Boyne- Morris IWMP Agriculture Information

REQUEST: The following questions arose during the public consultations. The project management team would greatly appreciate any information you could provide to answer these specific questions:

1) Are there any Manitoba-specific studies of tile drainage impacts to downstream water quality? Are there examples of tile drainage systems that have gated outlets or reverse irrigation potential? What do we know about the efficiency of these systems in Manitoba?
2) To what extent has land use and land cover changed in this watershed over the last 30 years? What are the driving factors behind these trends?
3) Are there specific beneficial management practices that could be implemented to help retain water during periods of drought or manage excess water during wet periods?
4) What adaptation tools or activities can residents of the watershed adopt to prepare for climate change and variability?
5) How vulnerable are dryland farmers in this watershed to agricultural drought? What variables best dictate this vulnerability? For example, are producers on sandy soils more vulnerable than those on heavy clay soils? Or would crop type play a larger role than soil type in determining vulnerability? Using the 2015 AAFC crop inventory below extracted for the Boyne-Morris watershed (if you think this is reflective of current conditions), please describe which types of crops being grown in the watershed that are most vulnerable to drought. Conversely, which crops are most drought tolerant? Are producers shifting to farm more drought tolerant crops overall?

Name	Spring Wheat	Canola/Rapeseed	Soybeans	Corn	Grassland	Oats	Beans	Barley	Winter Wheat	Pasture/Forage	Sunflower	Potatoes	Flaxseed	Rye	Hemp	Peas	Millet	Canaryseed
Percent	24.82	21.72	20.61	6.04	4.05	3.44	1.79	1.39	1.24	1.20	1.01	0.65	0.63	0.29	0.20	0.17	0.05	0.03

6) How vulnerable to drought are cattle (or other animal) farmers? What variables best dictate this vulnerability? For example, size of dugout and water source (e.g. spring fed, snowmelt fed, etc.), access to a deep and reliable groundwater source, hay availability, etc.
7) Is it common for producers to implement mitigation measures such as reduced tillage, shelterbelts, fallow management, or other methods to reduce drought impacts? Is there any information available on: (i) which mitigation techniques are most often implemented, and (ii) which mitigation techniques are most successful?
8) 2006 and 2011 census of Agriculture data suggest a general decrease in the number of cattle farms (including the number of animals), and to a lesser extent, similar trends for the number of hogs. Are these trends continuing into 2016? If available, please provide information on other observed trends in agriculture within this region.

In addition to the responses to these questions, the project management team would gratefully accept any land use planning and agricultural information you have relevant to this watershed.

Information/ March 2017

Q#1. Are there any Manitoba-specific studies of tile drainage impacts to downstream water quality? Are there examples of tile drainage systems that have gated outlets or reverse irrigation potential? What do we know about the efficiency of these systems in Manitoba?

The question regarding the impacts of tile drainage and water quality are addressed in a webinar that was held on February 28th. This was the second of a 4 part webinar series relating to tile drainage.

This webinar was funded by the Red River Basin Commission. Organization and support from Manitoba Agriculture was provided mainly by Mitch Timmerman.

The 2nd seminar – link attached looked at the downstream impacts of tile drainage, and address the questions raised by the questions from the Boyne Morris IWMP open house. The first webinar looked at the hydrology of tile drainage.

The link below will be active for 6 months and provides the answers to the questions in a webinar format.

https://www.youtube.com/watch?v=N7mSkY0lgKo&feature=youtu.be

Summarizing what is in the webinar information to answer the questions.

Water Quality changes from Tile

The installation of tile drainage will change to some extent the method that water leaves agricultural land. Some of the water will continue to leave farmland by surface runoff, while some will go through the tile.

Manitoba research data on water quality relating to tile drainage is available from the following sources.

University of Manitoba, Hespler Study, near Winkler, led by Dr. Sri Ranjan: While the main purpose of this study was to look at sub surface irrigation there is research data that may be able to provide information on the questions of water quality leaving a tile drained system. There are numerous research documents published from this study.

University of Manitoba, Classen Farm Study, near Culross, led by Dr. David Lobb: This study is still ongoing. Preliminary data is becoming available, and is referred to in the webinar series.

Agriculture and Agri Food Canada – Unpublished data, referred to in the webinar series:

To put the impacts of the change in water hydrology and water quality perspective in the water shed, and the changes that happen when tile is installed, there would have to be a very good understanding of the water shed. As tile is installed, there will be some impact to both flow rates and water quality. To fully understand these changes, from a watershed perspective, there needs to be a considerable amount of understanding of the impacts.

The Boyne Morris IWMP area is well developed in terms of drainage, both surface and tile, and irrigation. The watershed is a good area to develop a good understanding of the impacts of changes to a water shed from drainage developments. It will take a considerable amount of effort to quantify.

What do we know about gated outlets or reverse irrigation potential: The terms we use refer to "Control Structures (Gated Outlets)" and "Sub surface irrigation (Reverse irrigation)". For research data, refer to the U of M, Heslper Dr. Sri Ranjan, noted above.

There is one farm operation in the Boyne River – Morris IWMP that does have a sub surface irrigation system. This farm has a water rights licence for irrigation use. The water delivery mechanism that is used is to flow water back through the tiles to supply water to the crop roots.

There is potential for the use of more tiles drain systems to be used for sub surface irrigation. However, there must be a source of water. The Boyne River is fully allocated for firm flow (summer), but does have the opportunity to capture more spring flow to use for irrigation purposes. There is a water supply demand study (KGS Engineering 2008) that highlights the water use and demand in the Boyne River area.

<u>The above paragraph starts to answer question 3 Beneficial Management practices. (</u>Are there specific beneficial management practices that could be implemented to help retain water during periods of drought or manage excess water during wet periods?)

In periods of drought, or just "normal" moisture deficits farmers irrigate. In the Boyne River area, there is irrigation using summer flows on the Boyne, enhanced by the Stephenfield Dam. There are retention ponds built to capture spring flows, used later in the growing season as a water supply. The Pelly Lakes Project also captures spring flows. Other producers irrigate with water (summer flows) from the Assiniboine River, supplying water to land which is in the Boyne River Basin.

During wet periods farmers look to improvements in drainage systems, with surface and sub surface systems used to lessen the impacts of excess water.

Dufferin has developed a Policy and Procedures Manual for the municipality (Attached). This was developed to help guide the rapid increase in tile drainage installations in the area, for council and landowner information.

Q#2. To what extent has land use and land cover changed in this watershed over the last 30 years? What are the driving factors behind these trends?

The following information was taken from the Soils bulletins, which date back to 1995

Table 1: Landcover percent for the watershed based on Soil Bulletin information

land cover	hectares	%
Annual crop land	326072	79
Forages	7752	2
Grasslands	31902	8
Trees	27172	7
Wetlands	2601	<1
Water	2880	<1
Urban and transportation	16012	5

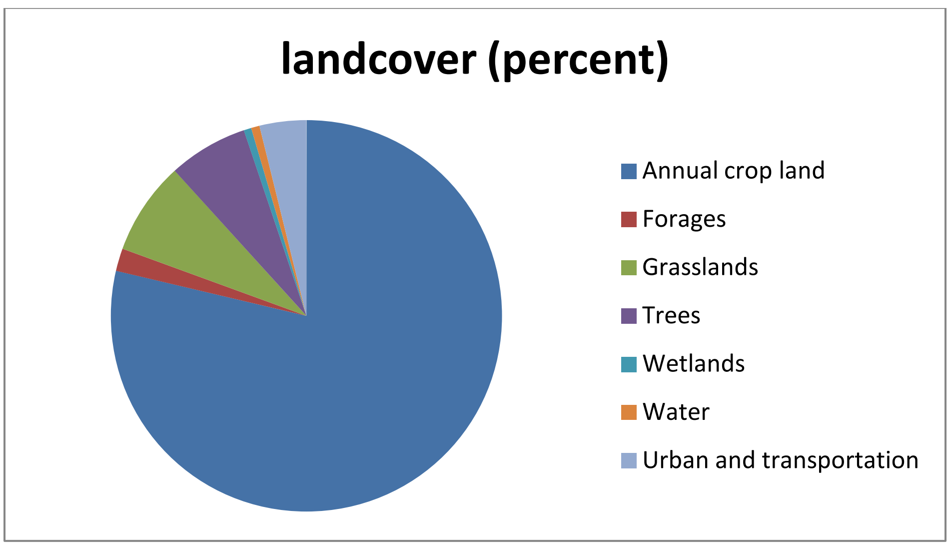


Figure 1: Percent land cover in the watershed based on Soils Bulletin information, adjusted by watershed area

Please see the attached landcover image based on 2015 satellite imagery. (BM Landcover 2015).

The area remains primarily in annual crops. (Table 1, Figure 1, Map of landcover) What has changed over time which does not show up well from satellite imagery, is the expansion of rural residential, the enlargement of settlements, and the associated development of roads and infrastructure. The town of Dufferin, for example, has recently gone through a major expansion of borders, to accommodate both increased growth of people as well as mostly agriculturally related industries.

Farmland Acres in the Watershed

There is a decrease in acres of farmland in some municipalities, but not others (Table2). The increase in Dufferin may reflect the increasing trend to own land outside of the municipality for large corporate farms. Overall, however, in this area, farmland is mostly staying as farmland, compared to areas around Winnipeg, where farmland is being lost to development at an alarming rate.

Table 2: Farmland acres based on Canada Census information.

These figures are not adjusted for watershed boundaries but include the entire RM.

RM farmland acres	1991	1996	2001	2006	2011
Norfolk-Treherne	159,761	160,053	164,010	161,647	130,482
Macdonald	264,345	283,156	282,399	276,992	270,688
Thompson	111,245	113,359	109,646	109,024	108,160
Roland	103,428	110,071	110,665	119,443	98,917
Morris	245,208	256,181	244,493	259,264	246,158
Dufferin	202,976	219,759	213,769	221,192	236,435
Lorne	226,897	227,478	230,560	231,552	223,593
Ritchot	78,463	83,134	66,126	63,152	71,319

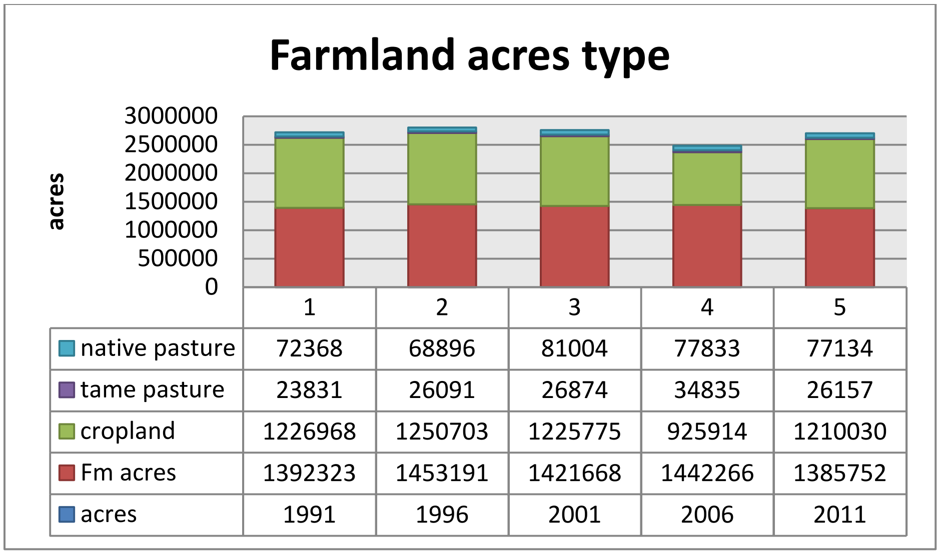


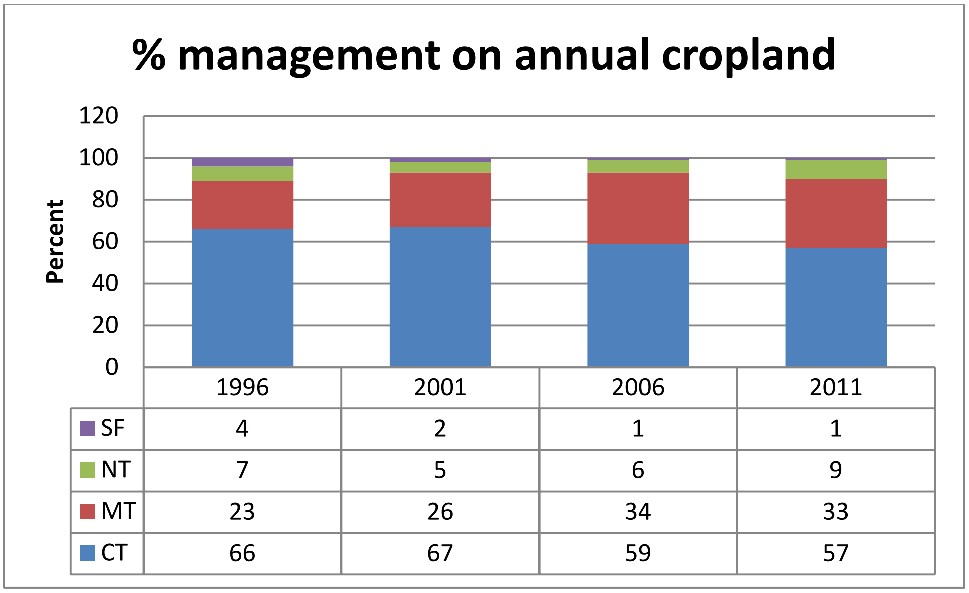
Fig 2: Farmland acre uses, based on Canada Census information 1991-2011.

For agriculture, land use trends have been relatively stable since 1991, maintaining farmland in annual crop production. (Figure 2, Table 3). The small amount of native pasture in the area has not deceased over the census period, but is remaining stable, probably reflecting the location of this land in hilly or riparian areas which are not easily changed.

Table 3: Agricultural land use based on census data

Land Use /a/yr	1991	1996	2001	2006	2011
farmland	2057612	2126088	2095895	2102961	2016219
Tame pasture	51218	47521	51838	61785	50284
Native pasture	145026	140995	155061	151414	127412
cropland	1752993	1767960	1753081	1445979	1704124
Tillage/yr					
Conventional T	0	1075686	1130961	179851	925221
Minimum T	0	370286	431995	567501	539515
No-T	0	115506	77509	110376	150044
Summerfallow	0	62612	37672	10142	16310
CMNS total/yr		1624090	1678137	876870	1631092

Annual Cropping Practices



	1996	2001	2006	2011
SF	4	2	1	1
NT	7	5	6	9
MT	23	26	34	33
CT	66	67	59	57

Figure 3: Annual Cropping Practices: Annual crops management according to the census information. (SF: Summerfallow: NT: No-Till: MT: Minimum Tillage; CT: Conventional Tillage)

These statistics (Figure 3) include neighbouring municipalities that touch on the watershed boundaries. Census information indicates that most of the tillage is conventional, with a slight increase in minimum tillage. What is not reflected in the numbers is that the common definition of conventional tillage is different than it used to be, being much closer to what used to be called minimum tillage, with some crop residue remaining after harvest to protect the soils surface.

Summerfallow is a practice only used when weather prevents a crop to be seeded, or when a field is being prepared for seeding of fine forage seed species. Rarely is it used for dry weather conditions, to build moisture as in the past.

Q#3 Are there specific beneficial management practices that could be implemented to help retain water during periods of drought or manage excess water during wet periods?

Any BMP that builds soil health will improve water retention during drought and improve porosity during wet periods. Soil structure and aggregate stability helps to allow water to infiltrate into the soil, which is beneficial if you are either trying to hold more moisture in a drought or increase water holding capabilities in extreme moisture conditions. To build soil structure, you could reduce tillage, increase perennial crops in the rotation, plant cover crops, add manure or other organic matter, decrease stubble removal/burning – anything that reduces disruption of the soil and increases the addition of organic matter.

In addition to building soil water storage capacity, any project that increases surface water storage capacity, including constructed retention ponds and restored wetlands would be beneficial for this purpose, on a larger scale.

As noted at the end of the first question related to tile drainage: In periods of drought, or just "normal" moisture deficits, farmers irrigate. In the Boyne River area, there is irrigation using summer flows on the Boyne, enhanced by the Stephenfield Dam. There are retention ponds built to capture spring flows, used later in the growing season as a water supply. The Pelly Lakes Project also capture spring flows. Other producers irrigate with water (summer flows) from the Assiniboine River, supplying water to land which is in the Boyne River Basin.
During wet periods farmers look to improvements in drainage systems, using surface and sub surface to lessen the impacts of excess water.

Q#4. What adaptation tools or activities can residents of the watershed adopt to prepare for climate change and variability?

A process to develop a watershed-based climate change adaptation strategy could be an effective way to determine adaptation tools and activities that could be adopted to prepare for climate change. Such a process would likely include at least some of the following activities, and should prioritize those most applicable to the watershed:

- Develop irrigation systems
- Develop and maintain water supply systems
- Avoid over-allocation of water resources
- Perform regular maintenance on wells to ensure they stay functional
- Adopt farming systems that build soil organic matter to:
    - increase water holding capacity
    - increase water infiltration rate
    - build soils with a structure that allows roots to grow without restriction from compacted layers
    - build soil structure that provides resistance to wind and water erosion
- Adopt water conserving practices and technologies
- Develop and maintain drainage systems, both surface drainage systems and well designed state-of-the-art tile drainage systems
- Build flexibility into crop and livestock systems to allow for changes in case of extreme weather events, e.g. strategies for selling off livestock in case of feed shortage; strategies for using weather damaged crops
- Develop a drought management strategy and a flood management strategy, or maybe an overall water management strategy
- Establish a committee responsible for drought and flood preparedness

Q#5. How vulnerable are dryland farmers in this watershed to agricultural drought? What variables best dictate this vulnerability? For example, are producers on sandy soils more vulnerable than those on heavy clay soils? Or would crop type play a larger role than soil type in determining vulnerability? Using the 2015 AAFC crop inventory below extracted for the Boyne-Morris watershed (if you think this is reflective of current conditions), please describe which types of crops being grown in the watershed that are most vulnerable to drought. Conversely, which crops are most drought tolerant? Are producers shifting to farm more drought tolerant crops overall?

Farmers will be impacted by drought, when the next major drought occurs. Farmers on sandier soils, which have a lower water holding capacity, will potentially be impacted more. Producers will shift crops, and crop varieties, if they feel it is appropriate based on climatic conditions.. Over the past few years, excess water and drainage issues are more of a concern than drought.

The level of vulnerability to agricultural drought of dryland farmers in this watershed depends on a number of factors and likely has not been fully assessed by anybody. The level vulnerability will depend to a certain extent on the level of access to the resources listed in the figure below.(Fig 4)

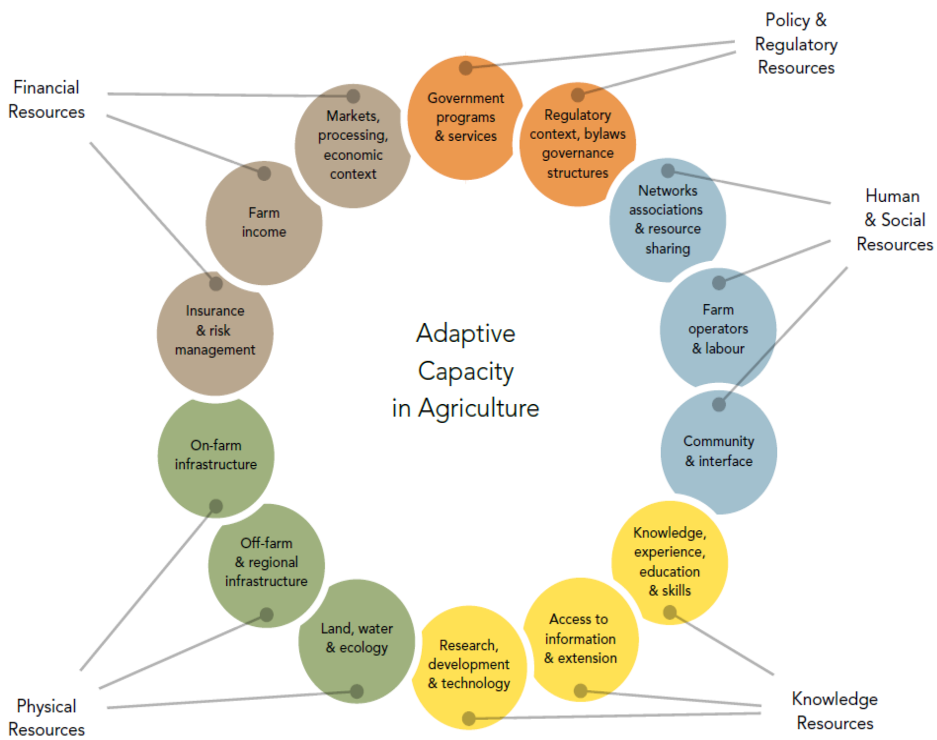


FIGURE 1. ADAPTIVE CAPACITY IN BC AGRICULTURE

Fig 4: Source: 2013. BC Agriculture Climate Change Adaptation Risk + Opportunity Assessment Series: Grain and Oilseed Production-Peace Region Snapshot Report

Both soil type and type of crop will influence vulnerability to drought. Sandy soils will be highly prone to drought, as are clay soils, due to their low available water holding capacity (i.e. while clays hold a lot of water, they can retain this water tightly making it unavailable to plants during short-term drought). Soils with the most available water holding capacity (and therefore, less prone to short-term drought) are loam soils. (Figure 5)

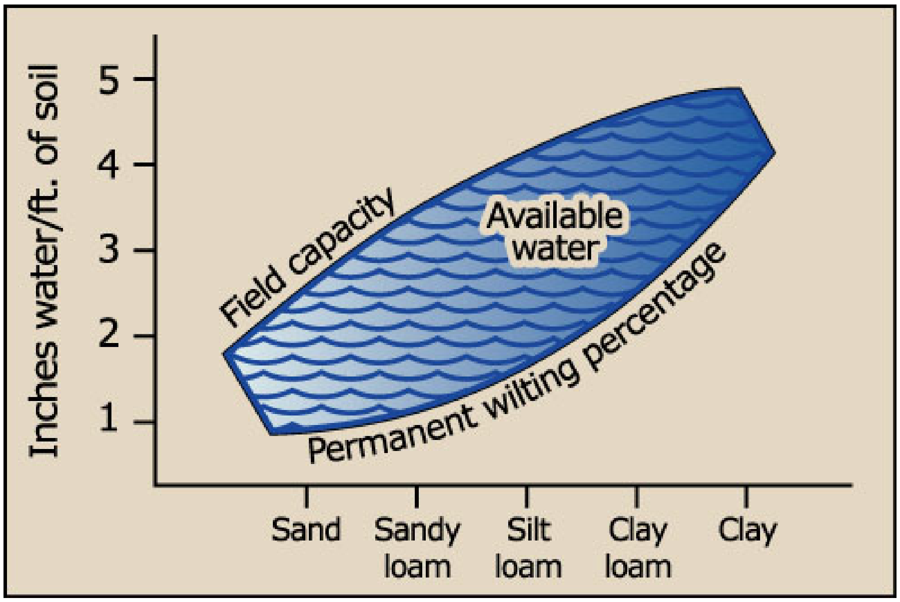


Figure 5: Available water range based on soil texture

In recent years excess moisture has been more of a problem than drought so farmers have not been shifting to more drought tolerant crops and have instead been adapting crops more tolerant of excess moisture such as soybeans.

All crops are vulnerable to drought, but some more than others. Perennial forages and grassland may be less vulnerable to drought than annual crops because of deeper root systems, but management also has a large influence on how drought tolerant a perennial pasture may be. Overgrazing of pastures, for example, deceased rooting depth and overall resiliency of plants to withstand any moisture extremes. Annual crops vary in level of drought tolerance with sunflowers, peas and winter cereals having some advantages over other crops due to deeper rooting (sunflowers), efficient water use (peas), and early maturity to avoid typical drought periods in mid-summer (winter cereals).

According to the green paper, *Moving Toward Prairie Agriculture 2050* (attached), market demand is one of the main drivers in determining what crops we grow on the Prairies. International demand will determine to a large degree what crops are grown on the Prairies. Below is an excerpt from the paper:

Crop selection and rotation is the core of our Prairie production system. Here, we provide some thoughts on a potential outlook for selected crops over the next few decades.

Wheat – Wheat area likely to remain the largest of any single crop. Winter wheat area likely to increase as winters become milder and crop stress increases in summer months. Market outlook is not compelling large increases in area, but world demand should be steady for the crop.

Canola – Canola area likely to increase slightly. Soybeans will cannibalize southern growing areas from canola, but central and northern growing areas will still be predominately canola growing regions. Strong oilseed demand will keep canola as one of the most profitable cropping alternatives.

Barley – Area likely to be under pressure as the humid, cooler growing areas are shrinking in the 2050 climate scenario. Barley is in direct competition with canola and wheat, the area likely to shrink. International demand is expected to be constant, but domestic use will be under pressure from increasing corn supplies.

Pulse crops – Pulse area likely to increase in the drier, more arid growing environments that are expected in 2050. Strong international demand structure is a positive for pulse crops.

Soybeans – The transition to larger soybean area in the Prairies is already underway with former marginal areas in southern Manitoba and Saskatchewan now growing the crop in a regular rotation. Strong international demand is expected to continue to support area growth.

Corn – The movement of corn is also underway to parts of southern Manitoba and southern Alberta, but the transition expected to take a longer time period than soybeans. This is primarily due to the fact that the international demand structure for corn is not as strong as that for soybeans. Corn will also be limited by the dryness in parts of the southern Prairies. Corn has large moisture requirements to produce economically attractive yields.

Sorghum and millet – Sorghum and millet are two possible crops to move into the drier areas of the Prairies in 2050. These crops represent a possible feed grain for the driest areas, but sensitivity to frost will limit area even with increased growing season. International demand for sorghum and millet is mixed, but domestic use as a feed grain is a possibility.

In conclusion, the cropping patterns on the Prairies in 2050 will be a mixture of new crops and existing old crops. Wheat, barley and canola will still dominate the landscape in the northern growing areas. In southern areas, the regular rotations will be supplemented with a significant amount of soybean and corn crops. Strong oilseed demand should be the primary factor in keeping oilseed area relatively high in relation to the cereal crop area. Pulse crops will also see strong international demand, which should in a drier, warmer climate result in a larger adaptive area.

The 4 major crops in the area, wheat, canola, soybeans and corn will likely have more acreage shifted by the impact of market prices, than by the farmers anticipation of drought.

Q#6. How vulnerable to drought are cattle (or other animal) farmers? What variables best dictate this vulnerability? For example, size of dugout and water source (e.g. spring fed, snowmelt fed, etc.), access to a deep and reliable groundwater source, hay availability, etc.

Most livestock producers have opted to develop water supply for livestock which is not totally weather dependant, such as piped water to troughs. However, most cattle on pasture likely have access to sloughs and other natural water, due to natural water collection in low lying areas, which may at times serve as the primary source of water. In this area, drought has not been a driving force behind changes in the cattle industry, related to water. Programs offered through the conservation districts for cattle watering have been helpful to make changes to keep cattle out of water, protecting human as well as livestock health.

It should be noted that grain farms predominate in this area, as the soil is predominately Prime Class 1,2,&3 soils, which have higher economic return under annual crops. If a drought were to occur, annual crop residue and available forages may support the livestock industry in the area, as livestock numbers are not high compared to the amount of cropland.

Q#7. Is it common for producers to implement mitigation measures such as reduced tillage, shelterbelts, fallow management, or other methods to reduce drought impacts? Is there any information available on: (i) which mitigation techniques are most often implemented, and (ii) which mitigation techniques are most successful?

Environmental Sustainability of Canadian Agriculture – Agri-Environmental Indicators Report Series (Report #4, 2016): http://publications.gc.ca/collections/collection_2016/aac-aafc/A22-201-2016-eng.pdf

Moving Toward Prairie Agriculture 2050 – Green Paper

Extreme events (floods or droughts) are very difficult for agricultural systems to adapt to.

These events have a limited impact on the long-term sown acreage choices.

The use of reduced tillage and no-till has been increasing continuously since the early 1990s, as a means to reduce fuel costs and improve soil health. In Manitoba, cropland area under conventional tillage (tillage practices that turn over the top 15 to 20 cm of soil, burying plant residues and exposing the soil, followed by secondary tillage to break up soil aggregates and produce a smooth, even seedbed) changed from 66% in 1991 to 38% in 2011. In the same timeframe, cropland area under conservation (reduced) tillage (tillage practices that break up the soil and kill weeds but do not turn the soil over, thus maintaining most of the crop residue on the surface) increased from 29% to 38% and no-till (management practice in which there is no tillage after one crop is harvested and the next crop is sown; all plant residues are maintained on the soil surface) increased from 5% to 24%.

Shelterbelts are a barrier of trees, shrubs or other perennial vegetation designed to reduce wind erosion. There has been a trend to remove shelterbelts and natural field barriers to accommodate larger machinery and remove older shelterbelts that have reached the end of their lifespan. Data has indicated that standing stubble is as effective as shelterbelts in snow/moisture capture.

Summerfallow is the practice of leaving a field without a crop for one year in order to control weeds and allow soil moisture levels to increase. Manitoba has less than 1% of its farmland in summerfallow. The decline in summerfallow has been driven primarily by the adoption of no-till, which has been made possible by the increased availability of effective herbicides and planting equipment that can effectively seed through crop residue on the soil surface. No-till offers several benefits: better retention of soil moisture, lower risk of soil erosion during fallow years, and reduced fuel use. Summerfallow acres increased in 2011 due to extreme moisture and an inability to seed. Summerfallow then allowed for weed control and to facilitate evaporation. This persisted for up for 4 years on some fields in southwest Manitoba.

Other methods to reduce drought impacts are discussed in question #4.

Q#8. 2006 and 2011 census of Agriculture data suggest a general decrease in the number of cattle farms (including the number of animals), and to a lesser extent, similar trends for the number of hogs. Are these trends continuing into 2016? If available, please provide information on other observed trends in agriculture within this region.

Market prices are reported weekly by Manitoba Agriculture at: http://www.manitoba.ca/agriculture/market-prices-and-statistics/livestock-statistics/livestock-market-prices-current.html

Livestock trends for the watershed are similar to those across the province. There is a trend to also market locally, especially into the Morden-Winkler area.

It should be noted, however, that the trend concerning the number of farms in total is likely going to continue to decline, which could lead to a further decline in livestock farm operations compared to grain farming. (Table 4, Figure 6)

Table 4: Number of farms (total), number of cattle farms, and number of Hog farms 1991-2011 census

	1991	1996	2001	2006	2011
# Farms	2157	2055	1796	1625	1365
#cattle	659	675	617	547	360
#hogs	350	282	234	177	86

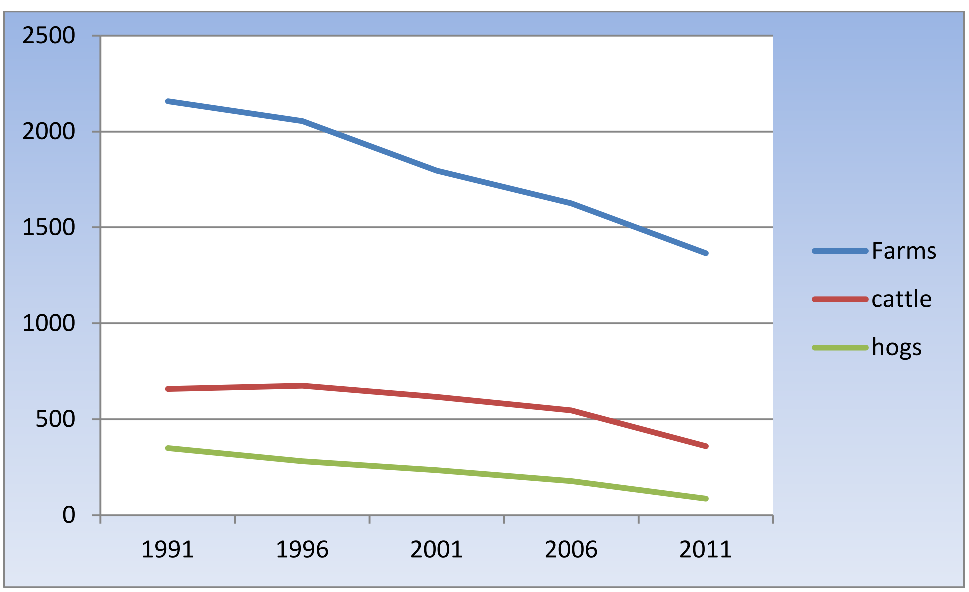


Figure 6: Number of farms, cattle farms and hog farms as reported in the 1991-2011 census.

Cattle and hog numbers fluctuate according to markets.(Table 5 and 6). The hog numbers have declined due to environmental regulations as well as market conditions. The area in the flood zone of the Red River Valley is particularly constrained for future hog industry expansion.

Tables 5: Number of cattle in municipalities 1991-2011 based on census information

RM # cattle	1991	1996	2001	2006	2011
Norfolk-Treherne	10,087	11,874	12,546	13,044	10,199
Macdonald	5,471	7,584	6,973	3,760	3,581
Thompson	4,941	5,906	6,422	6,831	5,280
Roland	1,170	1,667	1,320	1,621	472
Morris	1,299	2,661	1,414	1,204	1,450
Dufferin	11,840	13,423	12,925	14,605	14,501
Lorne	11,579	12,800	14,122	16,921	13,438
Ritchot	1,557	1,905	2,159	1,840	1,624
	47944	57820	57881	59826	50545

Tables 6: Number of hogs in municipalities 1991-2011 based on census information

RM # hogs	1991	1996	2001	2006	2011
Norfolk-Treherne	16,196	22,892	49,213	84,845	69,895
Macdonald	0	0	0	0	0
Thompson	7,623	28,759	27,521	30,308	29,069
Roland	5,185	20,657	5,895	6,438	x
Morris	21,666	40,282	50,769	119,709	118,966
Dufferin	28,383	21,512	32,157	39,017	37,242
Lorne	55,471	50,297	61,104	66,011	43,073
Ritchot	23,658	34,087	25,860	16,679	26,129
	158182	218486	252519	363007	324374

Currently, environmental issues related to land use and manure are reducing the flexibility of the livestock industry to respond to market demand. For example, livestock operations require setback distances (attached) to be followed, so large agricultural land parcels are required. Land designated for general agricultural uses are usually designated as having 80 acres for a minimum parcel size. This makes it possible to establish or protect livestock operations from interference of non-agricultural uses, such as housing development.

Increased non-agricultural housing in an area works against the establishment of new barns, and the expansion of others. The land base for manure applications needs to take phosphorus as well as nitrogen into consideration, which has increased the land required for application based on nitrogen alone.

The figures below indicate the observed trend in number of subdivision of agricultural land (Figure 7) and the acres involved (Figure 8) from 2013-2016. Stanley is included to illustrate the pressure to develop around larger centres such as Morden and Winkler.

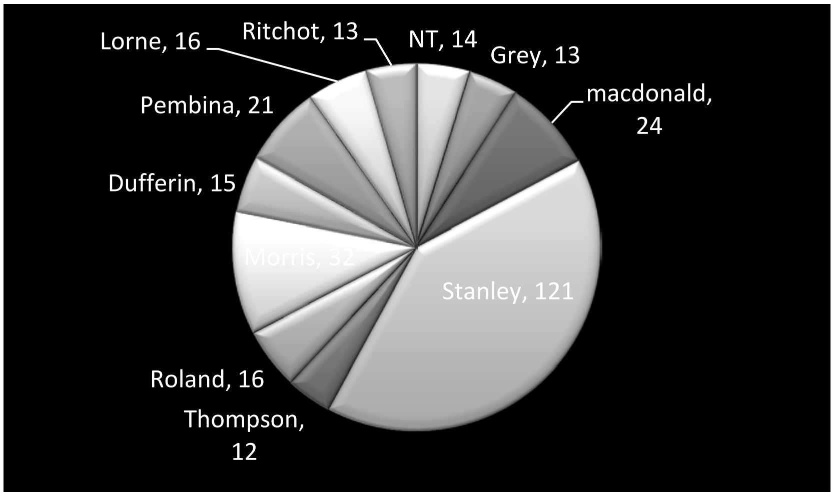


Figure 7: Number of subdivisions in agricultural areas 2013-2016 in area municipalities.

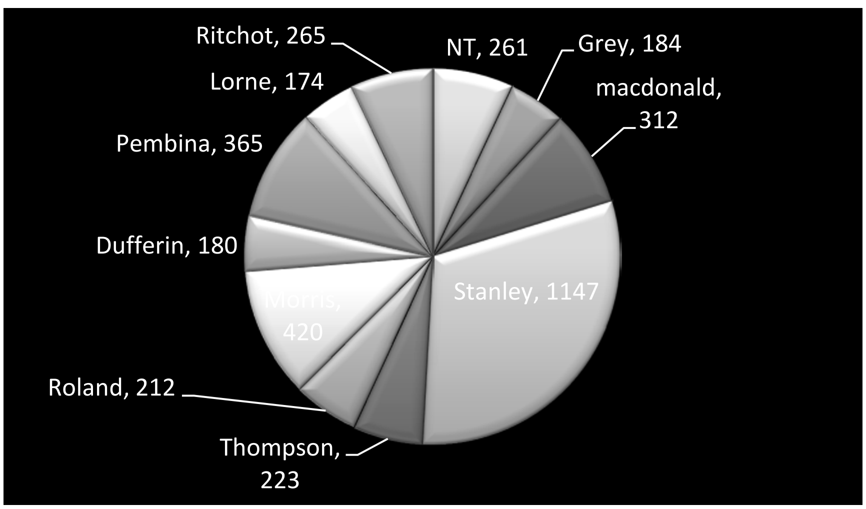


Figure 8: Number of acres of agricultural land removed from production due to subdivisions 2013-2016, in area municipalities.

Soils of Boyne-Morris Watershed

The Boyne Morris watershed covers parts of five physiographic regions. To the eastern side, the municipalities of Roland, Morris, Macdonald and Ritchot are mostly within the Red River Valley. The Pembina Escarpment divides parts of Dufferin and Lorne. The Lower Assiniboine Delta is found in the RMs of Thompson, the west side of Dufferin and the south part of Norfolk Treherne. The Pembina Hills cover parts of Thompson, Norfolk Treherne and Lorne.
Part of the Brandon Lake Plain is found in Norfolk Treherne, north of the town of Treherne.

The Red River Valley is a level to very gently sloping, lacustrine plain characterized by nearly level fluvial lacustrine loams and clays. Elevation ranges from 305 m.a.s.l in the western portion to a low of 260 in the east. Low relief and medium to fine textured deposits at or near the surface have resulted in imperfect drainage over much of this area. The soils in this area can be described by two general groupings based upon surface texture. Areas where the dominant surface texture is clayey are represented by the imperfectly drained Black Chernozems and poorly drained Rego Humic Gleysols. Soils impacted by freeze-thaw cylces causing vertical channels are mapped as Vertisols. These clays are either poorly drained (Ag capability of 3W) or imperfectly drained (2W), and fair to poor for irrigation suitability. Excess moisture and the occurrence of salinity are the main limitations.

The Pembina Escarpment consists of a steep sloping escarpment, and a lacustrine plain which slopes east to the Red River Valley. Elevation drops from 380 in the east to 305 m.a.s.l at the eastern boundary with the Red River Valley area. Beach and outwash sand and gravel deposits are interspersed throughout the area and are commonly mapped as rapid to moderately well drained Black or Dark Grey Chernozems. Well and imperfectly drained Dark Gray Chernozems are common where beach or outwash deposits have a thin overlay of loamy lacustrine materials. Black Chernozems are found in areas where a thin veneer of medium to fine textured lacustrine sediments overlie glacial till. Fine textured shaly alluvium is often found between the escarpment and glacial beaches, especially in the southern portions of this region. The water table is often near the surface (1m to 2m) and these soils are commonly mapped as the imperfectly drained Gleyed Cumulic Regosols and Gleyed Solonetzic Black Chernozems. Saline seepage of water containing soluble salts from the Pembina Hills has occurred in some areas.

Agriculture capability of the soils in this area generally fall into classes 2 and 3. Soils formed on beach and outwash deposits are rated class 4 and 5 due to their low water holding capacity. Saline soils, range from class 3 to class 5 depending upon the extent and severity of soil salinity. This area has an irrigation suitability of fair to poor depending upon drainage, water holding capacity and salinity

The slope of the Pembina Escarpment dissected by several streams marks the eastern edge of the Pembina Hills. Due to their erosional origin the soils on these steep slopes and channels are undifferentiated and classified as Eroded Slope Complex.

Pembina Hills: this upland area is comprised of bedrock controlled hummocky glacial moraine, ranging in elevation from 380 to 495 m a.s.l. with a local relief of 5 to 15 m on isolated knolls. Surface deposits consist dominantly of a variable thickness of loamy to fine loamy, slightly stony glacial till over shale bedrock. Dark Gray Chernozems and Luvisols have developed on these well drained, moderately permeable soils. In this upland area runoff is rapid and the water table is usually well below the rooting depth. The well drained and imperfectly drained soils are common where the till is overlain by shallow lacustrine deposits. Humic Gleysols occur in depressional areas associated with the upland knolls. Drainage in these is poor and surface ponding is common. Steeply sloping uplands are mostly wooded, with some cleared for grazing. Gently sloping uplands are mostly deforested and cultivated for cereal crop production. Localized areas of lacustrine loam over coarse textured glacial fluvial deposits occur within the Pembina Hills. Rego Humic Gleysols are found in depressional areas where drainage is restricted.

Due to local relief, soil erosion from water can be a serious problem in the Pembina Hills. In the lacustrine plains east of the Pembina Hills, coarser textured materials may be susceptible to wind erosion. In both cases proper management techniques must be applied to minimize soil losses.

Capability for dryland agriculture varies greatly within this region. The more level areas are rated as class 2 or 3 due to topography and drainage. Areas with steeper slope gradients have agricultural capability ratings that can vary from class 4T to 6T.

The Lower Assiniboine Delta is characterized by level to gently undulating lacustrine sands overlying fine textured materials at depths of 3 to 4 m. Soils in this area are dominantly imperfectly drained Black Chernozems with inclusions of poorly drained Rego Humic Gleysols. Wind modified lacustrine sands are also common within this area and are represented by well drained Orthic Regosols and imperfectly drained Gleyed Regosols. Most soils within the Lower Assiniboine Delta are affected by high water tables. Capability for dryland agriculture is class 3 and 4 for the imperfectly drained soils and class 5 or 6 for the poorly drained soils. The Lower Assiniboine Delta is generally suitable for irrigation, however, the high water tables and rapid permeability results in a high potential for adverse environmental impact. These soils are also very susceptible to wind erosion and proper management of crop residues is needed.

Brandon Lake Plain: Part of Norfolk Treherne in within the Brandon Lake Plain , which is a flat lying lacustine plain extending from the Assiniboine river to the Pembina and Tiger Hills. The Boyne River approximates the eastern edge of the Plain.

The moderately permeable loamy to fine loamy deposits common to the area are drained into the Assiniboine and Boyne Rivers by a series of short, shallow tributaries. Soils are mostly well drained, highly fertile (CLI class 1 and 2), Black Chernozems which produce a wide variety of crops including cereals, oil seeds, corn and potatoes. Soils conditions and capabilities are similar to those of the Lower Assiniboine Delta.

Soil Agricultural Capability of the Boyne- Morris Watershed

Please see attached map (Boyne-Morris Ag Capabilty PDF)

Most of the watershed is considered as being Prime Class 1, 2, &3 soils, capable of supporting annual crop production with few limitations.

Table 7: Agricultural capability in hectares, based on approximate area combined for watershed, from RMs, from RM Soils Bulletins

Agriculture Capability	hectares	Percent
Class 1	41405	11
Class 2	135169	35
Class 3	149318	39
Class 4	26091	7
Class 5	16544	4
Class 6	13015	3
Class 7	70	<1
Organic	1953	<1
Unclassified	1066	<1
Water	1762	<1

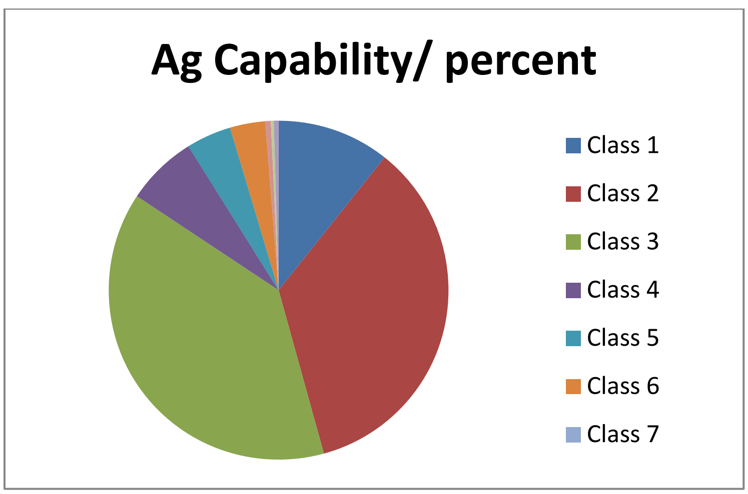


Figure 9: Percent Agricultural capability of Soils in the watershed, adjusted for watershed boundaries

Soil Drainage Classes

Soil drainage Class: most of the soils in the watershed are imperfectly drained, reflecting the clay soil texture of the Red River Valley in the north, and the higher water tables present along the lower slope of the escarpment. 61% of the soils are clays and clay loams. The management for this is evident in the amount and distribution of well developed surface drainage systems.

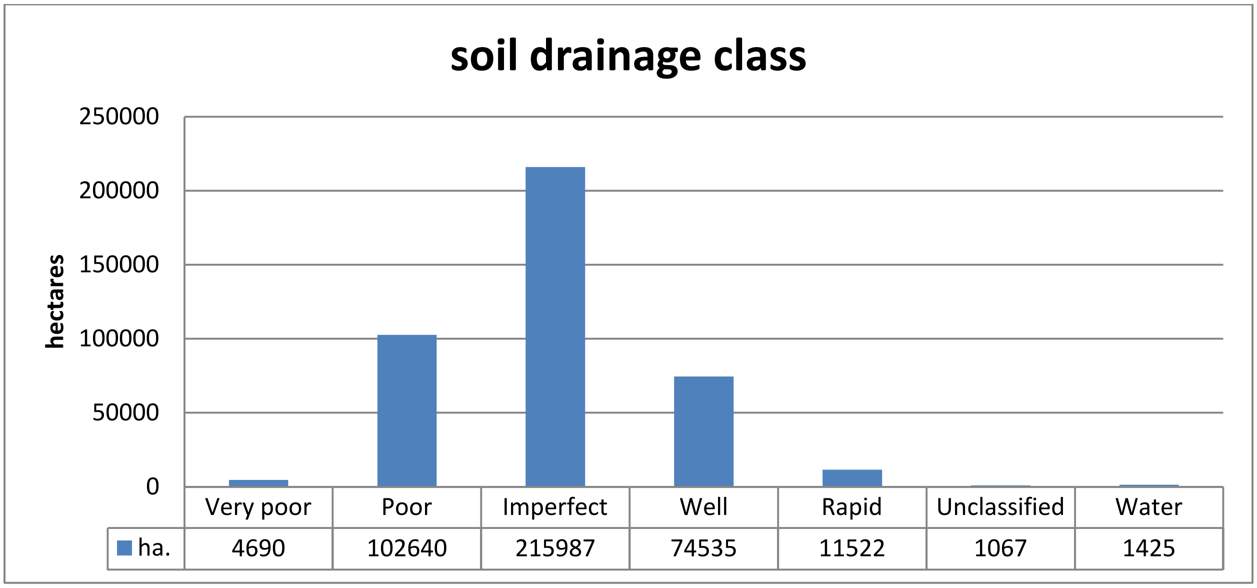


Figure 10: Area of soils according to soil drainage classes in the watershed, adjusted for boundaries.

Agricultural Land Values/ Improved drainage

Table 8: 2011 Value of farmland ($/acre) and average value of farm land and buildings per farm

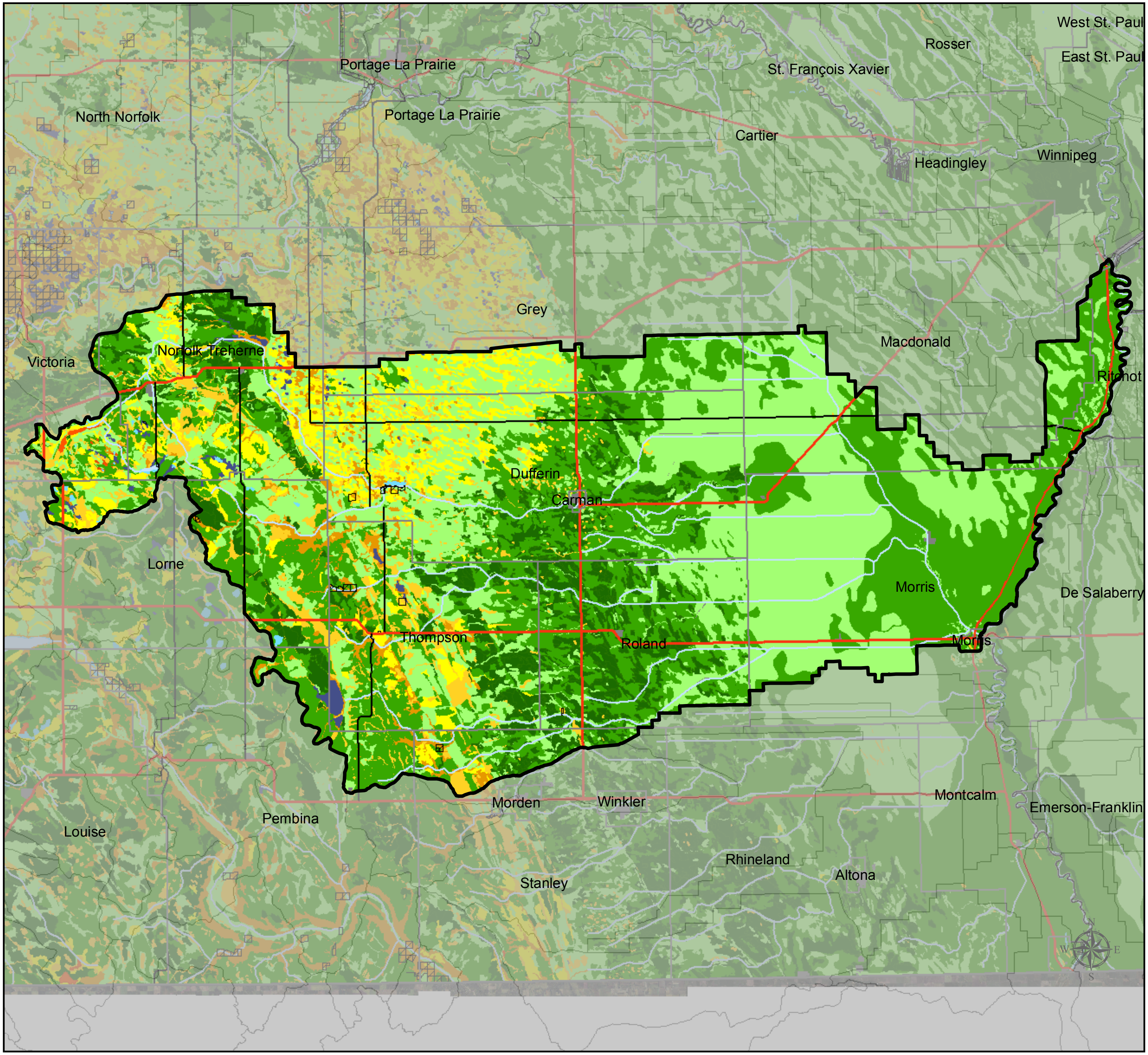
Municipality	$/acre farmland	Average $ of farmland and buildings
Norfolk-Treherne	1,711	1,518,905
Macdonald	1,766	2,233,754
Thompson	2,427	2,331,480
Roland	2,241	2,462,939
Morris	1,909	2,155,721
Dufferin	1,990	1,913,003
Lorne	1,630	1,463,949
Ritchot	2132	1,434,783
Stanley	2,427	1,375,062

Since the last census was taken, there have been significant increases in land values; 2012 and 2013 of 25.6%, 12.2% in 2014, and 12.4% in 2015. (Other than average values, reports of land selling for well over $10,000/ acre has been noted in the Morden Winkler area.)

Land values are high enough that tile drainage is a paying proposition, increasing yields in poorly drained soils, with a payback of about 5 years. This is a method of increasing farm productivity, without purchasing more land, if it was available; which often is not the case. Agricultural land is a limited resource, not a renewable commodity.

Irrigation:

The Boyne River Basin study (2008) considered irrigation as part of the study. Maps showing the suitability of the soil for irrigation, as well as the existing irrigated fields are attached. Irrigation has increased since 2008, as reservoirs for storing spring runoff have been build in some areas.



Boyne-Morris Watershed

Agricultural Capability

- Class 1
- Class 2
- Class 3
- Class 4
- Class 5
- Class 6
- Class 7
- Unclassified
- Water
- Organic

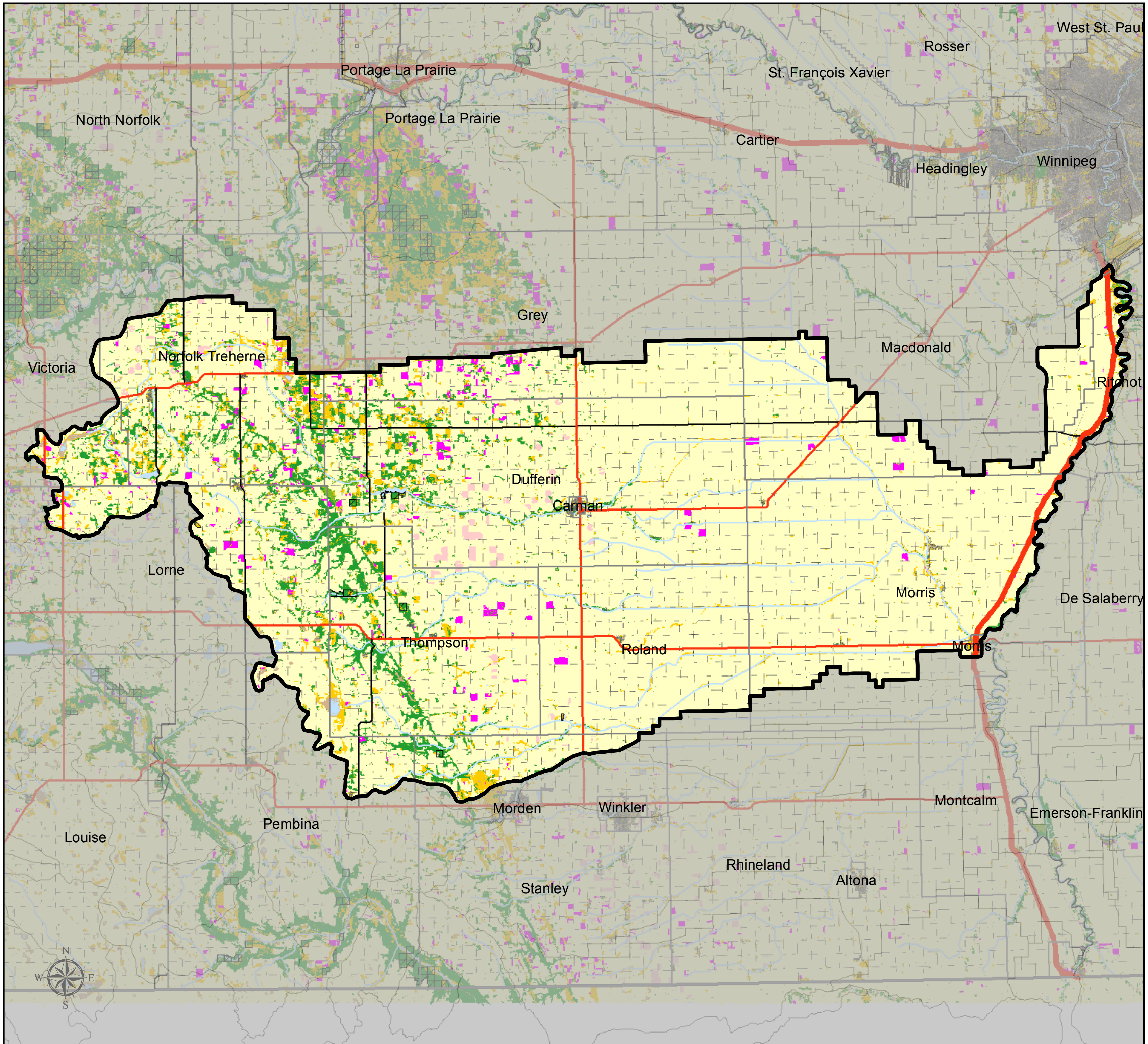
Showing the Agricultural Capability for the dominant soil based on available soil survey information.

Miles
0 3.5 7 14

0 4.5 9 18
Kilometers

Manitoba

Canada



Boyne-Morris Watershed

Annual Crop Inventory 2015

- Water
- Exposed Land / Barren
- Shrubland
- Wetland
- Grassland
- Agricultural Crop Land
- Pasture / Forages
- Fallow / Too Wet
- Potatoes
- Sod
- Forest
- Crown Lands

Source: Showing the Agriculture and Agri-Food Canada Annual Crop Inventory for 2015: http://www.agr.gc.ca/atlas/data_donees/agr/aafcCropTypeMapping/tif/

Miles
0 3.5 7 14

0 4.5 9 18
Kilometers

Manitoba

Canada