

Sustainable Forestry Benchmarks for British Columbia:

**A Geographic Information
Systems Assessment of
Undeveloped Watersheds as
Ecological Monitoring Units**

Mike Fenger and Matthew Wheatley



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ABSTRACT

Effective ecosystem monitoring requires valid comparisons between managed and reference areas, the latter consisting of representative areas that are considered as close to natural as is available within any given ecologically similar forested area. Forest management in British Columbia has fundamentally altered the structure of most forest ecosystems, which has created the need to develop forestry-based monitoring programs that identify ecosystem changes over time. A key step yet to be done in this process is to inventory available reference areas for use in forest monitoring contexts. The objective of this report is to define and locate within British Columbia forest-biomonitoring reference areas, termed here as “Sustainable Forestry Benchmarks” (SFBMs). We define SFBMs as undeveloped, watershed-scale areas that are representative of current natural forests, and that are suitable for use as biomonitoring reference areas. We employ Geographic Information Systems (GIS) to define “undeveloped watersheds” using the following criteria from a candidate set of more than 19 000 watersheds province-wide: percentage forested, variability in wood volume per hectare, and degree of road development. Once defined, we assess the percentage of candidate areas within Parks and Protected Areas and provide quality ranks and physical maps for each candidate undeveloped third-order watershed in the Interior of British Columbia. We focus on areas most affected by the recent spread of mountain pine beetle. We also denote areas where candidate watersheds are within protected areas and those where they are not; areas that have limited numbers of candidates; and areas that entirely lack candidates. Implications regarding large-scale biomonitoring are discussed.

KEYWORDS: *biomonitoring reference areas, cumulative effects, ecosystem monitoring, GIS assessment, mountain pine beetle, representative landscape/watershed-level benchmarks, results-based forestry, sustainable forestry, undeveloped watersheds.*

Author Contact Information

Mike Fenger*

Mike Fenger and Associates Ltd., 511 Foul Bay Road, Victoria, BC V8S 4G9

Email: mfenger@pacificcoast.net

Matthew Wheatley

Biology Department, University of Victoria. Current address: MTW Ecological Research, #18–113

Hardisty Ave., Hinton, AB T7V 1C4

Email: matt@mtw-ecological.netmt

*Author to whom correspondence should be addressed.

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EXECUTIVE SUMMARY

The objective of this report is to define and locate within British Columbia “undeveloped watersheds” for use as biomonitoring reference areas, termed here “Sustainable Forestry Benchmarks” (SFBMs). We define SFBMs as undeveloped, watershed-scale areas representative of current natural forests that are suitable for use as biomonitoring reference areas for detecting ecosystem change when compared to areas altered by forest management. SFBMs are fundamental to a science-based approach for understanding and monitoring terrestrial and aquatic ecosystems in a natural condition; however, SFBM areas remain to be ecologically defined, quantified, and located within British Columbia. In this report we employ Geographic Information Systems (GIS) to define “undeveloped watersheds” using the following criteria:

- Percent forested
- Variability in wood volume per hectare
- Degree of road development

Once the watersheds are defined, we assess the percentage of candidate areas within Parks and Protected Areas (PPAs). The results of this strategic-level GIS assessment will map “undeveloped” third-order watersheds in the Interior of British Columbia, with a focus on areas most affected by the recent spread of the mountain pine beetle.

A science-based approach is critical to provide objective understanding of changes in ecosystems resulting from our forest development and to make comparisons with natural disturbance-driven ecosystems. Natural disturbance benchmarks provide “experimental control areas” for long-term monitoring. They enable objective scientific comparisons of a variety of forest management approaches purporting to sustain ecosystem function within British Columbia. There is significant uncertainty regarding the effectiveness of different forestry practices, and both government and licensees are increasingly challenged to demonstrate how their harvest practices and plans sustain ecosystem function, integrity, and productivity. Additionally, the degree to which forest practices are, in fact, sustainable is complicated by climate change, continual changes in policy, and shifting accountability. An identified candidate set of SFBM areas is needed to provide ongoing baseline information from natural areas, and these must be large enough to be relevant to forest harvesting which functions at the scale of watersheds and landscapes.

The need for SFBMs is acute. The recent spread of the mountain pine beetle has expedited salvage logging, accelerating harvest in pine forests and increasing our uncertainty regarding the condition and function of future forests. There is also recognition that, despite best short-term efforts to mitigate the socio-economic effects of pine beetles, we will not be able to salvage all areas of dead pine. This report shows where it is possible to retain undeveloped watersheds as biomonitoring benchmarks. We also identify the extent to which representative undeveloped watersheds are within PPAs. We do not, however, recommend any specific monitoring indicators; that is beyond the scope of this report. This is a strategic spatial assessment of where opportunities for monitoring exist at a landscape and watershed scale, with a focus on forests affected by the mountain pine beetle.

Our assessment is based on a provincial inventory of roughly 19 000 third-order watersheds augmented with seamless digital forest inventory covering the entire defined study area. We assessed watersheds based on volume- and percent-forested thresholds representative of typical watersheds being managed for timber production in the British Columbia Interior. Based on existing ranges of road density and logging activity, candidate SFBMs were defined as watersheds with less than 2% area logged and less than 250 m of roads per km². We further assessed these candidate sites by selecting watersheds

with more than 100 m³ of wood per hectare, and more than 40% forest by area. Once values for logging, road density, and forested area were quantified, candidate SFBMs were ranked for quality based on wood volume. We assigned the highest rank to watersheds with greater than 70% by area having more than 200 m³ of wood volume per hectare, with the lowest ranks assigned to watersheds with 100% of forested area having 100–199 m³ of wood volume per hectare.

This assessment groups the province using study areas derived a-priori from eco-regional classification and major drainage systems. Thirty-nine study areas were identified province-wide. We completed analyses for 20 of these study areas, chosen based on priority areas most affected by mountain pine beetle. Each study area was mapped to show the location and colour-coded quality rank of undeveloped watersheds located within. Detailed maps for each study area are included, showing provincial watershed identification numbers so readers can link individual watersheds to actual locations, and to summary tables outlining: 1) the 15 highest ranked candidate SFBM watersheds within each study area and 2) SFBMs with the highest percent area in existing PPAs.

Limitations

Road information employed here was the most current available, but was approximately 10 years old, thus results may vary depending on recent on-the-ground road development. Although selected watersheds may no longer meet the “undeveloped” criteria, they likely still represent the best available SFBMs in any given area. Forest cover data from Tree Farm Licences (TFLs) was not available, so these areas were excluded from this analysis.

Findings

Once quantified and mapped, we categorized our study areas based on the number of potential candidate watershed areas, and their protection within existing parks. Below we describe five broad categories based on our findings.

1. Candidate SFBMs that are entirely within Parks and Protected Areas (PPAs).

There are three study areas where SFBMs would be available entirely from within PPAs. These study areas are:

- Study Area 20: West Kootenays (Nelson–Creston–Nakusp)
- Study Area 21: Shuswap Highland (Vavenby–Sicamous)
- Study Area 22: Selkirk-Bitterroot Foothills (Grand Forks–Castlegar)

There are no undeveloped watersheds outside of PPAs in these areas. With appropriate monitoring collaborations, these areas might be recognized within Park Management Plans, or established as Ecological Reserves within the existing PPAs.

2. Candidate SFBMs that are mostly from within PPAs.

There are five study areas within which most SFBM candidates are located within PPAs. These study areas are:

- Study Area 15: Upper Fraser Trench and Caribou Mountains (McBride)
- Study Area 23: Southern Interior Plateau (Vernon–Penticton–Princeton)
- Study Area 24*: North and South Thompson Uplands (Kamloops–Merritt)
- Study Area 26: Central and Western Chilcotin Ranges (Nemiah)
- Study Area 29: Northern Interior Plateau (Smithers–Tweedsmuir–Quesnel)

*Study Area 24 had a number of candidate watersheds identified but the quality of these could not be evaluated due to the absence of reliable forest cover information. Determination of the best candidate sites would require field verification. If the watersheds within PPAs are better suited, they

can be recognized within the Park Management Plan or established as Ecological Reserves within the existing PPAs. In the absence of formal land-use protection, candidates within this region that are outside of PPAs would require voluntary industry-led protection.

3. Candidate SFBMs that are primarily outside of PPAs.

There are nine study areas where most SFBMs are located outside of PPAs. These study areas are:

| | |
|----------------|--|
| Study Area 2: | Taiga Plains (Fort Nelson) |
| Study Area 12: | Omineca Mountains–Manson Plateau (Mackenzie–Germansen Landing) |
| Study Area 13: | Central Canadian Rocky Mountains (Pine Pass) |
| Study Area 14: | Upper and Mid-Fraser Basin (Prince George–Fort St. James) |
| Study Area 17: | Quesnel Highlands (Quesnel–Canim Lakes) |
| Study Area 19: | East Kootenays (Golden–Cranbrook) |
| Study Area 25: | Leeward Pacific–Pavilion Ranges (Lillooet) |
| Study Area 27: | Mid-Fraser Basin (Alexis–Anahim) |
| Study Area 30: | Nass Basin–Bulkey–Nass Ranges (Terrace–Hazelton–New Aiyansh) |

The condition of these candidate watersheds would need to be field checked. If the watersheds within PPAs are better suited, they can be recognized within the Park Management Plan or established as Ecological Reserves within the existing PPAs. In the absence of formal land-use protection, candidates within this region that are outside of PPAs would require voluntary industry-led protection. Currently they are beyond interim discretionary protection from provincial officials.

4. Candidate SFBMs that are of limited or poor quality.

| | |
|---------------|---|
| Study Area 1: | Boreal Plains (Fort St. John–Pouce Coupe) |
|---------------|---|

There are relatively few candidate watersheds in this area, likely reflecting the characteristic low forest productivity of the region. The condition of identified candidate watersheds would require ground truthing.

5. Candidate SFBMs that are no longer available due to development history.

There are two study areas where there are no options for SFBMs either due to an absence of forested PPAs or because of the history of forest development. These areas are:

| | |
|----------------|--|
| Study Area 16: | Bowron Valley (south east of Prince George) |
| Study Area 28: | Mid-Fraser Cariboo Basin Cariboo Plateau (Williams Lake–Clinton) |

Of the 20 study areas assessed, 15 require a more detailed assessment of the candidate watersheds within and outside of PPAs. Where high-ranked SFBMs are located outside of PPAs, industry support will be required to instate these as monitoring sites that are free from salvage logging.

Climate change adds additional uncertainty to adaptive forest management and, despite the best efforts to forecast climate change outcomes, benchmark forests will be needed to provide reference data to decouple climate-change responses from those responses that are associated with forest management. Forestry is a long-term endeavour in which measuring sustainability needs to be guided by science-based information; a co-ordinated system of SFBMs will factor highly in this process.

The co-operation of many is needed to initiate and then support a SFBM system. Support will have to be wide-ranging and include forest management tenure holders, colleges, regional universities, professional organizations, provincial and federal agencies with natural resource mandates, First Nations, and environmental organizations. As they continue to be developed and lost over time, it is urgent that we begin to recognize and protect candidate SFBMs, so we might maintain some form of litmus test to gauge our efforts at sustainable forest management.