The Importance of Headwaters to Watershed Health

And why Ontario needs indicators of headwater health in watershed monitoring and reporting

A Concept Paper from

The Ontario Headwaters Institute

Draft of November 2014
Comments welcome until January 30, 2015

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Executive Summary

The need for indicators of headwater health in Ontario is pressing, due to the extent of existing and proposed development, the lack of current data on the condition of headwaters, and the approaching impacts of a changing climate.

To address these challenges, this concept paper summarizes numerous research efforts on headwater and watershed health and suggests that:

- The health of Ontario's headwaters and their catchment areas are fundamentally important to the ecological integrity of our watersheds;
- Headwater conditions warrant the development of a set of indicators which should be included in watershed monitoring performed by our natural resource agencies and which should be readily available to the public;
- Some of those high-level indicators should be included in watershed report cards; and,
- Headwater indicators will help society to identify and encourage the implementation of remedial actions and enhanced stewardship opportunities, and to amend our policies where needed.

As a result, we propose a series of indicators that can be applied, to assess the condition of headwaters in a watershed, a sub-watershed, or a group of catchments, as needed. An over-arching set 15 indicators seeks to describe the general characteristic of a selected headwater area, and a second set of 25 indicators can then be applied to assess the nature and extend of human pressures on that area. Many of these indicators should also show change over time.

In addition, the OHI suggests that a set of indicators from the second group can be slightly massaged to form of key set of high-level indicators that should be included in Ontario's emerging template for watershed report cards.

These indicators, some of which should also show change over time, are:

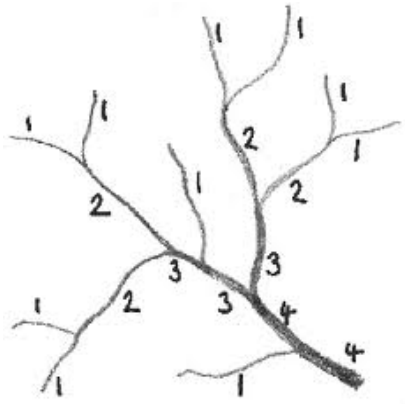
- Total area of the watershed
- Area and percentage of watershed in headwater catchments
- Area and percentage of headwater catchments in natural cover, including agriculture
- Area of headwater catchments in agriculture and percent in drainage tile
- Length of headwater streams in the watershed
- Length and percentage of headwater streams with 30 M riparian buffer
- Length and percentage of altered headwater streams in the watershed (streams that have been straightened, hardened, or put underground)
- Area and percent of wetlands in watershed and in headwater catchments
- Average Days/Year of Level III Low Water Science Criteria in watershed
- Temperature of headwater streams

The OHI further believes that inserting these or a similar set of high-level headwater indicators into in the current template for Ontario's watershed report cards is fundamental to protecting the ecological integrity of our their watersheds, as well as for our social and economic well-being.

1. Headwaters – The Foundation of Ontario's Watersheds

The Ontario Headwaters Institute - a provincial corporation with charitable status that focuses on research, education, and best practices to protect our headwaters - defines headwaters as:

- Surface drainage features, including ephemeral and intermittent streams;
- Groundwater recharge areas and aquifers;
- Areas of groundwater discharge and upwelling;
- Vernal pools, spring-fed ponds, and off-line wetlands; &,
- First and second-order streams.



While most scientific literature includes third order streams in the definition of headwaters, the OHI has selected a tighter area of focus due to the extent of development, the predominance of private ownership, the lack of current data on the condition of headwaters, and the need for enhanced stewardship for headwater health across southern Ontario.

A first order stream is one with no tributaries, as per the drawing, while a second-order stream starts where two first-order streams converge. First and second-order streams can be permanent, ephemeral (where flow is based on precipitation), or intermittent (where flow occurs when the water table rises).

Together, headwaters and their catchment areas, the area drained by small streams that are an integral component of watershed health:

- Comprise the majority of the surface area of most watersheds;
- Constitute the majority of stream length in most watersheds;
- Contribute the majority of the flow to most watercourses;
- Provide significant portions of a stream's nutrients, organic material, and sediment;
- Help regulate the flow of water into and can mitigate flooding in a watercourse; and,
- Furnish key habitat for the breeding, feeding, and sheltering of upstream species, thereby nurturing the majority, and in many ways the base, of a watershed's biodiversity.

In addition, as headwaters are by definition small watercourses, it is worth noting that:

- Headwater streams & their catchments are as important to terrestrial insects, a key element of the food chain, as they are to aquatic species;
- Forest cover in headwater areas and along small streams protects local water, and their biodiversity, from thermal heating;
- Headwaters may be more sensitive to smaller volumes of pollutants; and,
- Headwater areas may become both less resilient and increasingly important to watershed integrity in a changing climate

Given these core realities, the OHI believes that:

- The health of Ontario's headwaters and their catchment areas are fundamentally important to the ecological integrity of our watersheds;
- Headwater conditions warrant the development of a set of indicators which should be included in watershed monitoring performed by our natural resource agencies and which should be readily available to the public;
- Some of those high-level indicators should be included in watershed report cards; and,
- Headwater indicators will help society to identify and encourage the implementation of remedial actions and enhanced stewardship opportunities, and to amend our policies where needed.

2. Key Documents on Headwater Health

While a comprehensive effort to identify, review, and assess literature on headwater health and possible indicators was beyond the scope of this paper, we are happy to share results from an initial scan of a broad range of efforts.

Most of the literature we found was:

- more than ten years old;
- not conducted in areas with surficial geology similar to that in Ontario; and/or,
- focused on watershed monitoring, with only minor reference to headwater areas and virtually no references to headwater indicators.

Regardless, two documents merit significant comment on the importance of headwaters to local watersheds, as described below: The Natural Functions of Headwater Drainage Features and Why Should We Care About Temporary Waterways?

In addition, there were several documents that provide sound insight into overall watershed health or policy initiatives that clearly tie headwater health to the health of the whole watershed. Brief summaries of these documents can be found in Section 3.

2.1 The Natural Functions of Headwater Drainage Features

The Natural Functions of Headwater Drainage Features: A Literature Review was published in 2007 by the Toronto and Region Conservation Authority (TRCA) and is a seminal work summarizing and commenting on the most informative and useful headwater studies, some of which were encountered in the survey described in Section 3.1.

The report can be viewed at http://trca.on.ca/the-living-city/water-flood-management/headwater-study.dot, where it is complemented by a series of additional reports from other Ontario agencies. Some, such as those from MNR and the Ausable Bayfield Conservation Authority, provide additional insight, particularly with respect to headwaters in agricultural areas. None, however, including the TRCA report, focus on the issue of nor the need for indicators of headwater health.

Key sections of the TRCA Literature Review relating to this paper include that:

- Current Ontario development "is at or approaching the headwaters of (these) larger systems, which could have broad implications for water quality and quantity, recharge/infiltration, and the overall health of downstream habitats";
- "There is a need for a better understanding of headwater drainage features (HDF) to determine if and how development will impair the functioning of watersheds;
- "Headwater systems are thought to be important sources of sediment, water, nutrients, and organic material" for a watershed's downstream reaches; and,
- "The spatial context of HDFs account for the majority of total watershed catchment areas within a watershed (70 – 80% according to Gomi et al, 2002), while headwater catchments may derive as much as 90% of a river's flow (Kirby, 1978).

On the last point, the OHI notes that, in spite of ubiquitous references in Ontario to the percentages sited by Gomi et al and Kirby, real data for these aspects of Ontario's headwaters are not part of the normal discussion about our watersheds, and are not included in watershed report cards.

The OHI believes that this data is important, that it should be tracked, and that we would likely find a wide variation in the figures for different Ontario watersheds, such as in areas dominated by thinly-soiled Canadian Shield, Karst dolomite, or well-forested moraine.

Additional perspectives shared in the Review note that headwaters play important roles in the health of our watersheds with respect to:

- Ecosystem services - such as overland flow, hyporheic (saturated streambed areas) exchanges, groundwater infiltration, and erosion and flood mitigation; and,
- Biological vitality - as may relate to water temperature, riparian cover, sediment deposition, organic material & nutrient cycling, overall water quality, and biodiversity.

One aspect related to biodiversity sited in the Review of great interest to the OHI is the river continuum concept, under which there is significant recognition that smaller flora and fauna upstream support larger species, aquatic functions, terrestrial functions, and aquatic-terrestrial relationships found downstream. To the OHI, this means that the health of the Great Lakes is as linked to the cumulative vitality of our headwaters as it is to the protection of Great Lakes habitat and water quality.

Although an excellent summary of most of the literature available, the TRCA Review was not designed to address the key issue in this paper: identifying a set of standardized indicators of headwater health.

Given the state of increasing development in Ontario's headwater areas, the OHI believes that such indicators are clearly needed and that their development, as proposed in this concept paper, would benefit from broad discussion.

The Oak Ridges Moraine: one of Ontario's most extensive areas of contiguous upland headwater catchments and an area of controlled but increasing development that needs increased monitoring.

2.2 Why Should We Care About Temporary Waterways?

In March 2014, Science Magazine, published by the American Association for the Advancement of Science, printed a two-page article from ten international scientists on Why Should We Care About Temporary Waterways?, which contains direct implications for headwaters and healthy watersheds. (The paper can be found on-line but can only be read with a subscription to the magazine.)

While the focus of the article is a proposed ruling from the U.S. Environmental Protection Agency meant to clarify which bodies of water that flow intermittently are protected under law, and which has provoked conflict between developers and environmental advocates, the article shines a light on many of the ecological services provided by temporary waterways and the need to protect them in science-based policy.

The paper states, for example: "Failure to recognize, understand, and manage temporary waterways leads to serious degradation of aquatic ecosystems accompanied by negative impacts to the societies that depend on them."

Ecological services offered by temporary waterways described in the paper, with extensive footnotes to other work, include that they:

- Provide high contributions to biodiversity and eco-system processes;
- Offer critical flows of water, energy, material, nutrients, and organisms to downstream areas; and,
- Perform fundamentally important exchanges between channels and banks, riparian zones, groundwater, lateral surface flows, hyporheic biota, and even for fish that use temporary streams at some stages of their lifecycle.

In the US, it appears that temporary waterways fall under various regulatory codes on a case by case basis, exposing them to not be considered for protection normally accorded to perennial-flowing waterways.

With demand for withdrawals already resulting in even some large rivers running dry, such as the Colorado, and the prospect of climate change altering precipitation and/or evaporation norms, the lack of protection for US temporary waterways may become worse rather than better in the future. In their words, as cited in the article, "Temporary waterways are critical hydrologically, ecologically, and socially, and their number is expected to increase in many regions over the next several decades."

Application to Ontario

Ontario, with more water availability, different topography, a different climate, less population, and potentially less agricultural water demand than in the US, may have fewer temporary waterways than occur in the US. These may exist mostly as ephemeral and intermittent streams, and may be located primarily in our contiguous upstream catchment areas. Regardless, we need accurate mapping of ephemeral, intermittent, and the smallest of our permanent streams if we are to be able to track change over time.

Fortunately, the mandate of our conservation authorities may provide the regulatory means to ensure the protection of any temporary stream here that the US EPA currently lacks in the USA.

2.3 Lessons Learned

Both papers in this section present important messages that we can take to heart regarding the current state of headwater monitoring, analysis, and policy considerations for Ontario.

We need, for example, to:

1. Ensure accurate mapping of our ephemeral and intermittent streams, especially in areas of contiguous upstream catchments with extensive agricultural or aggregate operations;
2. Eliminate conflicts between the definition of a watercourse in the Conservation Authorities Act (2006) and competing definitions of a watercourse, or a waterway, in regulations focused on drainage, aggregate operations, energy, and other land uses;
3. Include headwater streams in the application of the Conservation Authorities Act (2006);
4. Expand the definition of water resources covered in the Low Water Response Plan to include water for nature, and not just water for human needs, especially vis-à-vis both wetlands and ephemeral and intermittent streams; and,
5. Fill the gap created by a lack of action to appoint committees to address reduced water-takings in times of low water, rather than waiting until there is an urgent need to divvy up less water amongst competing users in a time of crisis.

3. Additional Resources

In reading the material below, please bear in mind that the OHI did not have a great deal of time to pursue a broad range of questions, such as if and how other provinces may be monitoring headwaters.

As expressed above, most of the literature we found was:

- more than ten years old;
- not conducted in areas with surficial geology similar to that in Ontario; and/or,
- focused on watershed monitoring, with only minor reference to headwater areas and virtually no references to headwater indicators.

3.1 General Internet Research on Headwater Indicators

Various internet searches on headwater indicators were performed: a general search, a search using Google's academic search function, and one seeking to mine the US EPA website. Results were meagre, with most terms searched identifying a mega-byte of documents in which the term headwaters was used but which only mentioned headwaters in passing. Indeed, most studies were more than 10 years old, were not conducted in Ontario which has a different surficial geology than the areas studied in the other reports, and did not mention indicators.

That stated, a handful of excellent academic and agency studies demonstrate the utility of a small set of core indicators of watershed health that have clear relevance to headwaters. These build on the existing suite of watershed monitoring tools and include temperature, macro-invertebrates, sediment, hyporheic exchanges, whole energy attributes such as nutrients, detritus, and phosphorus, and the importance of terrestrial insects in ephemeral and intermittent streams.

In addition, new studies continue to bubble to the surface, such as Why Should We Care About Temporary Waterways as described in Section 2.2. Another, for example, is a September 2013 release from the US EAP: Connectivity of Streams and Wetlands to Downstream Waters: A Review and Synthesis of the Scientific Evidence. It adds to the understanding of headwaters, but currently has an embargo in place against quotes or attribution.

Both of these recent documents hopefully signal a new direction to move watershed monitoring upstream to include critical headwater areas that the OHI believes Ontario should emulate.

3.2 Notes on How Much Habitat is Enough

How Much Habitat is Enough (HMH) is a visionary document published by Environment Canada that suggests non-regulatory guidelines for healthy lands and waters.

Key issues it addresses, for example, and which have direct correlation to headwater health, suggest that:

- A minimum of 30% natural cover is a high-risk threshold for species diversity and healthy aquatic systems, 40% a medium-risk threshold, and 50% a low-risk threshold;
- At a minimum, the greater of (a) 10% of each major watershed and 6% of each sub-watershed, or (b) 40% of the historic watershed wetland coverage, should be protected and restored;
- Both sides of streams should have a minimum 30-metre-wide naturally vegetated riparian area to provide and protect aquatic habitat; and,
- Significant impairment in stream water quality and quantity is highly likely above 10% impervious land cover and can often begin before this threshold is reached.

While HMH does not directly suggest specific guidelines for headwater areas, it has particular relevance for protecting watersheds in highly developed and developing areas in Ontario, as well as the Greenbelt, the Ring of Fire, and other areas.

Moreover, given the state of development South of and even on the Oak Ridges Moraine, it is clear that achieving the guideline targets espoused in HMH, and approximated by several municipalities and conservation authorities, may depend on over-achieving them in our headwater areas.

3.3 Comments from the Environmental Commissioner of Ontario

The Environmental Commissioner of Ontario (ECO) has published annual reports with numerous sections on both broad policy issues affecting Ontario's headwaters and on issues more directly focused on headwaters.

On the former, the ECO has called for better protection in broad headwater-related policy areas related to planning, biodiversity, endangered species, forestry, aggregates, monitoring, the need to shift Ontario toward Integrated Watershed Management, and both staff capacity and departmental commitment to effectively deliver the province's mandates to maintain ecosystem integrity.

On the later, the ECO has tabled numerous reports on issues such as groundwater, permits to take water, Ontario's Low Water Response Plan, wetland protection, unregulated fill in rural areas, the Drainage Act, the Walkerton Inquiry & the Clean Water Act, the Greenbelt Plan, the Oak Ridges Moraine Conservation Plan, and how urban stormwater management is negatively impacting headwaters. These and other terms can be searched on the ECO website to access an impressive array of work.

This paper, like the reports of the ECO, does not oppose on-going development in Ontario. It agrees with the ECO, however, that development presents requirements for sound planning, monitoring, and adaptive management, and that we need to be vigilant with respect to both the local and cumulative impacts of development.

3.4 Documents and Protocols in Ontario's Existing Watershed Monitoring Toolkit

Ontario has an extensive set of resources in its existing watershed monitoring toolkit that could be applied or amended to be applied to provide indications of headwater health.

Tools include:

Provincial tools

- *Ontario Stream Assessment Protocol (Stanfield et al. 2013)* - This widely utilized protocol provides a series of modules to help ensure the standardized collection of field data for stream surveys. In particular, the recently-completed version 9 adds a module called "Assessing Headwater Drainage Features" to help field surveys to identify data that is important for headwaters and how to collect it in a standard manner;
- The Ontario Benthos Biomonitoring Network - Like the OSAP protocol above, the OBBN provides standard sampling protocols, training, and a database for a multi-sector collaboration, led by the Ministry of the Environment, in which bottom-dwelling aquatic invertebrates are used to monitor the ecological condition of lakes, streams, and wetlands;
- Other Provincial Tools - The Ontario Government, and in particular the Ministry of Natural Resources and the Ministry of the Environment, maintains or supports numerous programs and databases meant to assist society in understanding the health of our watersheds. The government runs or supports the collection of data on water quality and quantity, forests, wetlands, municipal and agricultural drains, and biodiversity, and gathers data submitted under requirements for Certificates of Approval, although the latter is not considered public domain;
- *Watershed Health Assessment: Assessing the Health of the Oak Ridges Moraine in a Watershed Context (Oak Ridges Moraine Foundation 2011)* - This initiative summarized various indicators by watershed, to assess the health of the Oak Ridges Moraine in terms of ecological health and hydrological health;

Tools in Conservation Authorities

- Watershed Report Cards - An historic approach that saw different CAs publish watershed report cards with different indicators and grading systems was recently harmonized into a model template in an exercise led by Conservation Ontario. Unfortunately, the template does not include any indicators on headwater health. Information about the indicators is available at http://www.watershedcheckup.ca/resource-categories-indicators;
- GIS and Terrestrial Natural Heritage – Many CAs maintain significant volumes of data greater than what is available in their report cards, especially those who operate GIS initiatives and those pursuing the establishment of terrestrial natural heritage systems;
- Other Core data – As a result of obligations under the Clean Water Act and other provincial initiatives, many CAs also track data relating to source water protection, wetland protection, groundwater, water budgets, and low water advisories; and,
- *Evaluation, Classification and Management of Headwater Drainage Features Guidelines (TRCA and CVCA 2013 Draft)* – Stemming from the work described in item 2.1, this effort provides a framework for practitioners to assess ecological and hydrological significance of headwaters within a development context, and suggests management alternatives (i.e., maintenance, enhanced protection, etc.) depending upon the assessment.

4. Headwater Characteristics and Pressures

As is the case in watershed monitoring, the health of individual headwater catchments or groups of headwater catchments is best understood from the identification and assessment of their core characteristics and pressures.

Characteristics consist of a broad range of physical and pre-settlement natural heritage, hydraulic, and geological aspects of a watershed, while pressures are human activities that have the potential to negatively impact watershed form, feature, and ecological function.

Any internet search on watershed characteristics will unveil a long list of candidate indicators. While some lists are longer or may have garnered greater consensus than others, sample characteristics include watershed size, shape, climate, physical geography, slope, vegetation, soils, surficial geology, and hydrogeology.

These characteristics tend to describe base-line conditions. Will water fall as rain or snow, due to climate and elevation? Does the area have extensive forests or wetlands, with high infiltration rates to groundwater, or rapid run-off, potentially with high quantities of nutrients, sediment, erosion, and downstream changes to stream shape? Do regional temperatures and other conditions result in the presence of cold, cool, or a warm-water fishery?

In addition, characteristics combine to play a strong role in the high variability of one headwater catchment to another.

For example, headwater areas that originate in areas with extensive deposits of sand, gravel, and good natural cover often have cold perennial flows, well-defined channels, and sustained groundwater infiltration and discharge.

In contrast, headwaters in clay plains or with little soil covering impervious rock formations are often ephemeral or intermittent, and provide rapid, warm flows downstream primarily through surface water runoff with less hyporheic exchange, contribution to surface flows, or groundwater infiltration and discharge.

For their part, pressures arise from human impacts and can be ubiquitous, such as acid rain or climate change, or highly localized, normally stemming from land use and poor substance management. High-impact activities in headwater areas include agriculture, forestry, mining & aggregate extraction, recreational use, urban and infrastructure development, and emissions from industries located in a headwater area.

Possible negative impacts include changes to natural cover, habitat destruction, and habitat fragmentation; altered surface flow, altered riparian edge, diminished wetland cover, changes to groundwater infiltration, channel realignment or straightening, altered sediment flows and/or erosion, flooding, changed water temperature, and impacts on wells & water availability, and; water pollution and changes to water chemistry.

A table of major headwater land-uses and possible negative impacts from human pressures follows.

Sector	Types of Impacts
Agriculture	Changes to natural cover, reduced wetland habitat, altered riparian edge, channel realignment or straightening, altered surface flow due to tillage or tile drainage, run-off with fertilizer / pesticide / manure, etc
Forestry	Changes to natural cover, habitat fragmentation, roads and ditches, altered surface flows, greater run-off with increased erosion and sediment, possible changes to infiltration, etc.
Mining and Aggregates	Changes to natural cover, altered surface flow, altered groundwater infiltration, increased sediment, chemical pollution, etc
Recreational Use	Changes to natural cover, impacts to fish and wildlife, invasive species, etc.
Urban and Infrastructure Development	Changes to natural cover, roads and infrastructure, altered surface flows, impervious surfaces, infilling, channel burying, channel realignment/straightening. Stormwater management impacts of erosion and heating. Pollution from salt, lawn-care, vehicles, sewage, industrial activity, etc.
Industrial Activity	Changes to natural cover, roads and infrastructure, impervious surfaces, altered surface and storm flows. Pollution from vehicles, industrial activity, etc.

Natural heritage agencies often have access to large volumes of meaningful data on watershed characteristics and pressures that could be used to depict conditions in headwater areas and shared in report cards. The OHI believes that this and other data, including data currently considered proprietary to reporting organizations, can and should be available to help society to both assess the state of our headwaters and watersheds and to inform remedial actions and enhanced stewardship, as described in Section 6.

5. Proposed Indicators of Headwater Health

5.1 Introduction to Proposed Indicators

Given the hydrological, ecological, and social importance of healthy headwaters, the anticipated impacts of a changing climate, and the continued expansion and intensification of development into headwater areas in Ontario, the use of indicators to monitor and report on the health of our headwaters should become a standard activity of our natural resource agencies.

Indicators that the OHI proposes are shown in the chart overleaf. Please note that the indicators can be applied at various levels, including to an individual catchment, a sub-watershed, a full watershed, or to a selected group of catchments.

For example, for large watersheds in a relatively natural state - with existing or proposed pockets of development, such as the Ring of Fire - an initial scan at the watershed scale could provide a needed overview prior to extensive development. As development proceeds, the table can be applied at a sub-watershed scale, then at smaller scales, as required.

For watersheds with a higher degree of existing development, the application of the table at the watershed level would be instructive, but the OHI perceives that the real value will occur from applying the table at the sub-watershed, group of catchment, and catchment scales. Decisions in this regard may flow naturally from watershed stakeholder knowledge, as well as from perceived needs to track a high negative impact identified in downstream monitoring, such as high algae and nutrient records, to their upstream source.

In addition, several of the draft indicators below would benefit from having a column to track change over time. While our draft suggests show ten years, we think there needs to be more discussion on suitable intervals. While it might be instructive to track the disappearance of Ontario's wetlands over ten years, we cannot lose sight of cumulative impacts going further back - a situation that has resulted in the loss of as much as 90% of our wetlands in certain counties over longer periods.

We also note a few core deficiencies in the draft indicators. For example:

- The indicators selected do not allow for watershed improvements, such as might denote the restoration of forests, stream naturalization, or the expansion of wetlands and riparian edge in natural cover. The OHI believes that current levels of degradation must be understood and quantified before we add remediation efforts and address the net ecological condition. In the short term, restoration efforts can be can be shown in notes to the table.
- Indicators assessed at multiple scales may be duplicative in some categories, or suggest expenditures that may not return adequate benefits. Natural heritage managers and others interested in watershed health need to apply the indicators, and adapt them, as needed; and
- While the OHI perceives a need for the development and application of a full suite of indicators to better understand the conditions and trends occurring in our headwaters, we suggest that a select few of the indicators must be include into the evolving provincial template for watershed report cards, which we consider as being developed without adequate public participation, as per section 5.4

Finally, we admit to an evolutionary bias of our own. As we developed both the OHMapping and this Indicator project, the OHI noted that headwater catchments tend to be close to or indeed abutt each other in upland areas, that these agglomerations often span sub-watershed boundaries, and that they might harbour significant, cumulative impact for their watersheds.

As a result, we propose that such areas be identified as Contiguous Upland Headwater Catchments, be included as a specific aspect of the Indicators shown below, and that these areas could be worthy of specific monitoring, reporting, protective measures, remediation, and stewardship.

5.2 General Characteristics

Feature	Notes / Data	
General Characteristics		
• Circle area being assessed: watershed, sub-watershed, group of catchments		
• Climate		
• Annual precipitation		
• Main aspects of surficial geology		
• Main aspects of surface soils		
• Slope		
Natural Heritage	**Current**	**10 years ago (% change)**
• Natural Heritage rating [1] for selected area		
• Natural Heritage rating for Contiguous Upland Headwater Catchments [2], if any		
Land Use	**Current**	
• Population		
• % in Natural Cover, excluding Agriculture and Forestry		
• % in Agriculture		
• % in Forestry		
• % in Industry, including Aggregate Operations		
• % in Urban Development and Infrastructure		
• % in public ownership		

Notes

1. Terrestrial Natural Heritage System ratings and/or ratings from Ontario Biodiversity Strategy
2. Contiguous Upland Headwater Catchments are defined as areas of two or more first and second-order catchments in the upper reaches of the watershed that touch each other

5.3 Indicators of Headwater Pressures

Feature Notes / Data

Indicators of Headwater Pressures	Current	10 years ago (% change)
• Total area (Km^2)		
• Number of catchments (and of headwater catchments) in area		
• Area (and %) in headwater catchments		
• Area (and %) in Contiguous Upland Headwater Catchments		
• Area (and %) of headwater catchments in natural cover [3]		
• Area (and %) of headwater catchments in agriculture		
• Area (and %) of headwater catchments in agricultural tile		
• Estimated annual flow (and % flow from headwater catchments)		
• Length of all streams in selected area		
• Length (and %) of headwater streams in selected area		
• Length (and %) of headwater streams with 30 M riparian buffer		
• Length (and %) of headwater streams altered [4] in area		
• Area (and %) of wetlands in area		
• Area (and %) of wetlands in headwater catchments		
• Fishery - warm, cool, or cold		
• Number of fish species		
• Flow Conditions [5, 6]		
• Average Days/Year of Level III Low Water Science Criteria		
• Temperature [6]		
• Sediment transport [6]		
• Macro-invertibrates [6]		
• Total Phosphorus [7]		
• E-coli [7]		
• Chlorides [7]		
• pH [7]		

Notes and Sources

3. Include areas in agriculture
4. Ephemeral, intermittent, 1st and 2nd order streams straightened, hardened, and/or placed underground
5. Stream Permanency Handbook
6. Ontario Stream Assessment Protocol
7. Provincial Water Quality Monitoring Network, Canadian Council of Ministers of the Environment

5.4 High-level Indicators for Early Inclusion in Watershed Report Cards

As mentioned above, the proposed indicators can be applied to a watershed, a sub-watershed, or a group of headwater catchments.

Natural resource managers and others seeking to apply the indicators will, naturally and hopefully, adapt them as necessary, tweaking theory to fit desired practical outcomes.

For our part, we perceive that several of the second group of indicators described above can be slightly massaged to form of key set of high-level indicators that should be included in Ontario's emerging template for watershed report cards.

These indicators, some of which could also show change over time, are:

- Total area of the watershed
- Area and percentage of watershed in headwater catchments
- Area and percentage of headwater catchments in natural cover, including agriculture
- Area of headwater catchments in agriculture and percent in drainage tile
- Length of headwater streams in the watershed
- Length and percentage of headwater streams with 30 M riparian buffer
- Length and percentage of altered headwater streams in the watershed (streams that have been straightened, hardened, or put underground)
- Area and percent of wetlands in watershed and in headwater catchments
- Average Days/Year of Level III Low Water Science Criteria in watershed
- Temperature of headwater streams

The OHI further believes that inserting these or a similar set of high-level headwater indicators into in the current template for Ontario's watershed report cards is fundamental to protecting the ecological integrity of our their watersheds, as well as for our social and economic well-being.

6. Remedial Action and Enhanced Stewardship

The OHI's proposal for an agreed set of indicators of headwater health is not just an educational exercise: we believe that improved understanding of our headwater areas and how pressures may impact their health can play an important role in identifying remediation efforts and opportunities for enhanced stewardship activities.

Armed with better intelligence, stakeholders will be able to make more-informed choices on options to deal with varying problems. These options will have both practical and economic realities. Faced with increased development and increasing stream temperature, which is the best remedial action: increasing forest and riparian cover, constructing wetland bypass channels to avoid solar warming of shallow water, or doing nothing and allowing a stream to convert from cold to warm water? Better understanding of headwaters may help us answer this and other questions.

While some remedial action consists of spades in the ground, others may involve amending policies or identifying and implementing enhanced stewardship opportunities.

In the policy realm, for example, contiguous upland headwaters in one area may have significantly more development than another. These differences might result in a perceived need for different future land uses, in one or both areas, to safeguard the cumulative health of the watershed with respect to forest cover, biodiversity, flooding, and groundwater infiltration.

With respect to stewardship, a headwater area with extensive aggregate, agricultural, or other development might have impacts that could include excessive sediment transport, high nutrient readings, or high chloride from the application of road salt. The ecological health of headwaters being impacted in one of these situations, and the health of downstream areas, might be better protected through enhanced stewardship within a specific community of practice.

7. Conclusion and Request for Comments

In conclusion, the OHI believes that:

- The health of Ontario's headwaters and their catchment areas are fundamentally important to the ecological integrity of our watersheds;
- Headwater conditions warrant the development of a set of indicators which should be included in watershed monitoring performed by our natural resource agencies and which should be readily available to the public;
- Some of those high-level indicators should be included in watershed report cards; and,
- Headwater indicators will help society to identify and encourage the implementation of remedial actions and enhanced stewardship opportunities, and to amend our policies where needed.

We consider our suggestions consistent with the existing framework of adaptive management already in place in most of our natural heritage agencies, that their implementation would not require significant additional resources, and that the information would be meaningful not just for the ecological integrity of our watersheds but also for our social and economic well-being.

Comments are welcome on this concept paper through January 30, 2015, and can be shared via the contact information below. In addition, the OHI will hold a webinar on this concept paper prior to that date. Please send your comments to:

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