# FLOOD CONTROL AND DROUGHT ALLEVIATION

## HIGH CONSERVATION VALUE 4, QUESTION 13

*Are there forests that provide a significant ecological service in mediating flooding and/or drought, controlling stream flow regulation, and water quality?*

### BACKGROUND

The HCVF Framework for Canada recognizes that forest areas play a critical role in maintaining water quantity and quality and that if these ecological services break down, they may be irreplaceable or there may be catastrophic impacts.

Canadian boreal forests perform numerous critical functions that help sustain life on earth, including filtering millions of litres of fresh water each day, producing oxygen, storing carbon and regulating local climatic process such as rainfall patterns (MEA 2005). More than 80% of world's unfrozen fresh water is found in the boreal. The Canadian boreal region includes one quarter of the earth's wetlands and approximately 1.5 million lakes that cover 30% of the region. These lakes and wetlands hold back floodwaters and release needed water throughout watersheds via rivers and streams.

We have identified three principal issues related to how this question has been addressed in HCVF assessments to date:

1. Multi-scaled spatial analysis: A multi scaled spatial analysis is a necessary element of a hydrologic analysis. Maps depicting the results of the analyses are vitally important for communicating results within the HCVF assessment document.

2. Cumulative effects: Climate, forest management actions, natural disturbances (*e.g.*, fire, beaver, landslides) and urbanization are all dynamic factors that influence water quality and quantity. Floods are usually attributable to unusual or extreme meteorological events, however other factors including removing forest cover and soil degradation may contribute.

3. Focus on management actions: Within existing assessments there is a tendency to explain that current forest management practices related to water quality and flow regulation (*e.g.*, stream crossings) are conducted within accepted guidelines or codes. Management regimes can change and should not be determining factors in HCVF identification; an analysis of forest areas providing water flow regulation or water quality services is still required to determine if any HCVF areas exist within the forest tenure.

### DATA SOURCES

The HCVF Framework for Canada lists the following possible data sources:

- Hydrological maps
- Hydrologists in government departments or local research institutions

Additional data sources that would be relevant to addressing the issue of flood control and drought alleviation include:

- Local terrain mapping and base maps showing topography
- Regional watershed plans and authorities (*e.g.*, Mattagami Region Conservation Authority)
- Provincial watershed maps, including Provincially Significant Wetlands (Ontario)
- Ducks Unlimited Canada – wetlands and hydrological data
- Regional studies on flood events and frequencies
- Alberta Environment flood risk map http://www3.gov.ab.ca/env/water/flood/
- Environment Canada water level and stream flow statistics for specific stream monitoring stations http://www.wsc.ec.gc.ca/staflo/
- Manitoba water information maps http://www.gov.mb.ca/waterstewardship/water_info/maps/
- Snow, frozen soils and permafrost hydrology in Canada, 1995-1998 (Woo *et al*. 2000)

### INTERPRETING REGIONAL AND LOCAL SIGNIFICANCE

Forest harvest may alter basin hydrology on a regional scale. Within a watershed, the specific effects of forest harvest and other management actions are related to the slope and soil depth of the modified landscapes. Removal of forest cover reduces the lag time between a precipitation event and stream flow response, and increases the tendency for overland flow of water rather than infiltration. A generally proportional relationship exists between total water yield (*i.e.* runoff) and the extent of forest disturbance (Sahin and Hall 1996).

Identifying what forest areas are important for flood control and drought alleviation requires an understanding of regional and local hydrologic features and systems. A hydrological assessment should be the first step toward fully addressing both Questions 12 and 13.

Drought and natural floods are driven by atmospheric events, therefore it is similarly important to understand regional and local climate history and flood regimes. Prolonged periods of moderate rainfall can lead to plain floods that build up over days and can affect large areas, whereas short lasting but intense rainfall or snowmelt may cause flash flooding.

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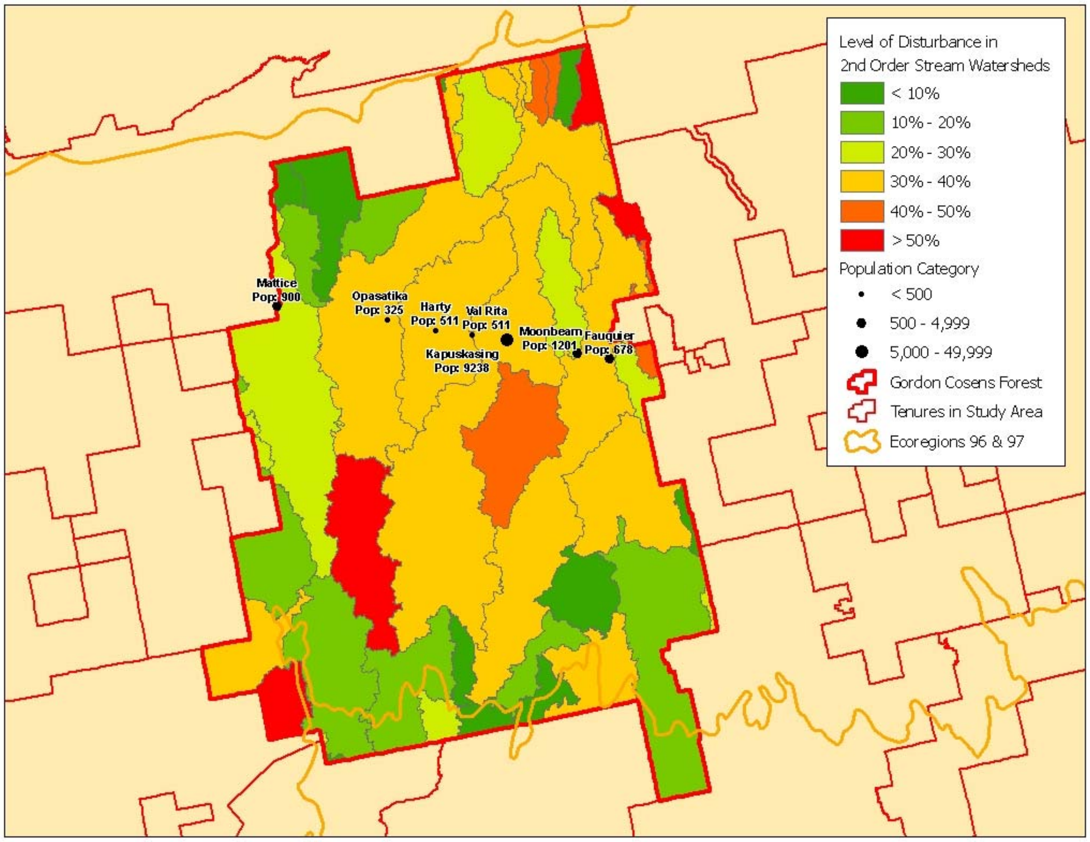
**Figure 13.1** Quaternary watersheds in Gordon Cosens Forest symbolized by level of disturbance within headwater areas (1st and 2nd order stream watersheds).




## Interpreting the Precautionary Principle

Analyses of forest areas important for flood control and drought alleviation should consider cumulative impacts of forest management, other land uses and natural disturbances. For example, post fire flooding is common and related impacts can result in sediment loading into rivers, streams and wetlands. The potential cumulative impact of a 100 year flood and forest management actions should be considered.

In addition, forest flooding regimes may change as a result of river regulation and water management associated with hydroelectric development. Finally, climate change is expected to increase total rainfall, rainfall intensity and soil erosion rates in North America (Nearing *et al*. 2004). To be precautionary, we recommend a water quantity monitoring program be established for HCVs identified under Question 13.

## Additional Guidance

Identifying forest areas that have high conservation value because of their role in retaining water quality and quantity is aided by an understanding of flood, drought and water quality history. Climatic and hydrological records should be examined over as long a temporal scale as possible (e.g, 100, 50, 10 and 25 year flood records). In cases where records are poor or lacking a modeling approach based on topography and climate data may be necessary.

Hydrologic modeling programs that may be useful include:

- European Commission LISFLOOD model - developed to simulate floods in large European drainage basins. Allows full basin-scale simulations including influences of land use, spatial variations of soil properties and spatial precipitation differences (http://natural-hazards.jrc.it/floods/Tools/index)
- Danish Hydraulic Institute for Water and Environment MIKE 11 software package - is a versatile and modular engineering tool for modeling conditions in rivers, lakes/reservoirs, irrigation canals and other inland water systems. It is designed for flood risk analysis and mapping, design of flood alleviation systems, integrated groundwater and surface water analysis, and other hydrologic analyses (http://www.dhisoftware.com/mike11/index.htm)

If a comprehensive hydrological analysis is not feasible, we recommend a spatial analysis of all hydrologic features, including wetlands and secondary, tertiary and quaternary watersheds within the forest tenure.

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**Table 13.1** Population centres in Gordon Cosens Forest and levels of 2nd order stream watershed disturbance.

| 3' Watershed | 4' Watershed | Total Area of 4' Watershed (ha) | Proportion of 4' Watershed in Gordon Cosens | Level of Disturbance in 2nd Order Stream Watersheds | Community | Pop'n | Total Pop'n in 4' Watershed |
|---|---|---|---|---|---|---|---|
| 4LD | 4LD-01 | 198,389 | 98.0% | 37.8% | Fauquier | 678 | 678 |
| 4LF | 4LF-01 | 264,997 | 100.0% | 35.0% | Val Rita<br>Kapuskasing | 511<br>9,238 | 9,749 |
| | 4LF-02 | 34,857 | 100.0% | 26.3% | Moonbeam | 1,201 | 1,201 |
| | 4LF-03 | 106,712 | 100.0% | 31.5% | Harty | 511 | 511 |
| 4LJ | 4LJ-01 | 174,336 | 81.5% | 25.5% | Mattice | 900 | 900 |
| 4LL | 4LL-01 | 208,634 | 84.4% | 30.7% | Opasatika | 325 | 325 |

This approach is one way to identify flood-prone areas (*i.e.* riverine areas where flow is restricted), catchment basins and other forest areas critical to flood control, drought alleviation and maintaining water quantity. We recommend that direct measurements of hydrology (water level, trends, timing and in-stream flow) be used as indicators of water quantity.

Water flow may change in response to disturbance of forest vegetation and soils. Pairing an analysis of hydrologic features with an examination of the level of disturbance within 1st and 2nd order streams within the forest tenure will further aid in identifying areas prone to flooding or drought.

For example, Figure 13.1 shows the 4' watersheds in GCF symbolized by their level of 2nd order stream watershed disturbance. Table 13.1 describes the level of disturbance in the headwaters (1st & 2nd order stream watersheds) of each 4' watershed within the Gordon Cosens. Disturbance was measured as the proportion of the "headwater" area that was covered by recent depletions, or was within 100m of primary & secondary roads, or was within 50m of a tertiary (logging) road. Those watersheds with higher levels of anthopogenic disturbance should be listed as HCVFs due to their higher susceptibility to flooding or drought events.

Note that Table 13.1 links to the analysis described for Question 12 by providing a summary of the watersheds with communities, the total populations per watershed and the level of disturbance present in each watershed's "headwater" areas (*i.e.* 2nd order stream watersheds). The proportion of disturbance in populated watersheds ranges from about 25% up to nearly 40%. The average disturbance figure for all of the watersheds within Gordon Cosens, is approximately 25%.

*Thresholds*

One threshold for a measurable response in water flow as a result of forest disturbance was found to be at forest cover changes at or above a 20-25% (Bosch & Hewlett 1982; Hornbeck *et al.* 1993). We suggest a threshold of 20% disturbance (as defined above) be set for forest practices in all watersheds, and a precautionary threshold of 0-10% be set for HCVFs identified under this criteria.

Stream crossing density – the number of times that roads, trails, pipelines and railroads cross streams – is another potential watershed indicator. Watersheds with many crossings are more likely to have increased erosion, water temperature, angling pressure and temporary or permanent barriers to fish movement. Salmo (2004) recommends a critical threshold of <0.5 km/km$^2$ calculated for subwatershed, and target threshold of <0.32 km/km$^2$ per subwatershed for the Deh Cho Land Use Planning Area. We suggest a similar threshold is appropriate for HCVFs under Questions 12 and 13 throughout the Canadian boreal region.

It should again be emphasized that these thresholds should not be assessed against forestry practices alone, but should be measured against the total sum of all anthropogenic stresses. This cumulative impact is more indicative of the state of the watershed than a series of individual indicators.

*Related HCVF questions/areas of possible overlap*

- Question 12 – drinking water supplies
- Question 14 – forest areas sensitive to erosion
- Question 16 – forest areas important for agriculture or fisheries

## Summary of Recommendations

- Conduct multi-scaled spatial analyses of hydrologic features and function and provide maps depicting the results of the analyses.
- Consider cumulative impacts from climate, forest management actions, other land uses and natural disturbances water quality and quantity.
- Identify HCVs based on inherent conservation value, not on management actions
- In cases where records are poor or lacking use a modeling approach based on topography and climate data to address this question.
- Establish a water quantity monitoring program for HCVs identified under Question 13.

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## Literature Cited


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Woo, M.K., P. Marsh and J. Pomeroy. 2000. Snow, frozen soils and permafrost hydrology in Canada, 1995-1998. Hydrological Processes. 1591-1611


## Methodology

Figures 13.1, Table 13.1

*Sources*

- Populated Places. Natural Resources Canada, Atlas of Canada. 1:1,000,000. 2003
- 2001 Census of Canada. Statistics Canada
- Secondary,Tertiary and Quaternary Watersheds. OMNR. 1:20,000. 2002.
- Road Segments. NRVIS layer. OMNR.
- Global Forest Watch Canada. Forest Tenures in Canada.
- Environment Canada & Agriculture Canada. Terrestrial Ecoregions of Canada.

*Methodology*

- 2001 Census figures were used to set precise population values for communities located within Gordon Cosens Forest, as the Populated Places dataset contains only coded population ranges for communities, and included several "No Data" values for this area
- Level of disturbance within each Quaternary watershed was estimated as the proportion of non-permanent, anthropogenic disturbance within the second-order stream watersheds for the portion of each Quaternary watershed within Gordon Cosens Forest
- The second order stream watershed layer was first intersected with the Quaternary watersheds and Gordon Cosens Forest Tenure
- The disturbance layer was calculated using the same methodology as Figure 7.2, utilizing depletion layers for Gordon Cosens Forest, and NRVIS roads data (applying 50m buffer to tertiary roads, and 100m buffer to primary and secondary roads)
- The level of disturbance was expressed as a proportion of the second order stream watersheds covered by the disturbance layer, and was used to populate Table 13.1, and this value was also used to symbolize the quaternary watersheds illustrated in Figure 13.1. It should be noted that due to data limitations, only the portions of watersheds that intersected Gordon Cosens Forest were analyzed, and disturbance levesl reflect these portions only.