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International Institute for Sustainable Development

BRIEFING NOTE

Geography Matters:

Targeting "hotspots" for cumulative environmental benefits

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Spatial Targeting for Environmental Management

Using publicly available spatial data, the International Institute for Sustainable Development is identifying "hotspots" in Manitoba that will benefit most from targeted investment in natural infrastructure and improved beneficial management practices. Targeting these areas will allow us to focus our limited resources and ultimately improve the overall environmental health of the province through better water quality, sustainable agriculture and carbon sequestration.

Natural Infrastructure is:

The strategic use of networks of natural lands, sustainable working landscapes, and other open spaces which conserve and enhance ecosystem services and benefits (Gartner et al., 2013)

Beneficial Management Practices (BMPs) are:

A set of evidence-based practices and activities that reduce or control discharge of pollutants or mitigate floods and droughts. BMPs are typically performed on working landscapes, like agricultural or urban environments, to minimize damage to ecosystems and enhance long-term sustainability.

Hotspots and Policy Actions for Improved Water Quality

The following three Manitoba sub-watershed regions were identified as "hotspots" for investment in water quality:

1. **Southwest Red River Valley**, including the LaSalle, Boyne and Morris River watersheds.
    - This region has the highest proportion of fertilizer applied relative to watershed area (Statistics Canada, 2017). Despite high reported nutrient uptake efficiencies (Heard, Grant, & Flaten, 2015), the intensity of agriculture in this region requires improved runoff interception.

2. **Southwestern Manitoba**, including a portion of the Assiniboine River between Brandon and Portage la Prairie as well as the Souris and Cypress River watersheds.
    - This area has the highest concentration of conservation tillage (zero till and reduced till) which has been promoted for soil conservation and, more recently, carbon sequestration. This may cause increased dissolved phosphorus runoff (Tiessen et al., 2010). Developing policies that balance conservation tillage implementation with mitigating nutrient runoff would increase the co-benefits of this practice.
3. **Southeast Red River Valley**, including the Seine, Rat and to a lesser degree the Rousseau River watersheds and the Manning Canal.
    - This region experiences the highest applications of manure, much of which is reported as "not incorporated into the soil" (Statistics Canada, 2017). To reduce runoff from this region, extension and management efforts can focus on soil incorporation of manure or pre-application manure treatment, such as composting manure with other organics.

These regions, highlighted in Figure 1, represent areas of concentrated activity that may benefit from targeted policy action to improve downstream water quality. Geography still matters: by incorporating location into policy action we can make a bigger difference and generate better outcomes on investment.

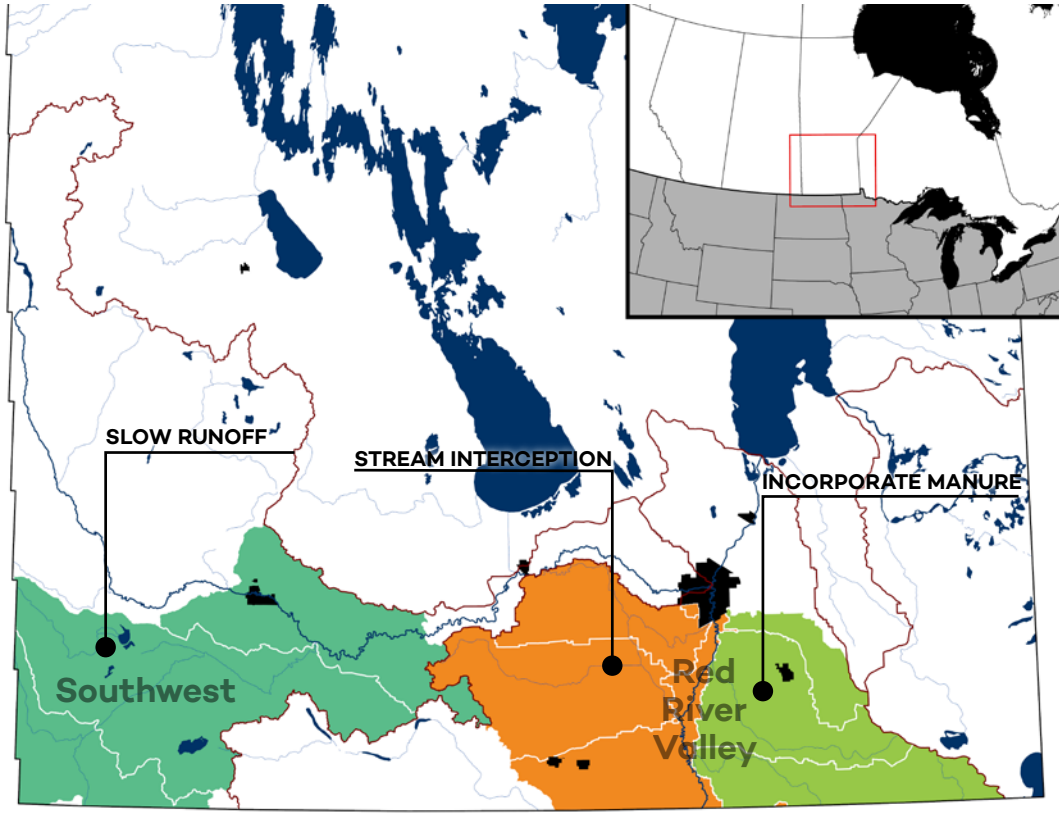

Figure 1. Water-quality watershed hotspots

Source: Author diagram, based on data sources listed in references.

Determining Hotspots

Geographic targeting, using new and historical datasets, is an important tool for environmental programming in Manitoba. Provincial priorities—including improved water quality, sustainable agriculture and carbon sequestration—can all be assisted by a geographically targeted approach to management actions. The geography of our landscape, including landscape characteristics, makes it possible to target actions regionally to improve the effectiveness and efficiency of resource, watershed and agricultural programs.

We examined land management practices related to agricultural water stewardship, necessitated by the extensive distribution of agricultural production in southern Manitoba and equally broad distribution of programming. Beneficial management practices (BMPs) need to be widely promoted as part of environmental stewardship, but priority areas where they can be most effective need to be identified for funding and implementation. Identifying hotspots and targeting action would deliver the greatest value for short- and long-term public investment.

We used the 2016 Census of Agriculture data to identify data and information indicative of environmental stress combined with a need for targeted management. These practices, when concentrated in small watersheds, can cause poor water quality that ultimately damages downstream rivers and lakes. They are:

1. **Area of chemical and organic fertilizers applied, relative to watershed area**
2. **Proportion of area with low-tillage or no-tillage (together called "conservation tillage") practices**
3. **Area of manure applied and not incorporated into soil, relative to watershed area**

Looking at the prevalence of these actions, we were able to highlight contiguous regions in the province where these potentially directly impact watershed health.

Runoff in Manitoba's Cropping Heartland

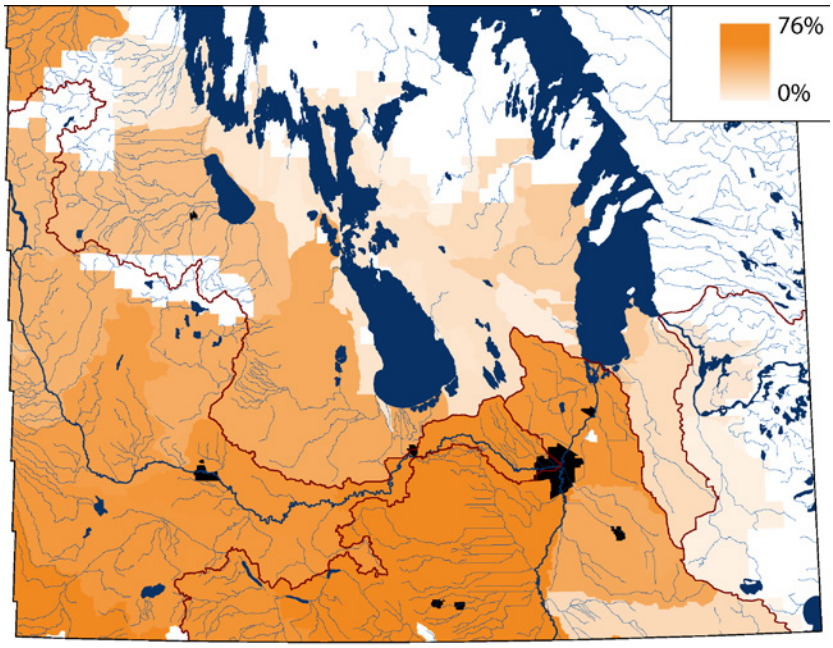

Figure 2. Proportion of watershed with commercial fertilizer applied

Source: Census of Agriculture, 2016.

At the economic centre of Manitoba's crop belt is the western Red River Valley. Watersheds in this region are the most intensively cropped parts of the province—and perhaps even the country—with production including corn, soybean and potatoes. Much of southern Manitoba is highly cropped, but the western Red River Valley (southwest of Winnipeg) reports watersheds with as much as 76 per cent of the total land area applied with commercial fertilizers.

This high application proportion is due to fertile soils and high agricultural capability for valuable crops like soybeans, canola, oats, corn and wheat. Flat, uninterrupted terrain makes fields easy to work, and the value of this land to Manitoba for agricultural production is reflected in assessed land value.

The three highlighted watersheds have the highest non-urban land values in the province, assessed in 2018 at approximately CAD 9,500 per hectare (CAD 3,845 per acre).

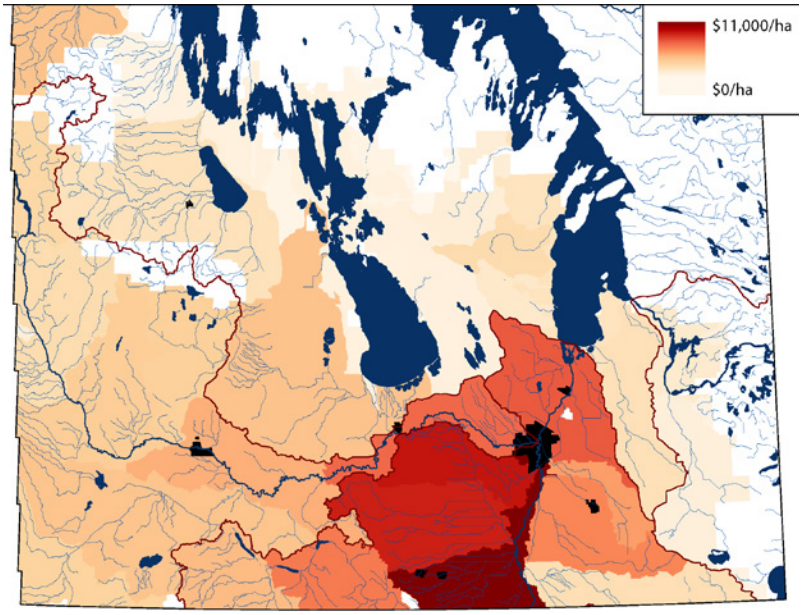

Figure 3. Average assessment land values, excluding urban land

Source: Manitoba Municipal Relations, 2018.

At the local scale, we can identify the challenges and opportunities on the landscape to reduce nutrient runoff without compromising the economic value of the land (Figure 4). The area shown is typical of the region, dominated by annual crop production with very little of the land covered by perennial plants, such as pastures or forests. Also note how little surface water remains—what still exists is mostly artificial drains and ditches designed to move water off the landscape as quickly as possible to enable earlier seeding.

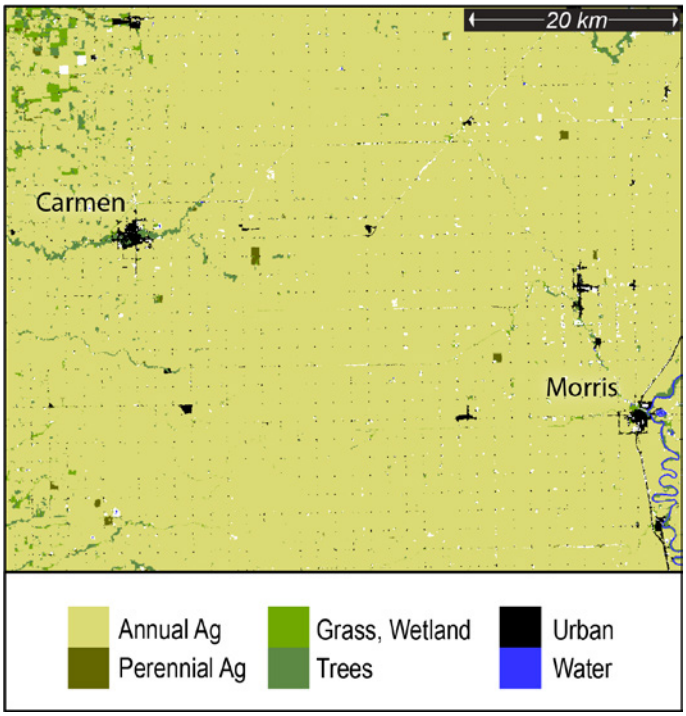

Figure 4. Comparison of annual vegetation to perennial vegetation in Western Red River Valley, Manitoba.

Source: Agriculture and Agri-Food Canada (AAFC) Crop Inventory 2018.

Despite high land values, field-edge solutions and alterations to drainage systems could slow down some of the water, allowing more infiltration. Grassed waterways, ditch wetlands and conversion of marginal cropland to water-retention features—natural infrastructure—will reduce nutrient runoff and may also reduce downstream flood risk.

Natural infrastructure like Pelly's Lake near Holland, Manitoba and Minnesota's North Ottawa retention project has been shown to effectively reduce flood peaks from spring melt and summer storm events, as well as capturing nutrients such as nitrogen and phosphorus carried in this runoff. Developing similar water-retention projects near the uppermost parts of the watershed—and replicated in lower, widened drains and frequently flooded fields—would offer receptacles for spring and summer floodwaters, and capture the nutrients running from agricultural fields and livestock holding areas.

Pelly's/North Ottawa

In Manitoba, the 500 ha Pelly's Lake engineered wetland provides 1,200 acre feet of controlled water storage and has removed over 5 tonnes of phosphorus. It also provides 5 to 15 tonnes of biomass per hectare through harvesting annually. In Minnesota, the 780 ha North Ottawa impoundment provides 16,000 acre feet of controlled storage: annually, it prevents chronic flooding of 40 km^2 of cropland, roads, and farms, reduces nitrogen and phosphorus loading by 68 per cent and 54 per cent respectively, and provides critical waterfowl habitat.

Impacts of Conservation Tillage

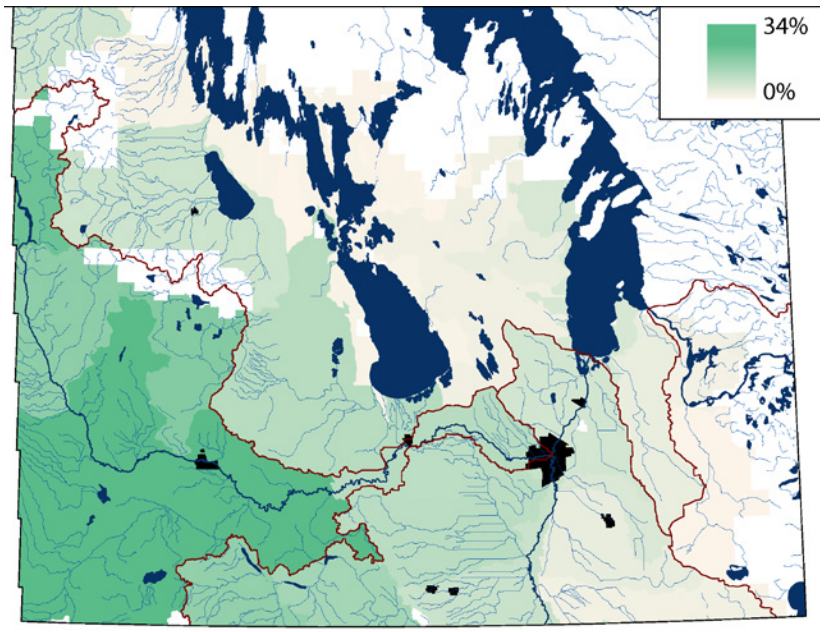

Figure 5. Proportion of watershed under conservation tillage practices including low-tillage and no-tillage

Source: Census of Agriculture, 2016.

Low-tillage and no-tillage soil management continues to grow in popularity as a means of improving soil health, storing organic matter in the soil and regenerating benefits from the landscape. Recent studies, however, have noted that these tillage management practices, although effective for soil health, may not work so effectively for nutrient capture, and in fact are increasing phosphorus runoff—negatively impacting water quality (Tiessen et al., 2010).

Manitoba's cold landscape and spring freeze-thaw cycles release water that pools around straw, dissolving and carrying nutrients off fields to join with spring meltwater. Higher stubble retention at the surface exposes more biomass to this process and in turn worsens this problem. Our analysis of data from the Census of Agriculture (2016) identified the southwest part of the province and sections of the Assiniboine river basin as having the highest concentration of this practice.

While individual fields may not contribute significantly more phosphorus, the popularity of this practice within a watershed may have large impacts. Field-adjacent options like grassed buffer strips and improved retention/infiltration ditches (or ditch harvesting) could mitigate some of the impacts by capturing and removing phosphorus from the system. If conservation tillage is closely paired with regenerative agriculture, there is lower net input of fertilizer, and more nutrients are held in healthier soils. There is encouraging research about regenerative agricultural practices—which include minimal tillage alongside crop rotation, residue grazing and intercropping—that shows them to be a promising suite of beneficial practices to sequester carbon and improve crop resilience.

Ensuring Responsible Manure Application

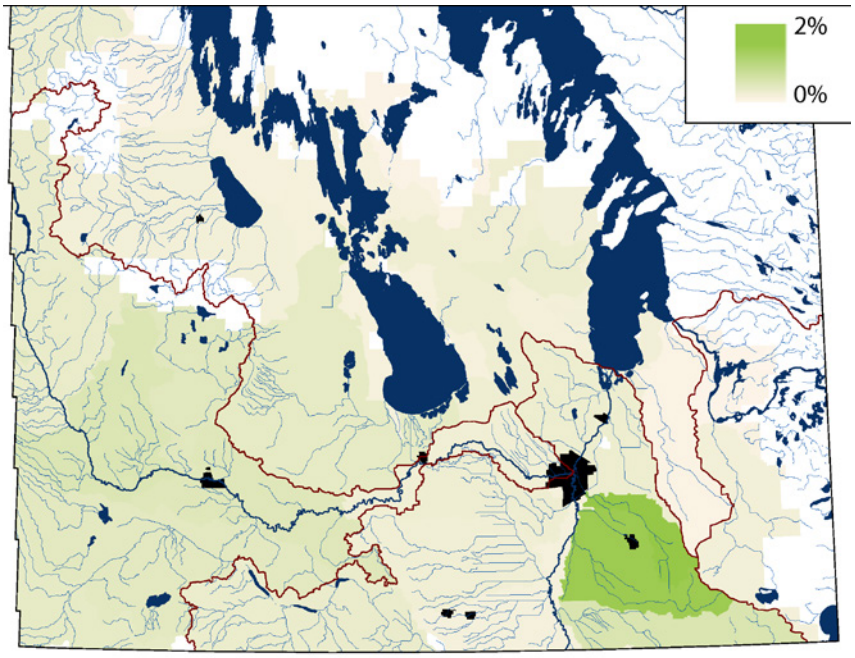

Figure 6. Proportion of watershed with manure applied but not incorporated

Source: Census of Agriculture, 2016.

Our analysis demonstrated a clear hotspot in the southeast Red River Valley, within the lower portions of the Rat, Seine and Marsh rivers: it showed area concentrations three to four standard deviations above the provincial mean.

Manure application in Manitoba is strictly controlled by both statute i.e., The Environment Act (Government of Manitoba, 2018) and regulation i.e., MB Reg 42/98 (Government of Manitoba, 1998) but the geographic distribution of spreading without incorporation is also concerning. Though relatively uncommon, these practices are still highly concentrated in the eastern parts of the lower Red River Valley—proximal to many intensive livestock operations. Since these practices are concentrated in a small geographic area, the risk of a large spring or summer storm moving manure off the landscape is higher.

Policy actions should focus on ensuring manure is incorporated after spreading and finding alternative value chains for manure so less is used as fertilizer in vulnerable areas.

Increasing manure incorporation may also generate demonstratable greenhouse gas reductions, as ammonia evaporation is minimized when manure is incorporated into soil less than 48 hours after application. In cases where manure must be disposed of without incorporation, larger setbacks (i.e., buffers) should be used.

A better approach would be finding alternative uses for manure, turning it from a waste product to a marketable commodity. Manure from the livestock operations in the southeast Red River Valley could potentially be used as biofuels or biomaterials.[1]

[1] For more on biofuel logistics, see https://iisd.org/bioeconomy-atlas.

Understanding Agricultural Intensity

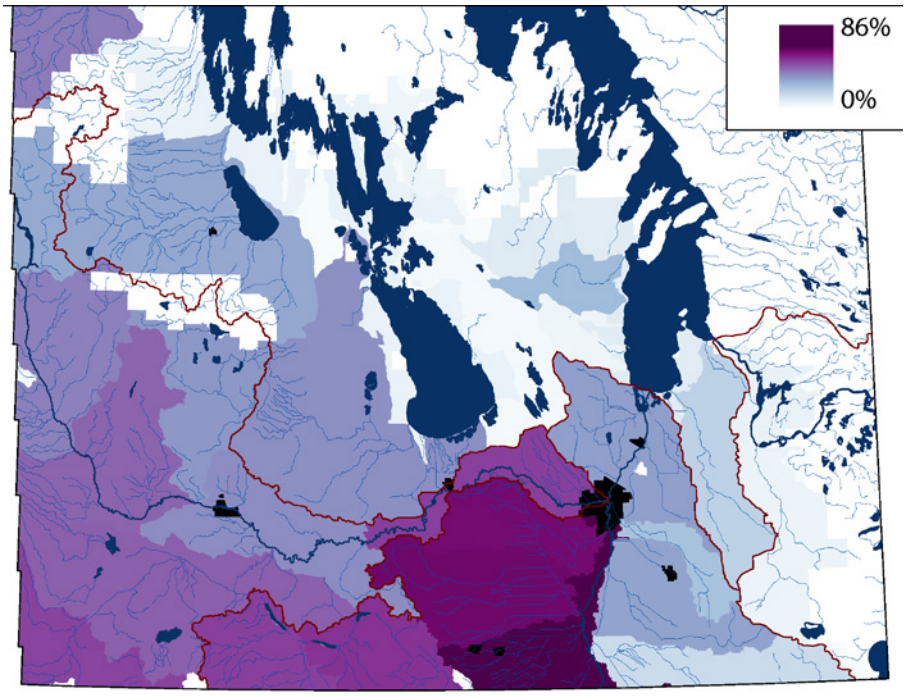

Figure 7. Proportion of land used for agriculture

Source: Census of Agriculture, 2016.

Methods

For this analysis, we examined data from the 2016 Census of Agriculture, 2016 Census of Population, Manitoba Land Initiative, Manitoba Agriculture's AGRIMAP, and the 2018 Manitoba Property Assessment Map. Varying geographies (census divisions, municipal boundaries) meant we needed to allocate values relative to total area. Where appropriate, densities were calculated for each census subdivision (CSD) or Census Agricultural Region (CAR) within Manitoba's agricultural ecumene. These densities were then recomputed to the closest scale of AAFC watershed boundaries—sub-sub-basins—and then analyzed using quartile divisions. After analysis, we validated spatial patterns with disaggregated data and other sources like the Lake Winnipeg Foundation community-monitoring results (Figure 8).

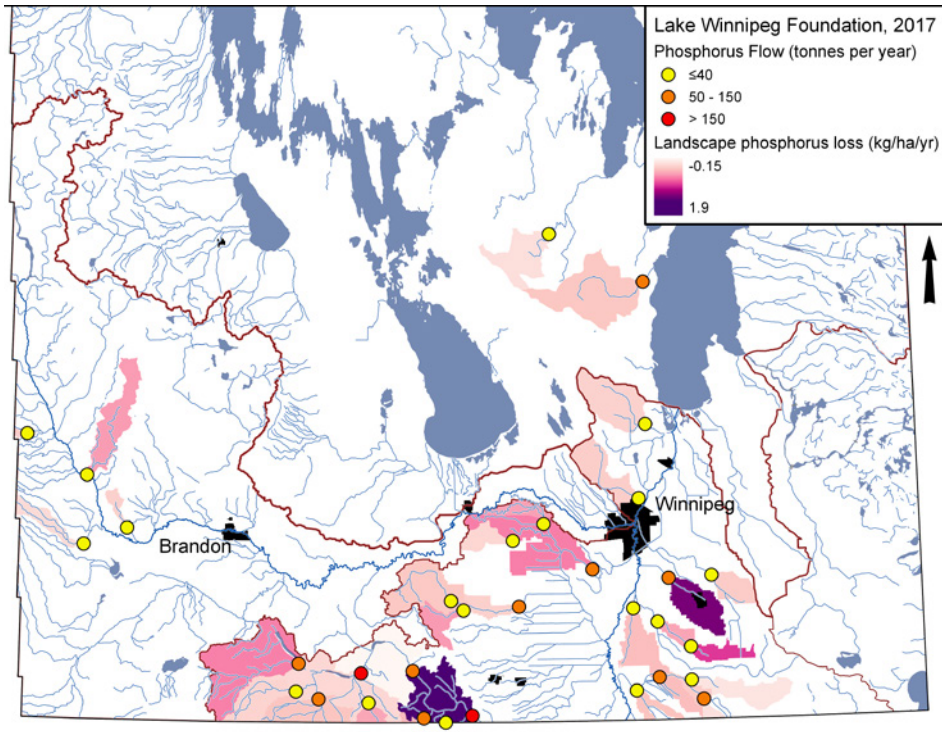

Figure 8. Lake Winnipeg Foundation Community-Based Monitoring Results, 2017

Source: Author map based on data from 2017 Lake Winnipeg Foundation and partners.

Targeted Landscape Management: Next steps

Water quality remains a concern in the Province of Manitoba and throughout Canada. Nutrient loading into Lake Winnipeg is still a problem: specific landscapes such as the Red River Basin are contributing almost 70 per cent of the lake's nutrient loads (Manitoba Sustainable Development, 2019). Current environmental programs are either not meeting targets or are unable to measure the impacts of our management efforts (ECCC, 2018; Auditor General of Canada, 2008). We cannot even measure the whole problem, as a recent assessment indicated that most Canadian watersheds are severely under-monitored, not only in terms of water quality but in biology and overall health (WWF Canada, n.d.).

Targeted investment in landscape-based management can improve the effectiveness and the cost efficiency of public programs. With new sources of open data (e.g., Manitoba Agriculture 2019), investment in LiDAR (NRCan, 2019), and the increase in citizen science projects (Lake Winnipeg Datastream), it is increasingly possible to target programs based on geography and other regional characteristics. Such spatial targeting of programs can also enable improved monitoring and evaluation of our land and water management programs, while maximizing investment and limited government funds.

Geographically informed programming presents clear opportunities for landscape-based investments. Ongoing efforts to develop better incentive programs for delivery of priority environmental services could use targeted approaches that make the best use of upcoming investments to improve carbon sequestration in agricultural soils, alongside investment into an upcoming GROW (growing outcomes in watersheds) program in Manitoba.

This initial effort demonstrates the benefits of spatially targeting management efforts across landscapes and watersheds in Manitoba for improved environmental outcomes and cost-effective investments in sustainable watershed management.

References

Auditor General of Canada. (2008). *Report of the Commissioner of the Environment and Sustainable Development to the House of Commons: Chapter 3—Managing Environmental Programming*. Retrieved from http://www.oag-bvg.gc.ca/internet/docs/parl_cesd_200812_03_e.pdf

Environment and Climate Change Canada (ECCC). (2018). *Lake Winnipeg Basin Initiative: Phase II Final Report*. Retrieved from http://publications.gc.ca/collections/collection_2019/eccc/En4-137-3-2019-eng.pdf

Gartner, T., Mulligan, J., Schmidt, R., & Gunn, J. (Eds.). (2013). *Natural infrastructure: Investing in forested landscapes for source water protection*. World Resources Institute. Retrieved from www.wri.org/publication/natural-infrastructure

Government of Manitoba. (1998). The Livestock Manure and Mortalities Management Regulation, MR 42/98. Retrieved from https://web2.gov.mb.ca/laws/regs/current/_pdf-regs.php?reg=42/98

Government of Manitoba. (2018). The Environment Act, CCSM c E125. Retrieved from https://web2.gov.mb.ca/laws/statutes/ccsm/e125e.php

Heard, J., Grant, C., & Flaten, D. (2015). *Phosphorus fertilization strategies for long term agronomic and environmental sustainability*. Retrieved from https://www.gov.mb.ca/agriculture/crops/soil-fertility/pubs/phosphorus-fertilization-strategies-for-manitoba.pdf

Lake Winnipeg Datastream. (n.d.). *Home page*. Retrieved from https://lakewinnipegdatastream.ca/

Manitoba Agriculture. (2019). *Agrimaps*. Retrieved from https://agrimaps.gov.mb.ca/agrimaps/

Manitoba Sustainable Development. (2019). *Lake Winnipeg: Nutrients and Loads, a status report*. Retrieved from https://www.gov.mb.ca/sd/pubs/water/lakes-beaches-rivers/lake_winnipeg_nutrients_status_report.pdf

NRCan. (2019). *National Elevation Data Strategy*. Retrieved from https://www.nrcan.gc.ca/earth-sciences/geography/topographic-information/free-data-geogratis/whats-new/21742

Tiessen, K.H.D., Elliott, J.A., Yarotski, J., Lobb, D.A., Flaten, D.N. & Glozier, N.E. (2010). Conventional and conservation tillage: Influence on seasonal runoff, sediment, and nutrient losses in the Canadian Prairies. *Journal of Environment Quality 39*(3), 964. Retrieved from https://doi.org/10.2134/jeq2009.0219

WWF Canada. (n.d.). *Taking the pulse of Canada's rivers*. Retrieved from http://watershedreports.wwf.ca/

Data Sources

Agriculture and Agri-Food Canada. (2018). *Annual Crop Inventory*. Retrieved from https://open.canada.ca/data/en/dataset/ba2645d5-4458-414d-b196-6303ac06c1c9

Manitoba Agriculture. (2019). *Agrimaps*. Retrieved from https://agrimaps.gov.mb.ca/agrimaps/

Manitoba Municipal Relations. (2018). *Manitoba Assessment Online Map*. Retrieved from https://www.arcgis.com/home/item.html?id=2c09ffc330684c7a9a7ff1065ee6859b

Statistics Canada. (2017). *2016 Census of Agriculture – CANSIM Tables 004-0200 to 004-0246*. Retrieved from https://www150.statcan.gc.ca/n1/pub/95-640-x/95-640-x2016001-eng.htm

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