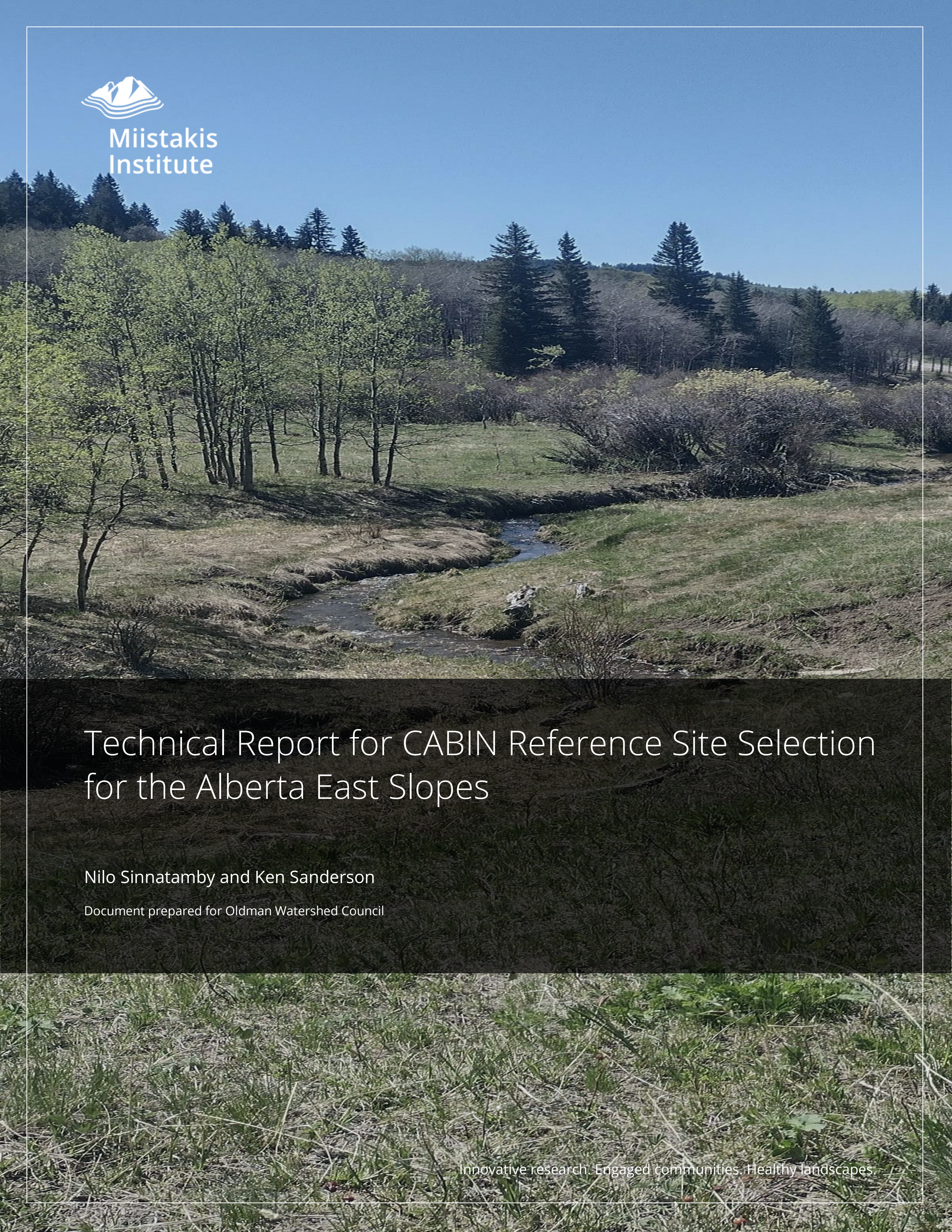

Miistakis Institute

Technical Report for CABIN Reference Site Selection for the Alberta East Slopes

Nilo Sinnatamby and Ken Sanderson

Document prepared for Oldman Watershed Council

Innovative research. Engaged communities. Healthy landscapes.

Technical Report for CABIN Reference Site Selection for the Alberta East Slopes

Prepared by Nilo Sinnatamby and Ken Sanderson
June 2024

Miistakis Institute
EB3013, Mount Royal University
4825 Mount Royal Gate SW
Calgary, Alberta T3E 6K6

Phone: (403) 440-8444
Email: institute@rockies.ca
Web: www.rockies.ca

Contents

Executive Summary

This technical report provides the methods and outcomes in the reference site selection for the Canadian Aquatic Biomonitoring Network (CABIN) in the Alberta East Slopes. This work addresses the absence of a reference condition model for this region, which is crucial for the effective monitoring and management of aquatic ecosystems using the Reference Condition Approach (RCA). The initial phase involved identifying potential reference sites that exhibit minimal human disturbance, thereby serving as benchmarks for assessing the health of other aquatic ecosystems in the area.

Study Area

The study area encompasses 109,965 km², including the Eastern Slopes and foothills of the Canadian Rocky Mountains, extending across five major watersheds: Peace, Athabasca, North Saskatchewan, Red Deer, and South Saskatchewan. This region, characterized by diverse ecoregions and natural variability, required a comprehensive approach to ensure the selected sites represent the full range of environmental conditions.

Method

Building upon previous work by fRI Research, this study refined site selection criteria and employed GIS techniques to identify and evaluate potential reference watersheds. To ensure natural variability was captured, we stratified the study area by ecoregion and classified a human activity gradient score (HAG Score) in to ten classes for each ecoregion. We also removed watersheds affected by recent wildfires and proximity to significant anthropogenic impacts.

Results

From the initial pool, 8,579 candidate watersheds were identified, spanning all HAG score classes. A refined selection, focusing on the most pristine sites (HAG score classes 1-4), resulted in 6,537 potential reference watersheds with the recommendations to use the most pristine classes where possible. These sites offer a broad representation of the natural variability across the East Slopes, crucial for developing a robust reference condition model.

Recommendations and Next Steps

The report provides a detailed list of potential reference sites, stratified by ecoregion and HAG score. Practitioners are advised to conduct further desktop assessments and field validations to finalize site selection. Key principles for site selection include prioritizing the most pristine sites, ensuring a range of stream orders, and collaborating with other watershed groups to adequately cover the ecoregion.

Conclusion

This comprehensive approach to reference site selection lays the groundwork for establishing a reliable reference condition model for the Alberta East Slopes. By doing so, it enhances the capability of CABIN to monitor and protect the region's aquatic ecosystems effectively.

Acknowledgements

We would like to thank fRI Research for providing access to their reports and the data they used and produced during the initial stage of the project. We would also like to acknowledge Shelley Humphries from Parks Canada Agency, Emily McIvor from Environment and Climate Change Canada (ECCC), Wendy Monk from ECCC and the Canadian Rivers Institute at the University of New Brunswick and Adam Yates from the University of Waterloo for providing guidance on CABIN protocols. Thanks to Sofie Forsstrom at Oldman Watershed Council for helping us navigate this process.

Introduction

What is CABIN?

The Canadian Aquatic Biomonitoring Network (CABIN) is an initiative led and maintained by Environment and Climate Change Canada that provides standardized methods for monitoring water quality of aquatic ecosystems based on the species composition of benthic invertebrates that live there. CABIN includes a training system where participants can be trained as project managers, data analysts, field technicians and data entry technicians. Once trained, and depending on the training level, participants can lead projects, design studies, collect samples, run analyses and/or enter data into the online database. Once trained, users also gain access to the online database where they have access to data by other contributors.

While CABIN's standardized sampling protocols alone add to the consistency and rigor of these studies, there is still typically a need for a thoughtful study design (e.g., Before-After-Control-Impact (BACI), and the use of parametric statistics (e.g., analysis of variance [ANOVA]) with several assumptions that must be met. Studies designed to meet these assumptions can be costly and time consuming.

What is the Reference Condition Approach (RCA)?

The reference condition approach (RCA) provides an alternative that often overcomes the need for complicated or expensive study design. To use the RCA, a reference model must be developed by sampling benthic communities and measuring associated environmental variables from a wide range of reference sites – reference sites are those with no or minimal human disturbance. Benthic community structure is then analyzed and modelled against environmental characteristics from each site such as channel width, pH and nutrient levels. The resulting model produces a relationship between environmental variables and benthic communities across the natural environmental variability within the region. When samples from test sites – potentially impacted sites – are collected and analysed for benthic community structure, that information can be compared against the reference model using tools within the CABIN database platform. The result indicates whether the test site is within the natural range of environmental variability, or if it is indeed likely impacted by anthropogenic impacts.

East Slopes: No Reference Condition Model Available

Not all regions have a reference model available. A nearby model exists for the National Parks in the Rocky Mountains (i.e., Banff, Waterton and Jasper National Parks), but no such model exists for the East Slopes in Alberta. Since the RCA is dependent on capturing similar natural environmental variability in the reference sites as test sites, the existing mountain parks reference model can not be applied to the foothills of the East Slopes.

The first step towards building a reference condition model is to identify reference sites. The reference sites would then by sampled and the environmental characteristics and benthic community structure data would be used to build the model. fRI Research recently conducted an analysis to provide a list of potential reference sites as the first step in developing an East Slopes reference model (Humeny, 2021). They identified 2,709 potential reference watersheds and of those, they selected 127 sites for field reconnaissance based on distance from road. Their candidate watersheds and subset of candidate reference sites are illustrated in Figure 1.

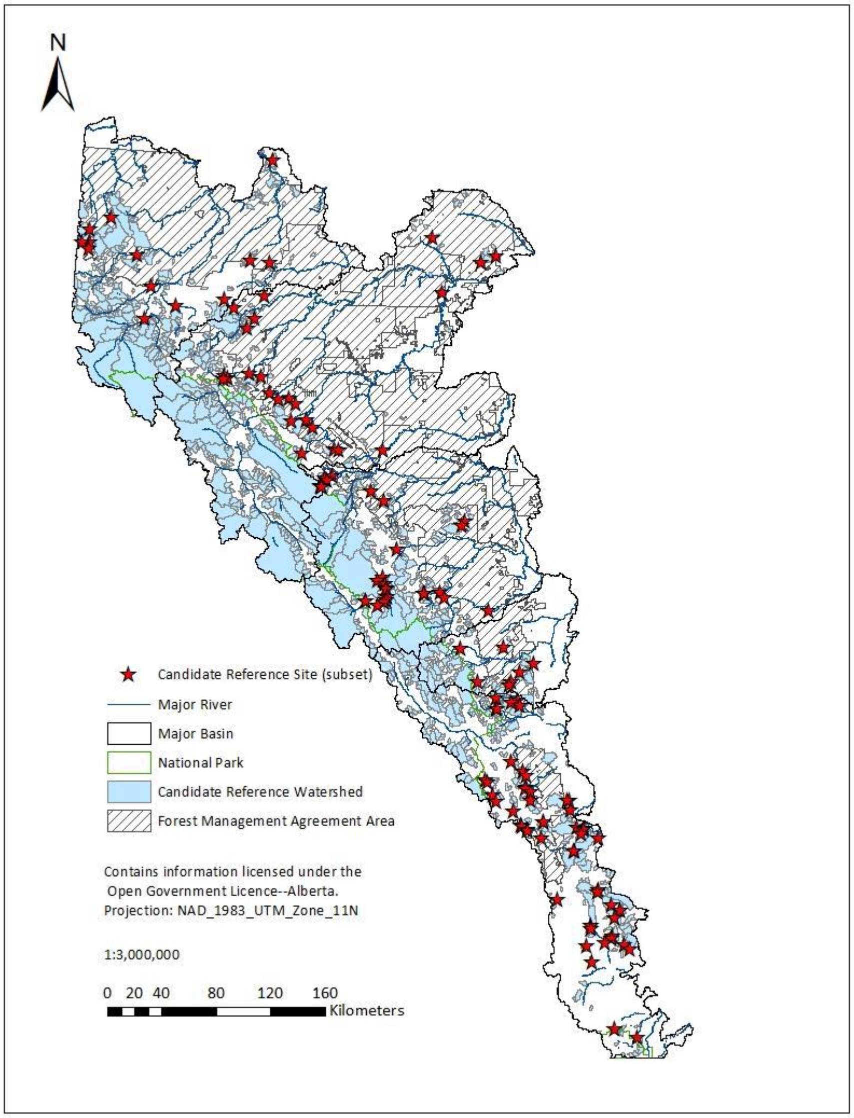

Figure 1. Map of the East Slopes and Foothills area illustrating candidate reference watersheds and with a subset of candidate reference sites that resulted from analyses conducted by fRI Research. The image is taken from Humeny (2021).

This analysis did not move to the sampling phase for the broader East Slopes Collaborative (made up of several conservation groups and WPACs interested in CABIN sampling) because of concerns that the distribution of sites were not adequate to cover the natural variation across the region. The distribution of sites was largely limited by the threshold of what was considered a pristine site; these sites tended to be located closer to the mountains and in the national parks.

Project objectives

The Oldman Watershed Council (OWC) recently took over the project management role for development of a reference model for the East Slopes. They reached out to the Miistakis Institute for to provide technical support in site selection. We were provided access to many of the spatial data products that fRI Research developed as a starting point for this process. The goal of this project was to identify a new set of potential references sites that practitioners could sample to contribute to the development of a reference model in Alberta's East Slopes.

Methods

Study Area

The study area encompasses the Eastern Slopes and foothills of the Canadian Rocky Mountains in Alberta (Figure 2). The delineation of the study area was based on the extent used in the original work by fRI Research (Humeny, 2021), which is similar to, but does not exactly overlap the Rocky Mountains' Eastern Slopes Priority Place identified by Canada Nature Fund for Species at Risk (CNFASAR). The study area is 109,965 km^2 covering five watersheds at the HUC 2 scale (Peace, Athabasca, North Saskatchewan, Red Deer, and South Saskatchewan watersheds).

The study area primarily encompasses Rocky Mountain and Foothills natural regions with small sections of Boreal, Parkland and Grassland natural regions (Natural Regions Committee, 2006).

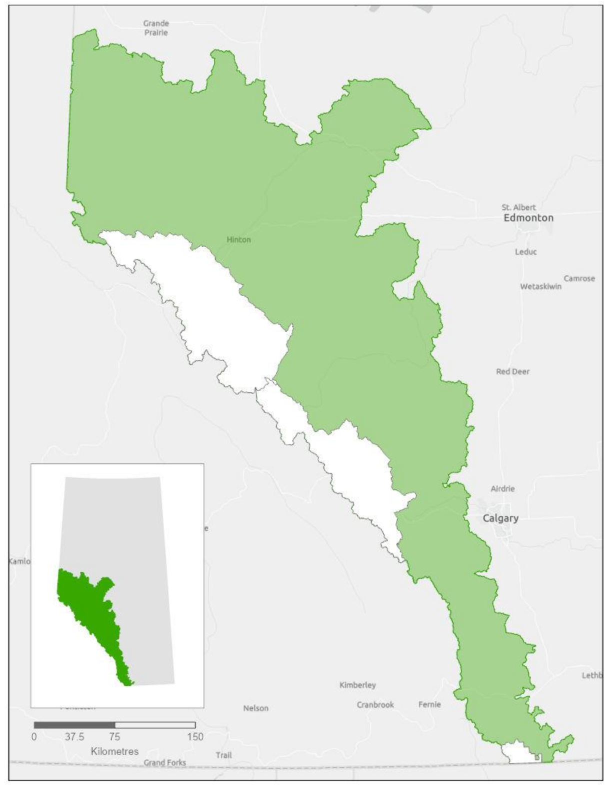

Figure 2. Study area with its location in Alberta in the inset map. Our analysis included the mountain national parks, but those areas are indicated in white.

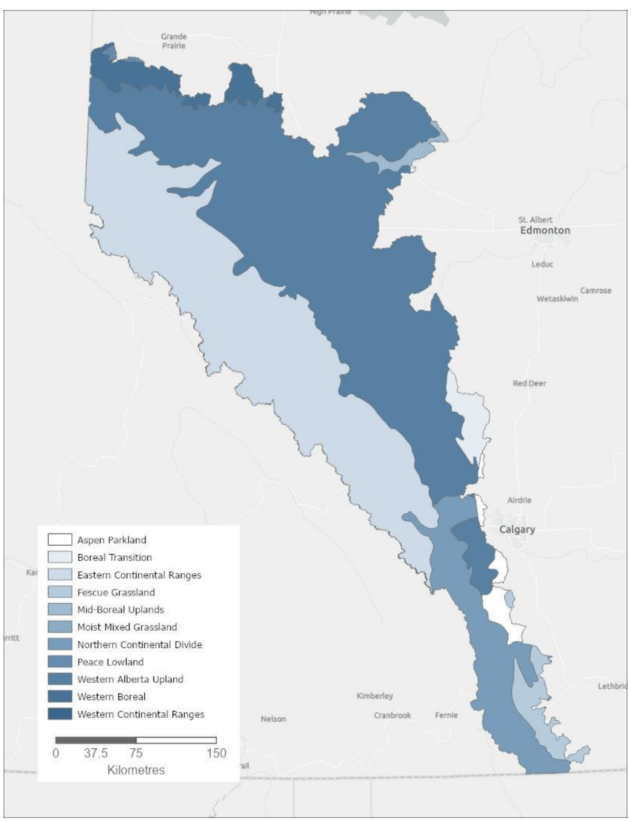

Figure 3. Study area of East Slopes CABIN Reference Model project delineated by ecoregion.

The study area can also be delineated by ecoregion, which are characterized by distinct regional attributes such as climate, landforms, vegetation, soil, flora and fauna. There are 11 ecoregions within the study area: Aspen Parkland, Boreal Transition, Eastern Continental Ranges, Fescue Grassland, Mid-boreal Uplands, Moist Mixed Grassland, Northern Continental Divide, Peace Lowland, Western Alberta Upland, Western Boreal and Western Continental Divide. These areas are not evenly distributed and vary by size between 21.2 km^2 in the Moist Mixed Grassland and 51215.7 km^2 in the Western Upland Boreal regions (Figure 3).

Summary of Previous Methods by fRI Research

In our approach to increasing the spatial distribution of potential references sites, we began with the data outputs provided by fRI Research and deviated from some of their methods at certain decision points to allow us to expand distribution. Since our methods were heavily reliant on the early steps taken by fRI Research, we summarize *what* they did below. For a more detailed description on *how* they conducted their methods, please refer to Humeny (2021).

Delineating watersheds and groupings

To delineate watersheds, fRI Research repaired connectivity in the Fish and Wildlife Management Information System (FWMIS) – Hydrology Arcs dataset and created a drainage catchment point for each catchment. This initially resulted in 173,287 watersheds, which was reduced to 9,247 complete watersheds at least 5 km^2 in area. They then divided those watersheds into two natural groups based on statistical analyses of natural characteristics (e.g., bedrock, surficial geology, climate, land cover and terrain). The full list of these variables can be found in Appendix B of the Humeny report. The resulting two natural groups were generally divided along the eastern boundary of the subalpine natural subregion, resulting in a highly pristine group along the Rocky Mountains, and a more disturbed group along the foothills.

Determining reference criteria

fRI Research quantified human activity within each watershed by calculating a human activity gradient score (HAG score) for each watershed (Yates & Bailey, 2010). These HAG scores were then used to define “pristine” separately in each of the two natural groupings. From there, they refined the list of potential reference watersheds by described in Strachan (2020), removing watersheds depending on recent wildfire activity, with point sources (e.g., mines, mills, confined feeding operations/high-density livestock, urban areas) within 100 m of a stream, or 10 or 20 km from drainage point of a small or large stream, respectively, and checked for the presence of major dams.

Other considerations

To help with reconnaissance, fRI Research calculated distance from the drainage point of each potential watershed to the nearest road. They also considered whether the drainage point was located within a National Park. The drainage point was the most downstream point of the delineated watershed, below which the stream order changed.

New Methods

All GIS methods conducted during this phase of the project were conducted using ArcPro 3.2.1.

Delineating watersheds and groupings

We did not use the two natural groups determined by fRI Research, but we did use their watershed delineations and began our methods with 9,247 watersheds. Instead of natural groupings, we divided the study area into smaller areas to ensure coverage of natural variability despite varying pristineness across the area. We considered using either natural subregions (Natural Regions Committee, 2006) or ecoregions. We decided to use ecoregions since CABIN is a federal program that requires users to enter ecoregions with their data submissions already. As well, recent CABIN reference models from BC used ecoregion as a basis for stratification because ecoregion incorporates variation in climate, geology and land use by definition (Raynoldson & Raggett, 2023; Somers et al., 2021; Strachan & Gledhill, 2021). Although there are 11 ecoregions within our study area, we excluded the two smallest ecoregions – mixed moist grassland and western continental – which were under 40 km^2 each.

We assigned each candidate watershed an ecoregion. For watersheds that contained multiple ecoregions, the ecoregion that accounted for the largest proportion was assigned.

Determining reference criteria

We then used the HAG scores calculated by fRI Research to calculate a HAG score class between 1 and 10, where 1 was the most pristine, and 10 was the least pristine. Classes were determined using the reclassify field function with natural breaks (jenks) as the reclassification method. HAG score class was determined separately for each ecoregion resulting in a different scale of what HAG scores defined the most pristine class etc.

Instead of only keeping the most pristine class for further analyses, we retained all classes and further refined the list of potential watersheds by removing watersheds where over 50 percent of the watershed was affected by fire within the last 10 years, or 20 percent was affected by fire within the last 5 years, following criteria outlined in Strachan (2020). Note that the data used for this assessment was not part of fRI Research's data package and so the range of years covered by this data spanned up to 2022. Strachan (2020) also had a criterion to exclude that watersheds with <20 percent of the watershed affected by fire in the last year; this criterion was not included since the data we used went up to 2022.

The remaining list of candidate watersheds were further trimmed based on whether point sources of various anthropogenic sources. To do this, we calculated distance between various human footprint categories (e.g., mines [not including sand/gravel], distance to mills and urban-industrial, urban-residential) and took the minimum distance to any one of those sources to any streams or rivers within the delineated watershed. If the minimum distance to any of those sources were within 100 m of a stream or river, the watershed was removed.

Strachan (2020) also removed watersheds based on distance of sampling points to lakes or wetlands, and culverts and other flow structures such as dams, weirs and waterfalls. These were not considered in our analysis because these criteria are more suited to specific sites rather than watershed-scale evaluations.

Once these additional watersheds were removed, we evaluated the number of watersheds that remained within each ecoregion, what Strahler order they represented and the distribution of those watersheds across each HAG score class.

Other considerations

In an initial draft of our assessment, we calculated distance from road to the drainage point to understand how feasible access was, similar to fRI's assessment. However, in discussions with OWC, and based on feedback at the BRBC's CABIN Workshop (March 25, 2024), it was suggested that this step was unnecessary and would limit the site choices too much.

Results

After watersheds were removed based on wildfire and point source criteria, 8,579 candidate watersheds remained, but this included all HAG score classes. The distribution of the candidate watersheds across ecoregion and HAG score class can be found in Table 1 along with the area of the ecoregion to give a sense of potential reference site density. The watersheds by HAG score class are shown spatially in Figure 4. Since the watersheds are nested, the map does not effectively depict all watersheds.

Table 1. Number of candidate watersheds within each ecoregion and Human Activity Gradient Score Class where 1 is the most pristine and 10 is the least pristine.

Ecoregion	Area (km^2)	Human Activity Gradient Score Class									
		1	2	3	4	5	6	7	8	9	10
Aspen Parkland	1543	10	14	15	14	7	6	12	10	10	1
Boreal Transition	1810	1	7	18	18	35	16	12	8	4	0
Eastern Continental Ranges	37178	2234	242	149	115	89	79	67	16	3	6
Fescue Grassland	2423	18	20	21	20	21	12	12	10	2	1
Mid-Boreal Uplands	958	6	5	7	7	7	6	6	2	3	0
Northern Continental Divide	9539	230	122	101	89	62	69	45	30	13	3
Peace Lowland	52798	2	2	3	0	0	0	0	0	0	0
Western Alberta Upland	3373	437	791	841	871	536	343	189	81	38	9
Western Boreal	138	23	30	28	26	37	29	31	24	26	14

A fundamental principle in reference site selection is to use the most pristine sites available, and as such, we do not recommend selecting sites less pristine than HAG score class 4. HAG score classes 1-4 demonstrated a reasonable density and distribution across the study area and represented 6,537 watersheds. The spatial distribution of watersheds from HAG score classes 1 to 4 are illustrated in Figure 5.

Selected sites should also represent a good distribution across available Strahler orders. Table 2 provides a tally of the number of watersheds within each HAG score class and Strahler order combination for each ecoregion.

We used overall density of reference sites within each ecoregion, the distribution across Strahler orders, and the spatial distribution of the sites to provide recommendations on what HAG score class should be used as a maximum for each ecoregion. Recommendation and the rationale are presented in Table 2.

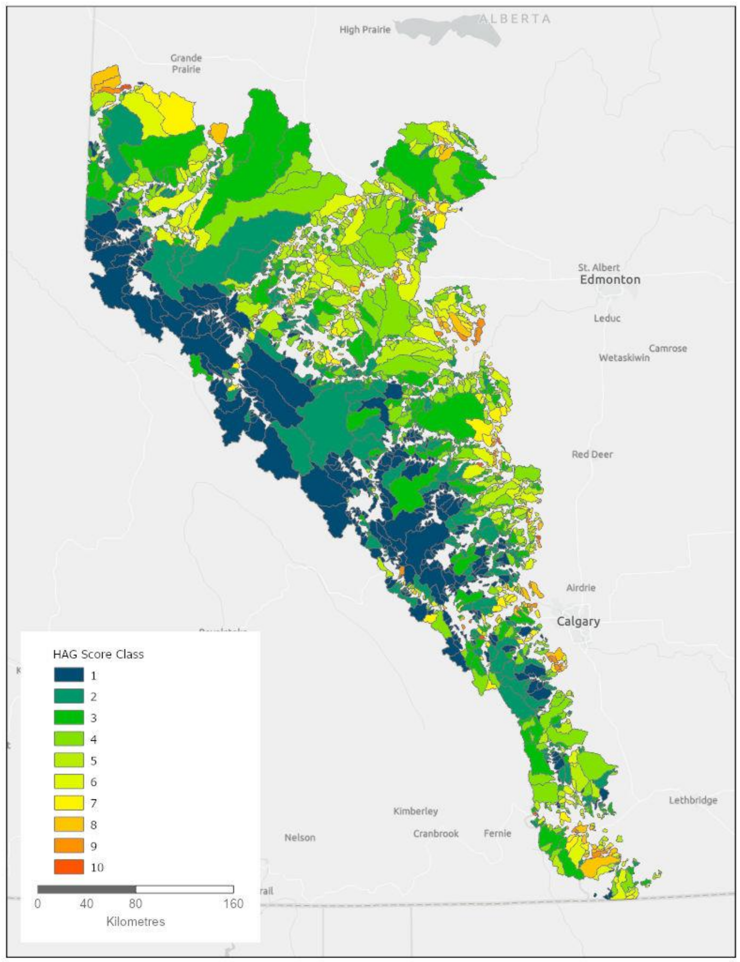

Figure 4. Map of candidate watersheds after wildfire and point source criteria were applied. This map shows all Human Activity Gradient score classes by colour with 1 indicating the most pristine and 10 indicating the least pristine.

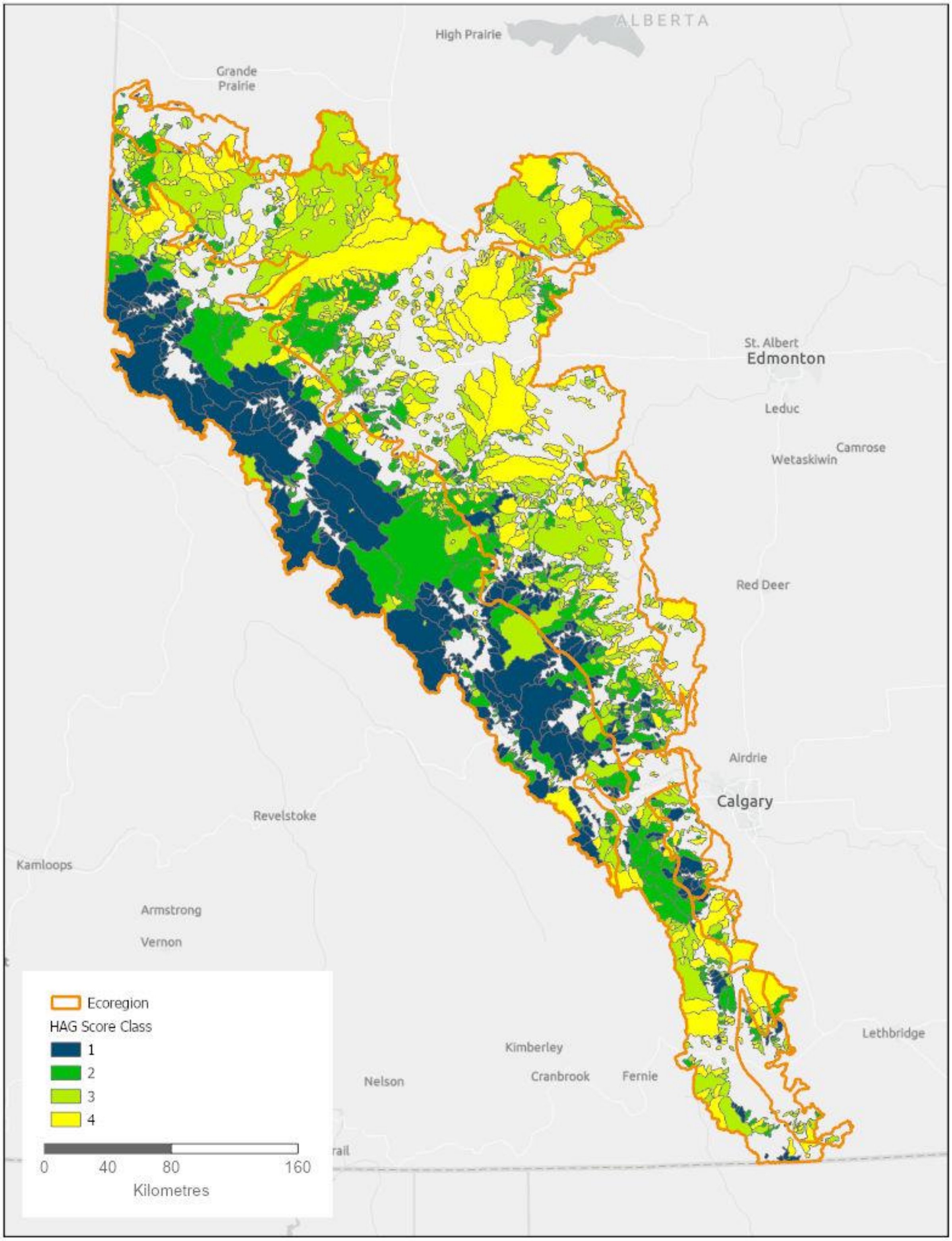

Figure 5. A map of candidate watersheds showing the more pristine watersheds (≤HAG Score Class 4) with Ecoregion outlined.

Table 2. Number of watersheds with each Strahler order of the most downstream drainage point of the delineated watershed. This tally is shown for only the top four HAG score classes by ecoregion. The HAG score classes recommended for use are highlighted in light green and recommendation column indicates the rationale.

Ecoregion	HAG Score Class	Strahler Order							Recommendation
		1	2	3	4	5	6	7	
Aspen Parkland	1	0	0	9	1	0	0	0	Density of HAG Score Class 1 is sufficient but add up to Class 4 for better coverage of strahler order.
	2	0	5	6	3	0	0	0	
	3	1	4	8	2	0	0	0	
	4	2	3	5	2	2	0	0	
Boreal Transition	1	1	0	0	0	0	0	0	Density of HAG Score Class 1 is low, add up to Class 2 and 3 for better density, and up to Class 4 for better coverage of strahler order.
	2	1	5	1	0	0	0	0	
	3	8	7	3	0	0	0	0	
	4	5	9	3	1	0	0	0	
Eastern Continental Ranges	1	414	819	681	263	52	5	0	HAG Score Class 1 is sufficient for density, strahler order and spatial distribution.
	2	15	68	97	43	16	3	0	
	3	14	41	57	26	7	4	0	
	4	7	35	50	18	5	0	0	
Fescue Grassland	1	0	4	11	3	0	0	0	Density of Class 1 is sufficient, but add Class 2 for better strahler order coverage.
	2	1	4	10	4	1	0	0	
	3	0	8	10	3	0	0	0	
	4	6	7	4	2	1	0	0	
Mid-Boreal Uplands	1	2	3	1	0	0	0	0	Class 1 is sufficient for density, but add up to Class 3 for better strahler order coverage.
	2	2	1	2	0	0	0	0	
	3	2	2	1	1	1	0	0	
	4	2	4	1	0	0	0	0	
Northern Continental Divide	1	7	51	116	52	4	0	0	Class 1 is sufficient for density, but add up to Class 3 for better strahler order coverage.
	2	1	14	55	39	12	1	0	
	3	1	16	40	32	8	4	0	
	4	2	16	36	28	5	2	0	
Peace Lowland	1	1	1	0	0	0	0	0	HAG Score Class 1 is sufficient for density, strahler order and spatial distribution.
	2	0	2	0	0	0	0	0	
	3	1	2	0	0	0	0	0	
	4	0	0	0	0	0	0	0	
Western Alberta Upland	1	25	146	202	52	10	2	0	HAG Score Class 1 is sufficient for density and strahler order, but consider Class 2 to improve spatial distribution.
	2	129	325	243	74	17	2	1	
	3	144	328	280	72	14	3	0	
	4	166	387	241	64	11	2	0	
Western Boreal	1	8	12	3	0	0	0	0	HAG Score Class 1 is sufficient for density, but consider Class 2 to improve spatial distribution and strahler order coverage.
	2	12	12	5	1	0	0	0	
	3	16	10	2	0	0	0	0	
	4	12	10	3	1	0	0	0	

Next Steps to Refine Site Selection

We have provided a list of potential references sites based on the results of GIS analyses (conducted by Miistakis Institute), which built upon GIS and statistical analyses conducted previously by fRI Research. This list provides a starting point for practitioners to evaluate sites further based on a desktop assessment using Google Earth Pro, and also by combining local knowledge of the landscape, other potential sources of human impacts that were not captured by GIS, and knowledge on site access.

We analysed data at a watershed scale rather than a specific sampling point. Sampling could occur anywhere upstream of the designated point (called drainage point throughout this report). As such, we did not consider some of the reference point selection criteria described by Strachan (2020) that were more suited to specific site evaluation. These included distance from lake or wetland, and distance from culverts and other flow structures.

For each ecoregion, key principles in site selection are to:

- **select the most pristine sites possible (i.e., lowest HAG Scores available)**
- **covering the full range of stream orders available within each ecoregion**

It may be necessary to work with other watershed groups working in the same ecoregion to ensure that a good range of stream orders are sampled in the ecoregion as a whole. This means that the sites sampled by each group may not cover the breadth of stream orders on their own.

Practitioners can begin site selection using the spreadsheet provided or using the attribute table in ArcGIS. The table can be filtered based on ecoregion or watershed to allow users to focus on their geographic areas of interest.

From there, practitioners should create a short list of potential sites from the most pristine watersheds available based on HAG score class. As an example, Parks Canada's Mountain Parks Cabin model includes 7-10 replicate sites for each site type they identified (i.e., different elevation and stream order combinations); a short list of potential sites should contain more sites (e.g., 20 sites) to allow some sites to be discarded through the remainder of the process. Please refer to Table 2 for recommendations on what HAG score classes are likely to be needed based on the ecoregion you are working in.

Once the short list of sites is identified, practitioners should explore those sites using Google Earth Pro to evaluate each site for the following:

- Potential point sources that may not have been captured in the GIS analysis:
    - Strachan (2020) suggests avoiding point sources when possible and selecting sites that are >10 km downstream of point sources for small streams (stream order 1-3) or >20 km for large streams (stream order 4-6).
- Proximity to lakes:
    - Strachan (2020) suggests selecting sites that are >2 km downstream for small lakes and 5 km downstream for large lakes.
- Proximity to culverts and other flow structures:
    - Strachan (2020) suggests selecting sites that are >500 m downstream of and >50 m upstream of flow structures (e.g., dams, weirds and waterfalls).

- Access:
    - Use local knowledge or Google Earth imagery to evaluate access to potential sampling sites. To assist in some watersheds that are less well known, we have included a field in the attribute tables called “DP_dist2road” which indicates the distance to the nearest road for just the drainage point of the watershed.

It is important to ensure that watersheds recently impacted by fire are not included as reference sites. Although some watersheds may look recovered, or unimpacted watersheds may be challenging to find in some areas, this is an important detail. Recovering watersheds are likely to have altered trophic status for some time following the fire (Martens et al., 2019) and will have an unintended impact on the reference condition model (pers. comm. S. Humphries).

Despite GIS methods helping to speed up the process in site selection and standardize some of the decision-making at this step, the desktop and in-person field assessments are vital to this process. There will still be situations where potential reference sites are deemed not appropriate as a reference site at the field visit stage, or even during the model building (pers. comm. W. Monk).

References

Humeny, E. (2021). *Applications of a Standardized Aquatic Biomonitoring Program and research priorities for informing cumulative management in Alberta foothills forested watersheds*. www.westfraser.com

Martens, A. M., Silins, U., Proctor, H. C., Williams, C. H. S., Wagner, M. J., Emelko, M. B., & Stone, M. (2019). Long-term impact of severe wildfire and post-wildfire salvage logging on macroinvertebrate assemblage structure in Alberta's Rocky Mountains. *International Journal of Wildland Fire*, *28*(10), 738–749. https://doi.org/10.1071/WF18177

Natural Regions Committee. (2006). *Natural Regions and Subregions of Alberta*. Compiled by D.J. Downing and W.W. Pettapiece. Government of Alberta. Pub. No. T/852.

Raynoldson, T., & Raggett, J. (2023). *Reference Model Supporting Documentation for CABIN Analytical Tools: North and Central Coast BC*.

Somers, K., Proulx, C., Kilgour, B., & Raggett, J. (2021). *Reference Model Supporting Documentation for CABIN Analytical Tools: Vancouver Island Updated Model*.

Strachan, S. (2020). *Reference Model Supporting Documentation for CABIN Analytical Tools: Columbia Basin 2020*.

Strachan, S., & Gledhill, M. (2021). *Reference Model Supporting Documentation for CABIN Analytical Tools: Fraser Basin*.

Yates, A. G., & Bailey, R. C. (2010). Selecting objectively defined reference sites for stream bioassessment programs. *Environmental Monitoring and Assessment*, *170*(1–4), 129–140. https://doi.org/10.1007/s10661-009-1221-1

Miistakis Institute
EB3013, Mount Royal University
4825 Mount Royal Gate SW
Calgary, Alberta T3E 6K6

www.rockies.ca

Miistakis Institute