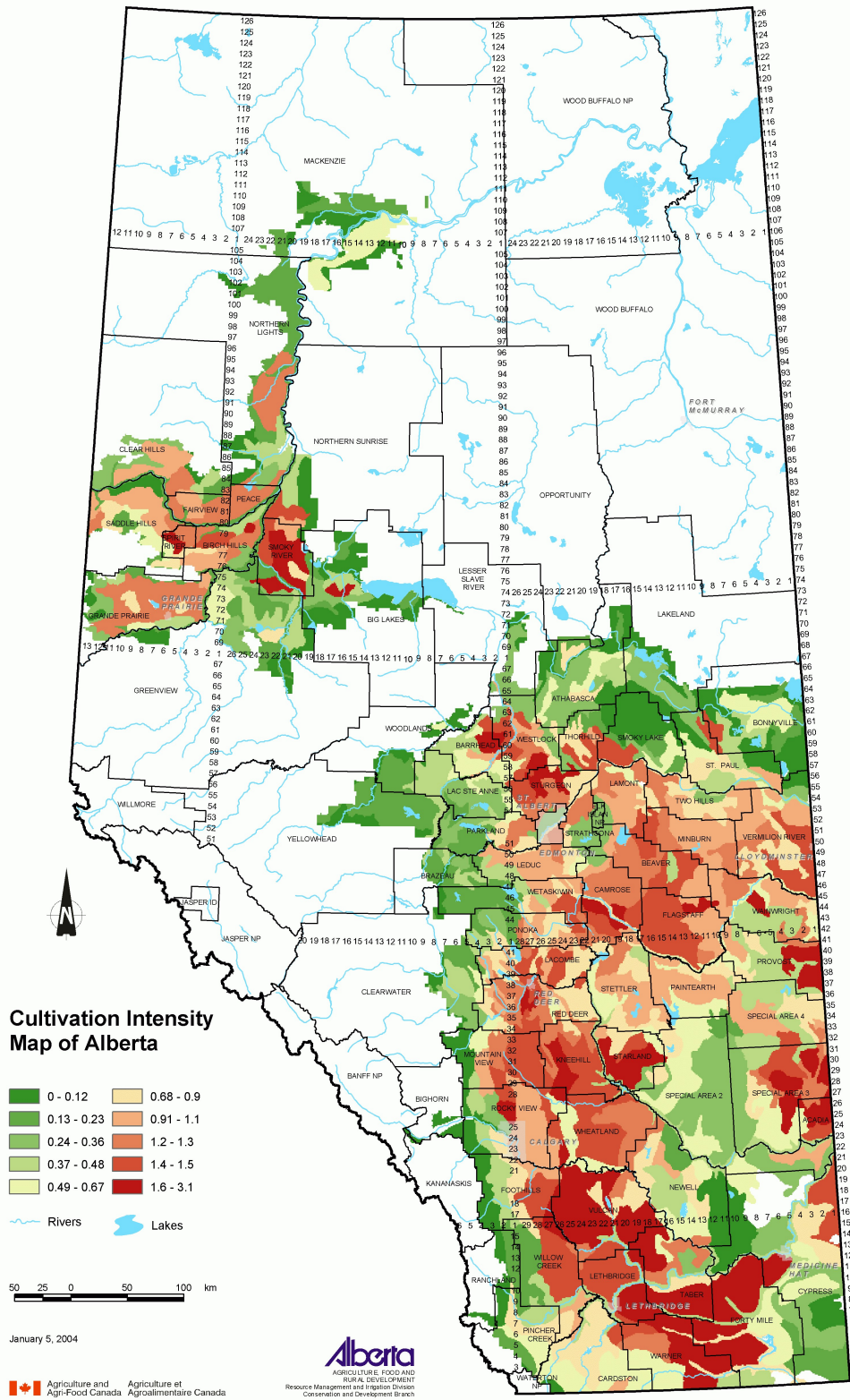


Figure 5. Cultivation Intensity Rating Map.

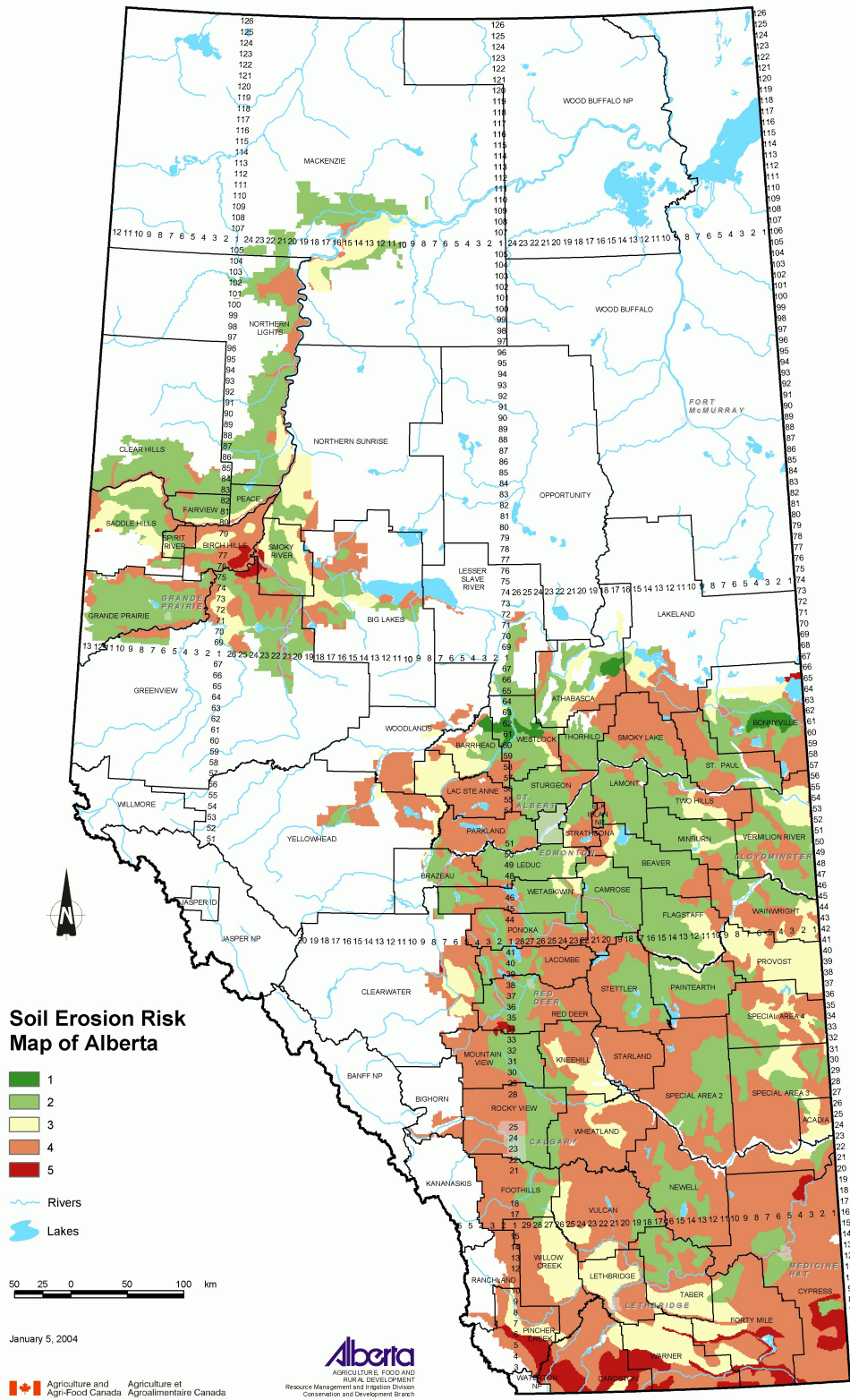


Figure 6. Map of Soil Erosion Risk.

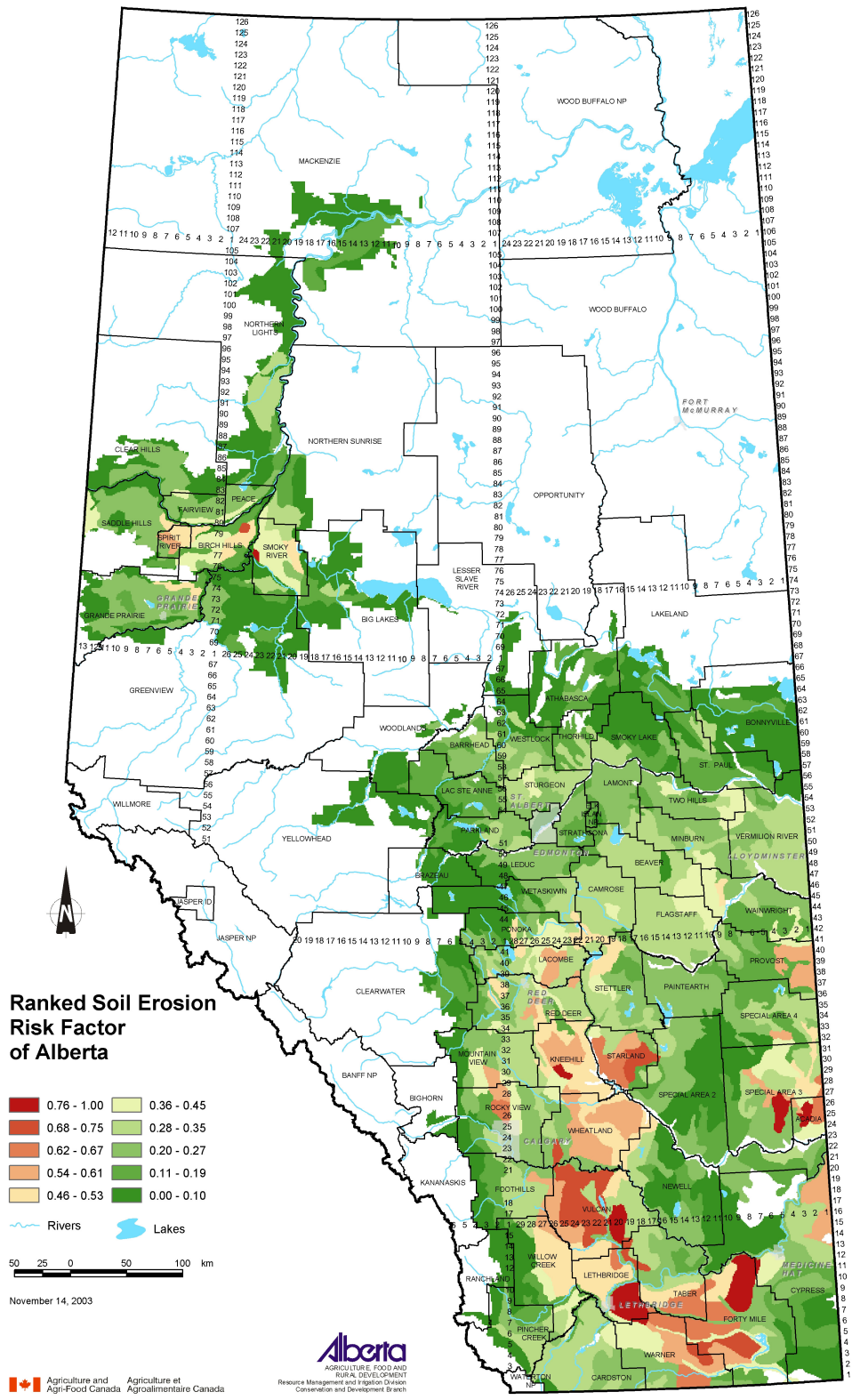


Figure 7. Soil Risk Map.

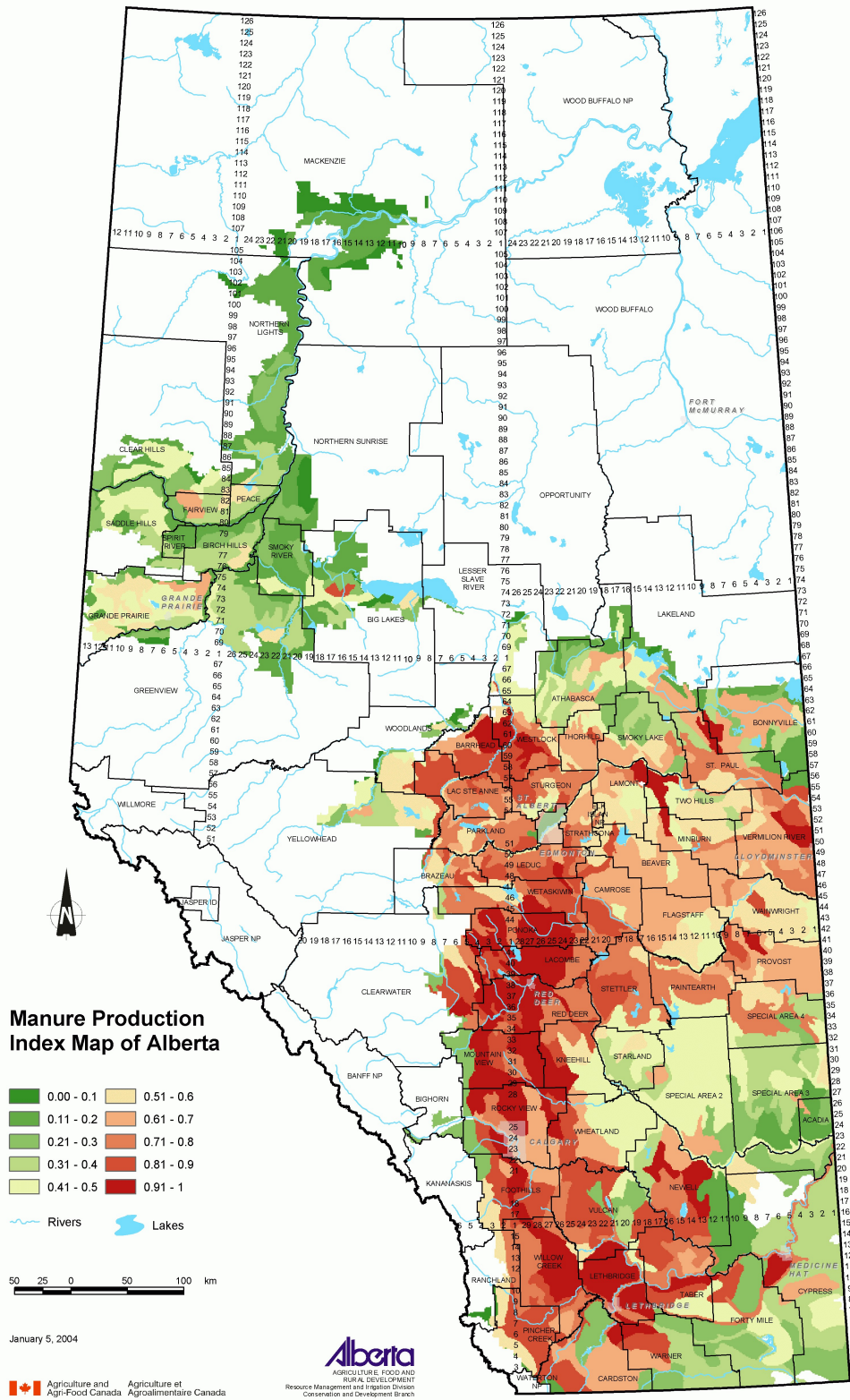


Figure 8. Manure Production Index Map.

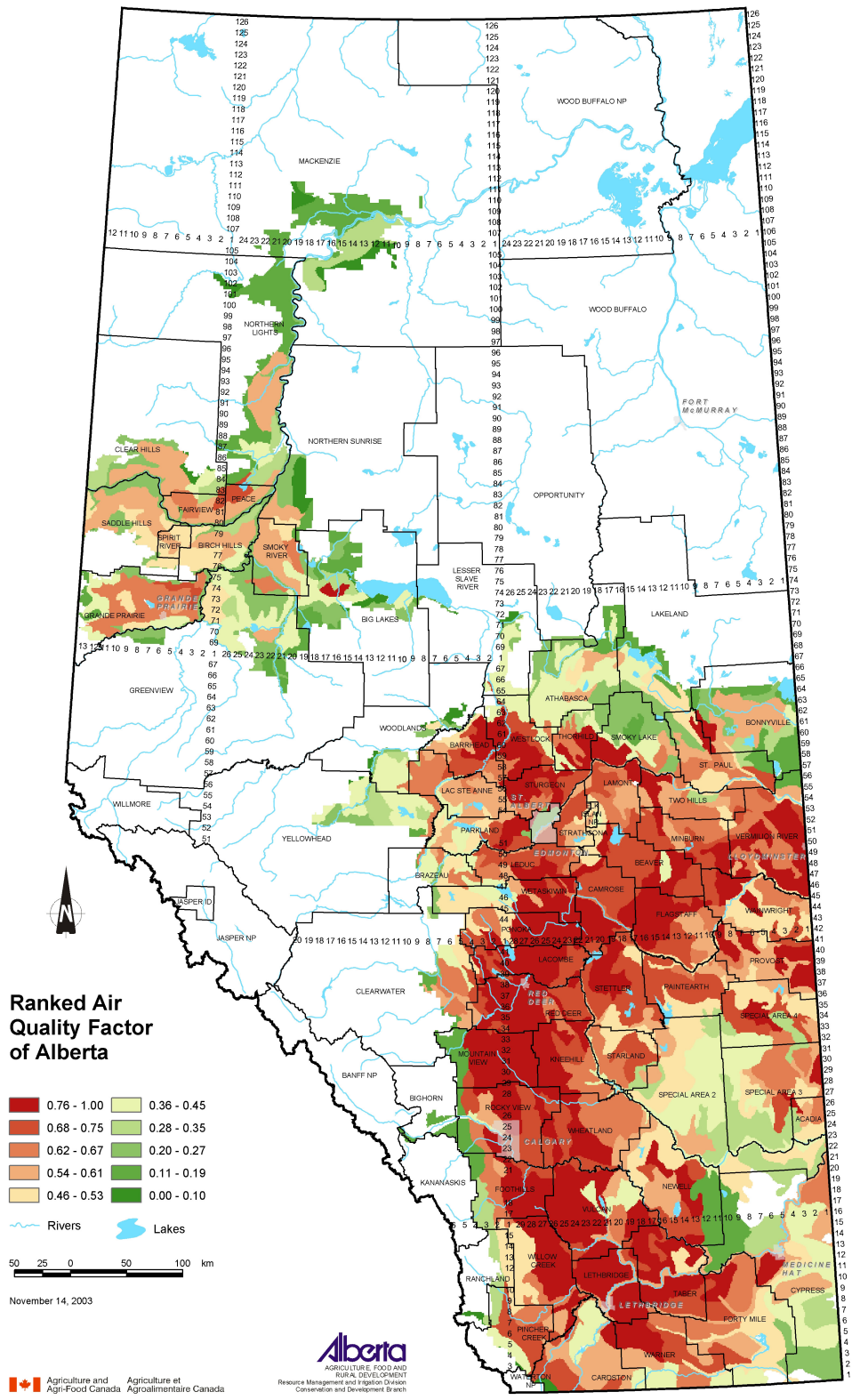


Figure 9. Map of Air Quality Risk.

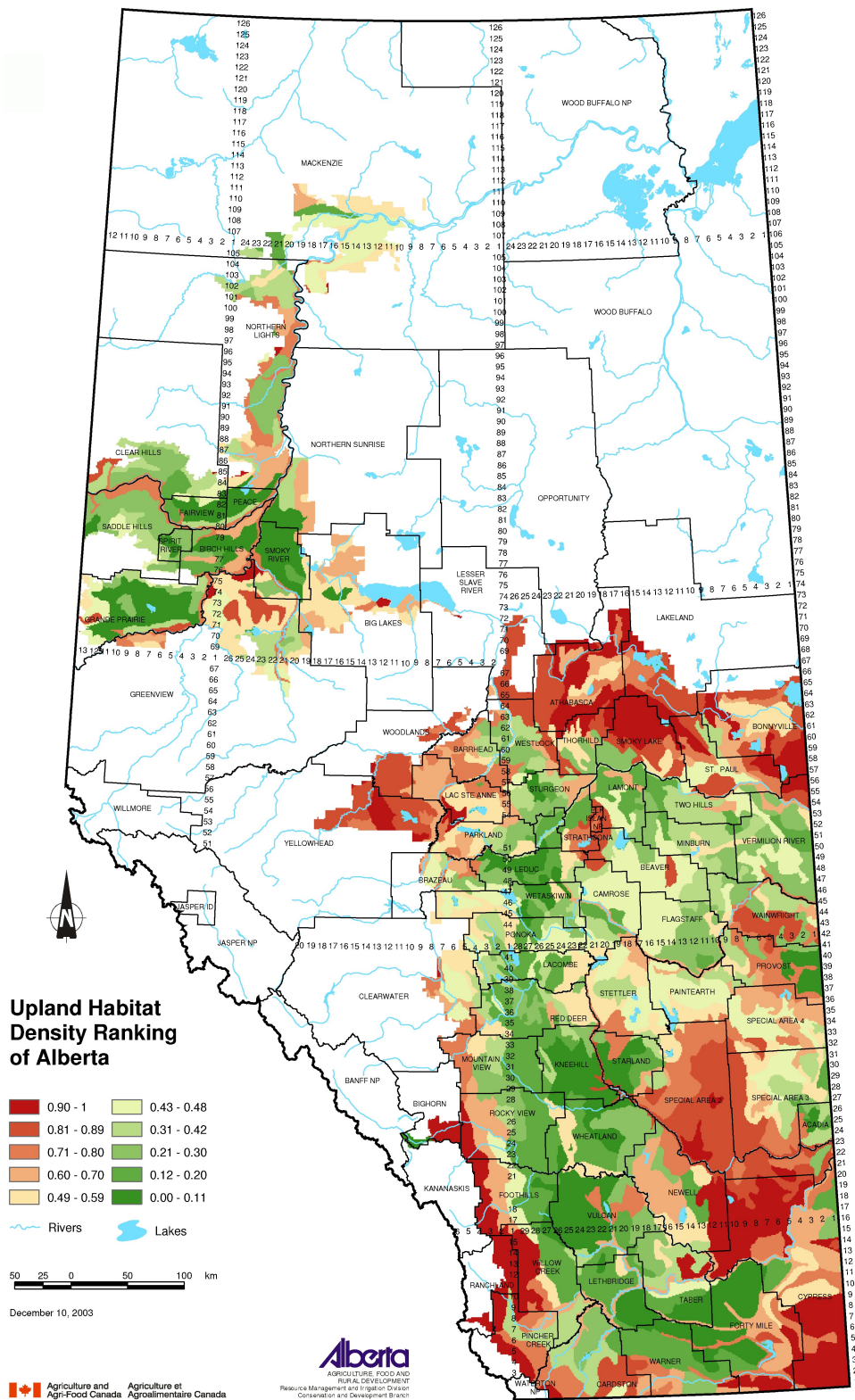


Figure 10. Density of Upland Habitats Map.

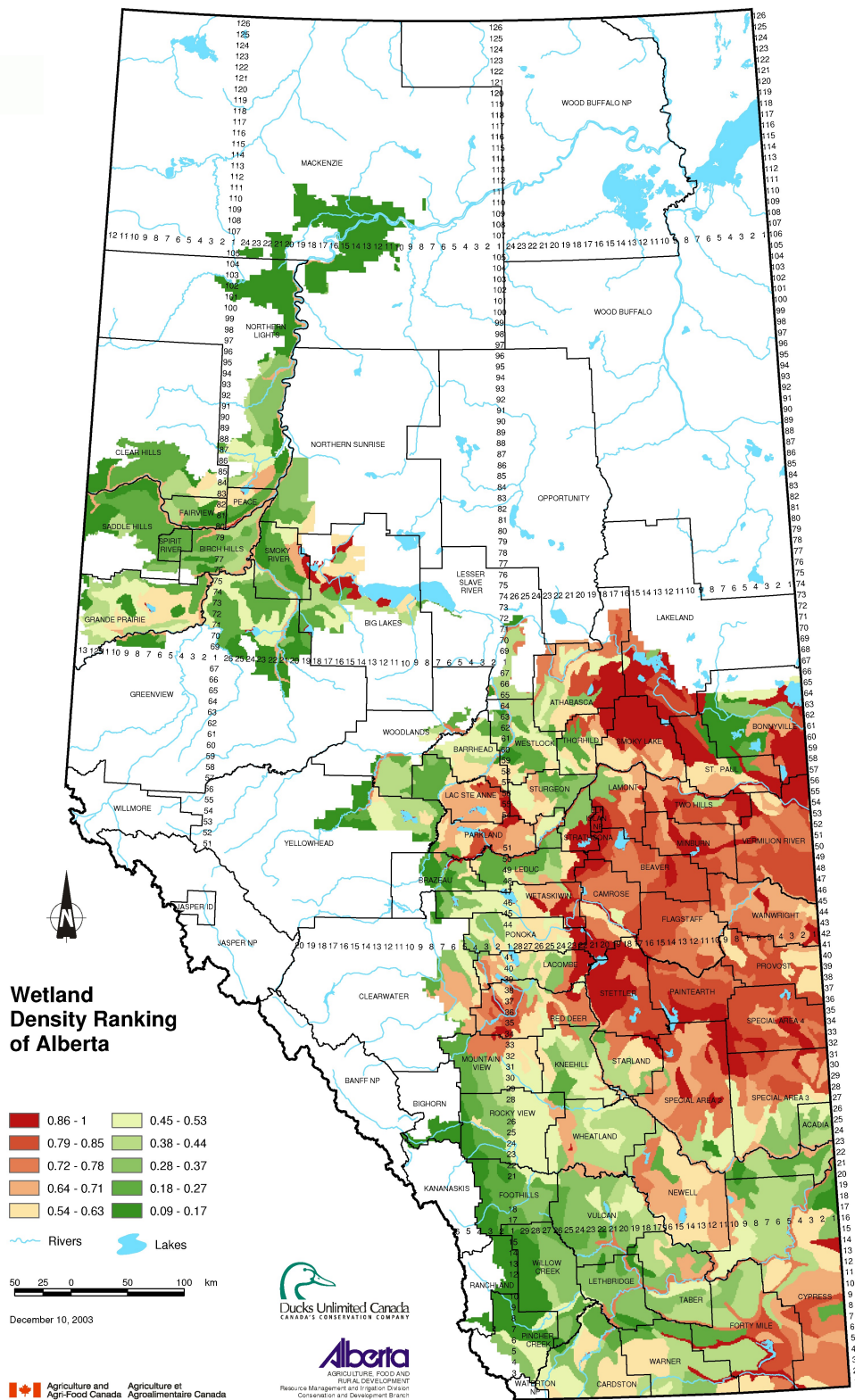


Figure 11. Wetland Density Map.

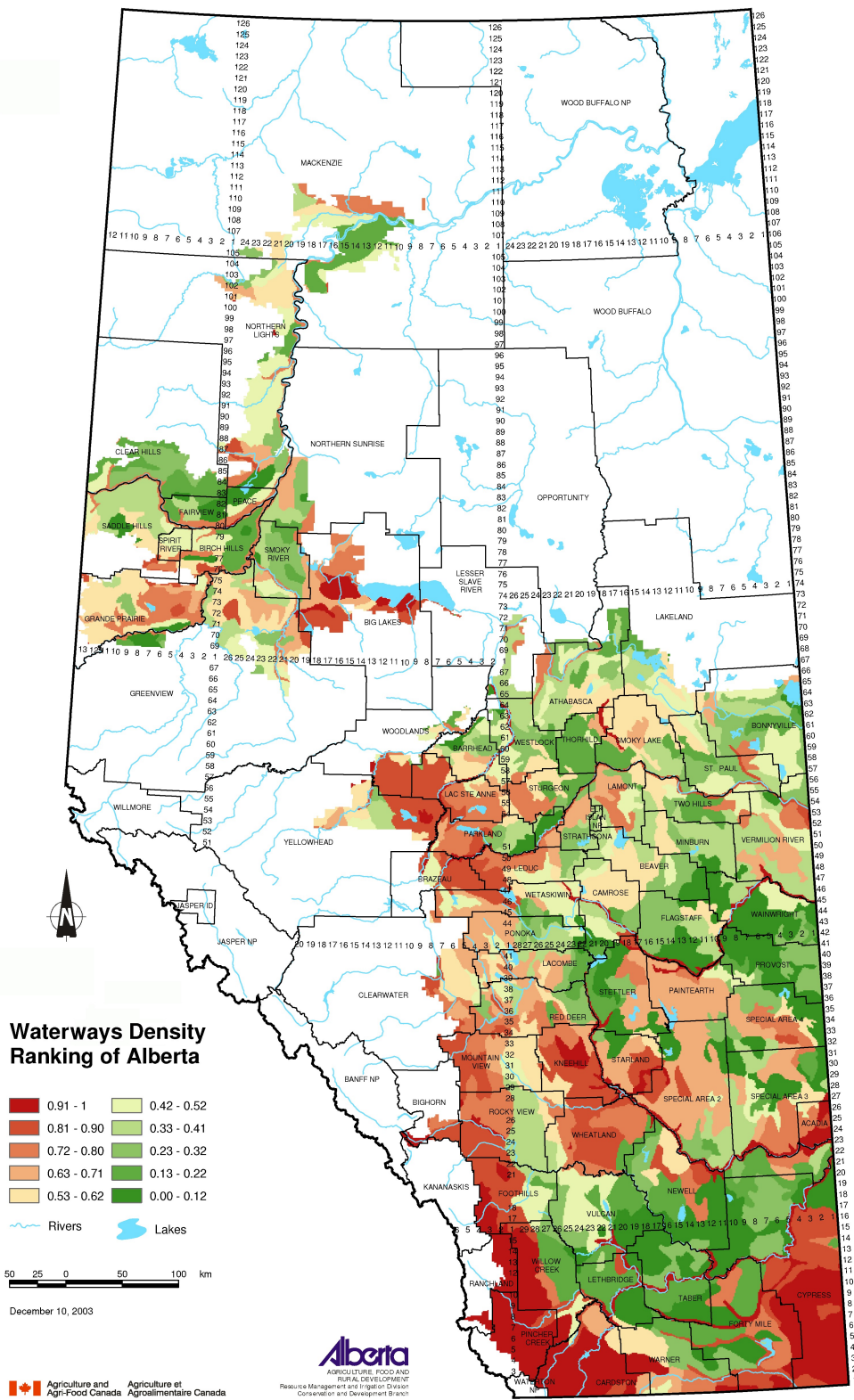


Figure 12. Waterway Density Map.

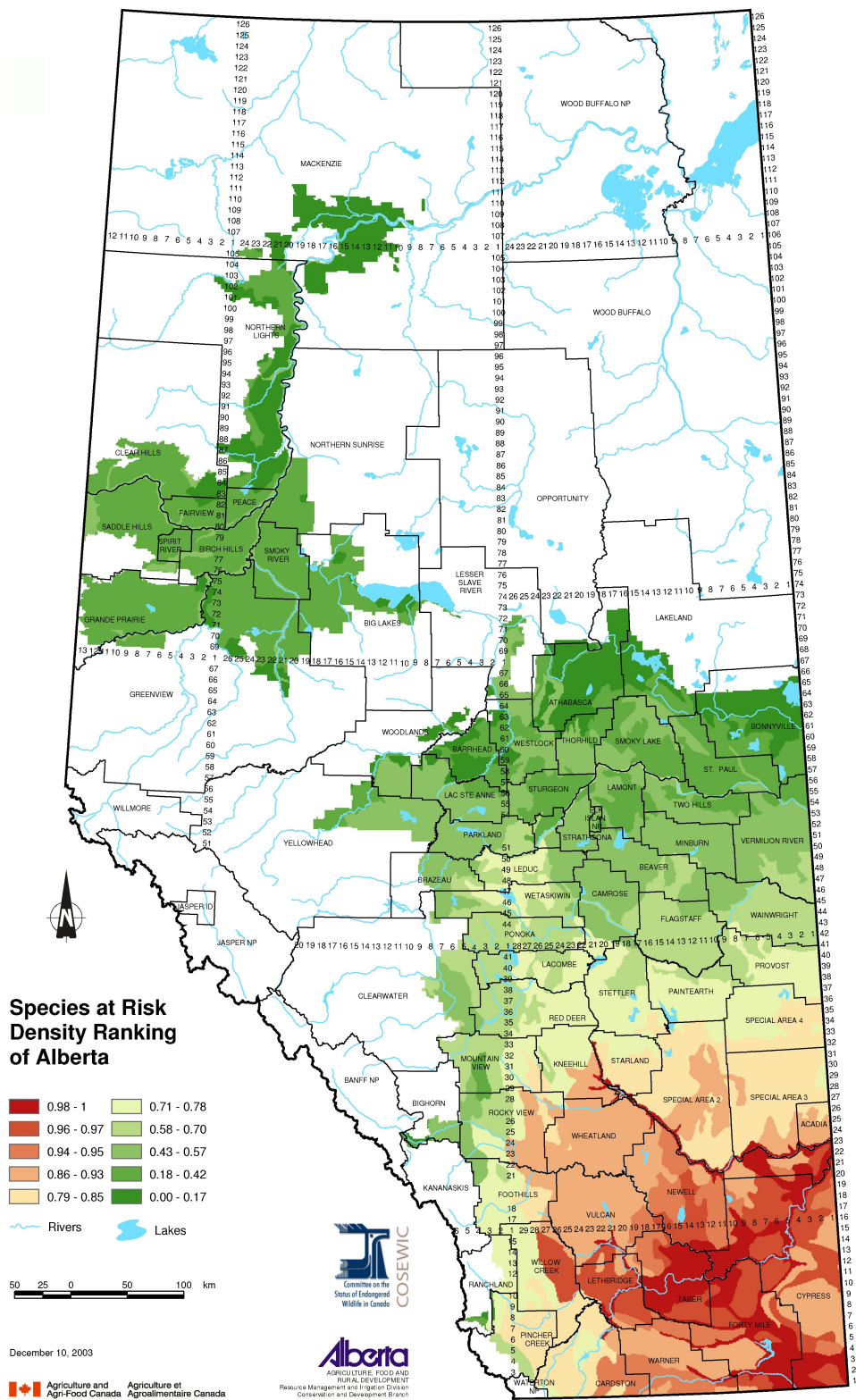


Figure 13. Number of Species at Risk Habitats Map.

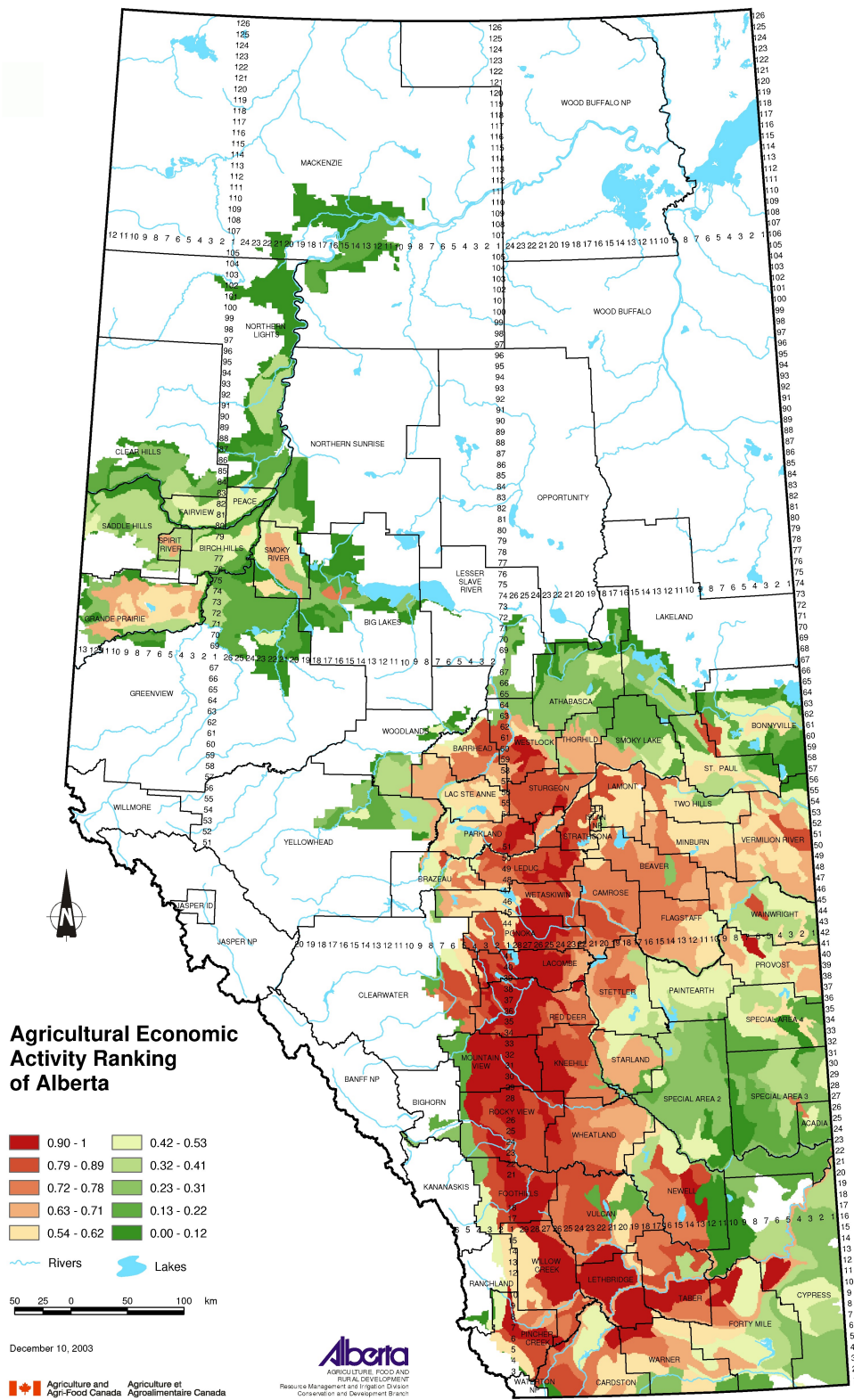


Figure 14. Economic Activity Index Map.

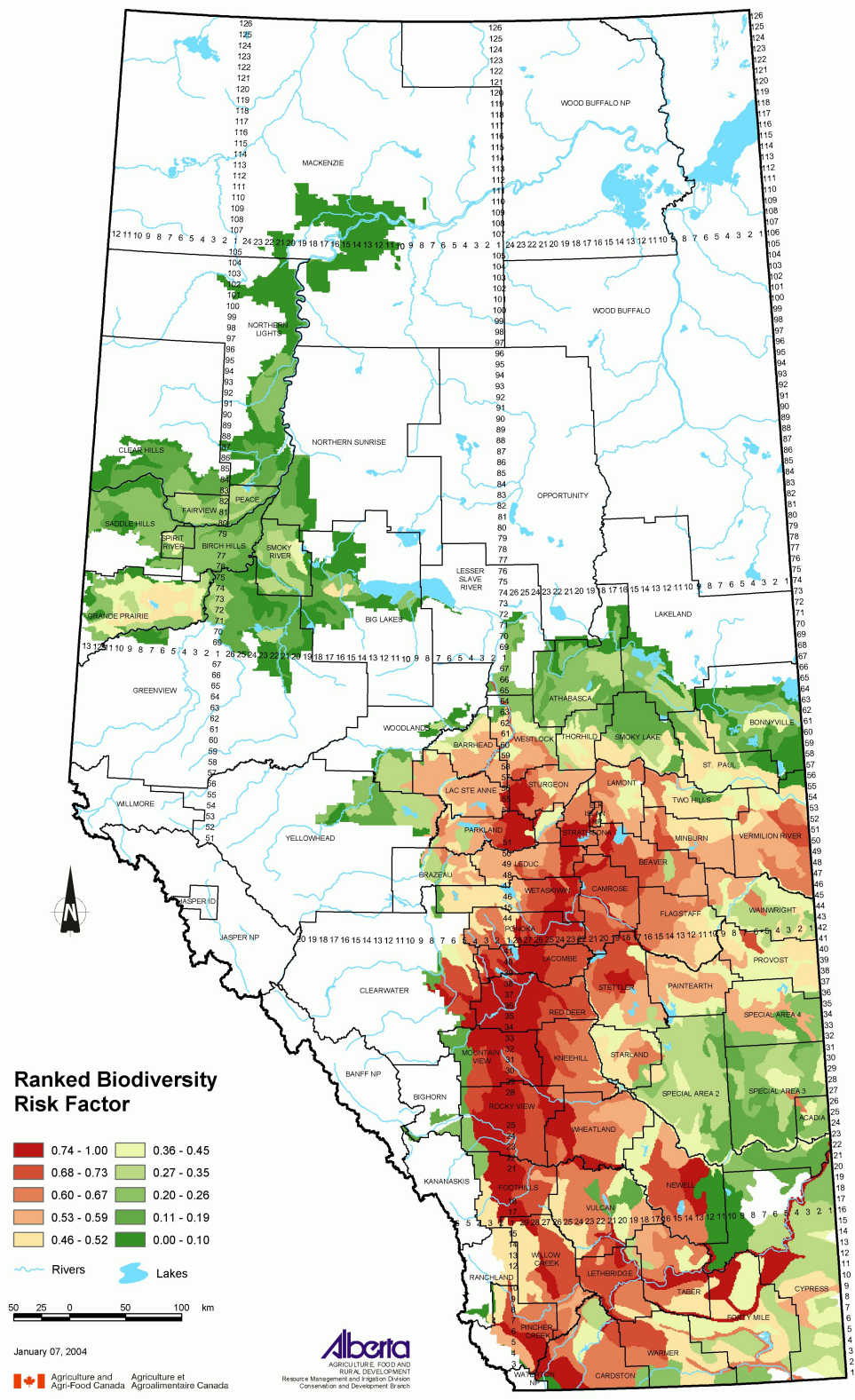


Figure 15. Map of Biodiversity Risk.

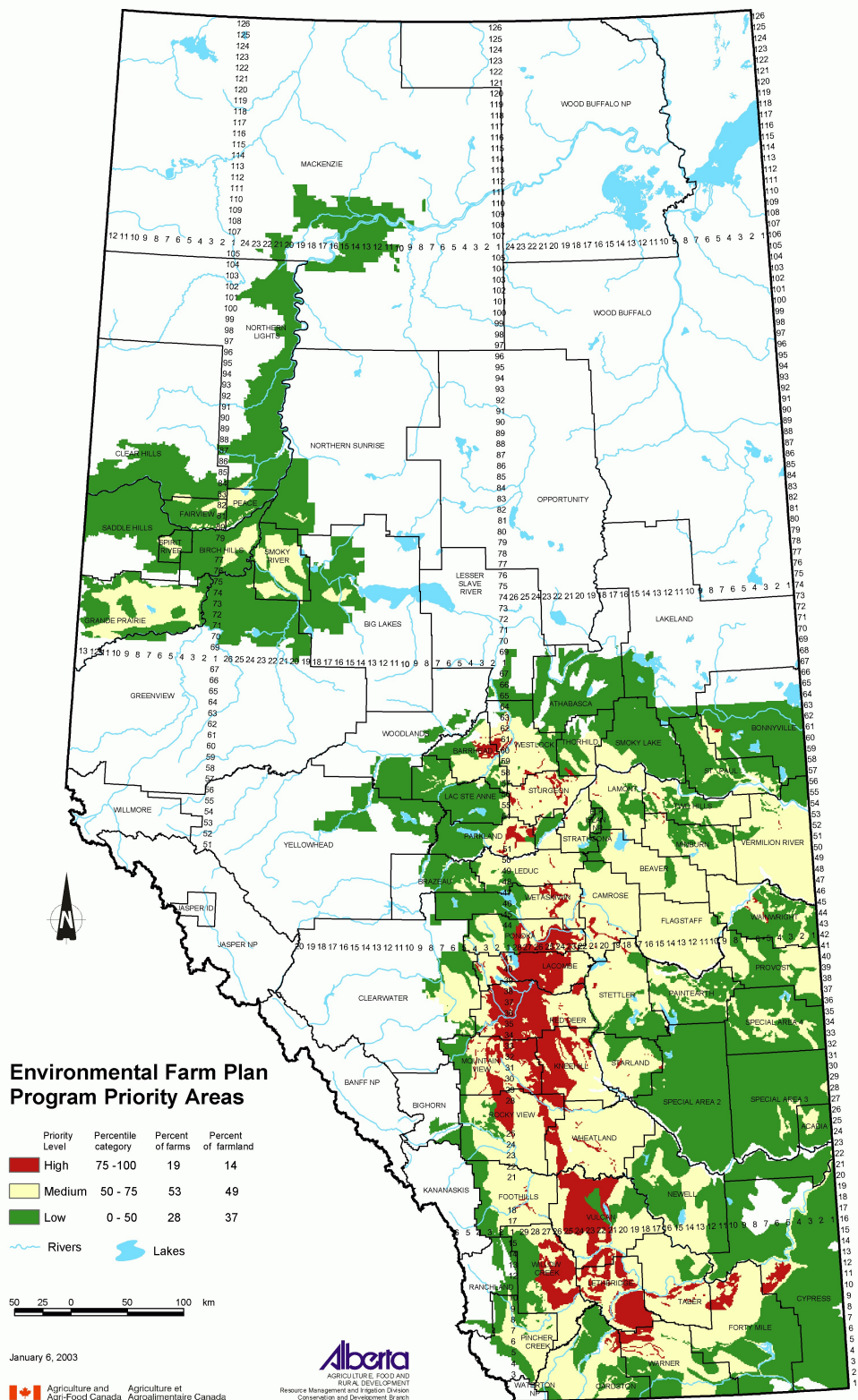


Figure 16: Environmental Farm Plan Program Priority Areas Map.

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