ANTHROPOGENIC DISTURBANCE:

Forest Harvest

Forests play a crucial role in regulating microclimatic conditions in interconnected ecosystems, influencing factors such as light, wind, temperature, and moisture.[1] Forests also regulate hydrologic conditions such as hydroperiod, water budget, and water storage potential. In the western boreal forest, characterized by a mosaic of upland forests and wetland ecosystems, **activities that occur in forests, such as forest harvest, may affect adjacent or nearby wetlands.**

Forest harvest may affect wetland extent, hydrology, soils, and nutrient cycling. The type and magnitude of effects depend on the harvest methods, season, wetland classification, and environmental conditions. While wetlands may be considered part of the non-productive land base in forest management planning and operations, theyare highly interconnected with upland forests (*Factsheet #2*) and these interconnections need to be considered as part of a whole landscape approach to ecosystem based management.

Good planning combined with an understanding of wetland classification and inventory (*Factsheet #2* and *Factsheet #3*), wetland hydrology (*Factsheet #4*), and wetland values (*Factsheet #1*), can minimize potential impacts to wetlands.

Effect of Forest Harvest on Wetland Extent

Merchantable timber harvesting in forested wetlands is not common in the western boreal forest.[1,2] Treed wetlands are typically avoided during harvesting because they are often perceived as unproductive with unmerchantable harvest volume.

However, treed wetlands may be crossed to access harvest sites or used for landings. Some incidental harvest may occur when merchantable margins are harvested, due to the difficulty of identifying treed wetland classes from treed uplands. Treed wetlands such as conifer swamps and treed organic wetlands can be mistaken for upland forests, especially during dry periods.

In instances where wetlands are harvested, the regeneration process may shift towards an upland forest community, leading to the loss of wetland area.[3] These shifts can lead to a loss of wetland functions and values (*Factsheet #1*).

Figure 1. A buffered wetland witin a harvest block.

Effects of Forest Harvest on Wetland Water Quality and Quantity

The main hydrologic processes that can be affected by forest harvest activities are:

- Seasonal pattern of flooding duration, frequency, and water depth (hydroperiod);
- Changes in water volume from precipitation, streamflow, or groundwater (water budget); and,
- Capacity of the wetland to store water (storage potential).[4]

Harvesting may directly alter hydrology by reducing canopy interception and evapotranspiration, leading to **increased surface flow increased groundwater recharge and decreased soil moisture potential.**[5]

Figure 1. A harvest blog next to a treed wetland.

"**Watering up**," or a rise in the water table, is a consistent finding in western boreal wetlands adjacent to harvest sites, immediately post-harvest .[6,7,8] Following harvesting, peatlands typically experience an increase in water table height, ranging from **4 to 30 cm**.[5,6] This rise in the water table is linked to reduced interception and evapotranspiration due to tree removal, but can also be attributed to flow path disturbances from access road construction.[8,9] Depending on topography, soil, and surficial geology, these alterations to the water table can lead to:

- **Increased surface runoff:** water flows over the ground surface from excess precipitation.
- **Increased groundwater recharge:** water moves downward from surface water to groundwater.
- **Reduced forest productivity**: high water tables and flooding can result in paludification, the process by which upland forest is converted to peatland.[6,8]

The above effects are typically seen, but are dependent on local conditions. Some studies have found contrary effects on the water table in wetlands following the harvest of adjacent forests:

- Thompson et al. (2018) found limited water table increases from aspen harvesting near peatlands. However, it should be noted that the adjacent peatland was characterized as having glacial substrate under the cut blocks, resulting in low hydraulic conductivity, deep-water tables, and low connectivity between adjacent uplands and hillslopes which may have masked the potential water table increase.
- Plach et al. (2016) discovered a decline in soil moisture from clear-cut harvesting immediately adjacent to a peatland. Canopy cover loss resulted in increased rates of wind causing increased evapotranspiration and reduced soil moisture.

Harvesting not only alters the hydrology of the harvested area but also has the potential to **effect connected wetlands and uplands**, though this is dependent on storage capacity and underlying geology. Some paired-catchment studies reveal a direct relationship between harvesting and increased streamflow in downstram systems, while others indicate that harvesting has little to no effect on downstream systems in areas with large storage capacity and deep glacial deposits.[9]

Effects of Forest Harvest on Wetland Soils

Forest management activities in or adjacent to wetlands can potentially result in erosion and sedimentation (***Factsheet #13***), the introduction of deleterious materials via mechanical leaks (e.g., fuels, hydraulic fluids), and vegetation management inputs (i.e., herbicides), which can significantly affect wetland water quality and soil health.

Activities that expose soils, including construction of access roads, site preparation, and bared areas (e.g., landings), may increase erosion risk, with soil being transported into wetlands' surface water if mitigation strategies are not implemented. If sedimentation occurs, it can:

- Alter plant community structure by reducing seedling establishment or suffocate growth;
- Affect aquatic invertebrates, fish and amphibians by burying bottom dwelling organisms and eggs;
- Lower community biomass, diversity, and richness; and,
- Increase turbidity levels from suspended sediment can reduce light penetration, reduce plant growth and reduce visibility for fish.[10,11]

In the western Boreal, a small shift in evapotranspiration can have significant effects on hydrology.[1]

Drying peat can become hydrophobic, meaning that until it reaches a certain soil moisture content again, it will repel water and infiltration, leading to runoff and erosion.[12] Therefore, the effects of harvest cannot be assumed in the boreal plains as there are a variety of factors that impact how they might respond to adjacent harvest.

Effects of Forest Harvest on Wetland Nutrient Cycling

Disturbing wetland soild during harvesting can create hydrologically mobile sources of dissolved organic carbon (DOC).[6] Since wetlands are often hydrologically connected to lakes, this can lead to an increase in surface water DOC concentrations in boreal lakes post-harvest.[6] Changes in DOC can modify the relative abundance of different organisms in wetland environments and create food-web imbalances.

Similar nutrient flushing effects are observed for phosphorus and nitrogen, influencing peat oxidation during summer water table drawdowns and weed establishment in disturbed areas of peatlands.[2,7]

TEMPORAL IMPACT OF FOREST HARVEST

Recovery from disturbances, such as forest harvest, is influenced by regional conditions, pre-harvest forest composition, and the harvested tree species. In wetlands adjacent to harvest sites, a consistent finding is watering up, characterized by a rise in the water table, with post-harvest oragnic wetlands typically showing increases in water table height ranging from 4 to 30 cm.[5,6]

- In studies conducted in the eastern boreal region in a coniferous stand, it was observed that **five to ten years after harvesting**, water tables in adjacent peatlands had still not recovered.[8,11]
- Conversely, another study in the boreal plains located in an aspen stand, found that the water table returned to pre-harvest levels **two years post-harvest**.[5] Aspen has a higher regeneration rate than coniferous species resulting in greater water uptake demands in the years immediately following harvest.[8] The greater water demands counteract the watering-up impacts that wetlands experience post-harvest, allowing expedited recovery.

While these two studies differ by ecoregion and, therefore, have different controls on wetland development and function, they both indicate that recovery was triggered upon the initiation of canopy regeneration and subsequent crown closure.[5,13]

Resources:

- Forestry and Waterfowl: Assessing and Mitigating Risk Practitioner Guide
- Guiding Principles for Wetland Stewardship and Forest Management Practitioner Guide
- Wetland Best Management Practices for Forest Management Planning and Operations Practitioner Guide
- Resource Roads and Wetlands: A Guide for Planning, Construction, and Maintenance
- Forest Road Wetland Crossings Operational Guide

1. Lavoie, M., Paré, D., Fenton, N., Groot, A., & Taylor, K. (2005). Paludification and management of forested peatlands in Canada: A literature review. In Environmental Reviews (Vol. 13, Issue 2, pp. 21–50). https://doi.org/10.1139/a05-006
2. Locky, D. A., & Bayley, S. E. (2007). Effects of logging in the southern boreal peatlands of Manitoba, Canada. Canadian Journal of Forest Research, 37(3), 649–661. https://doi.org/10.1139/X06-249
3. Forest Management and Wetland Stewardship Initiative (FMWSI). (2018). Guiding principles for wetland stewardship and forest management: Technical report. Ducks Unlimited Canada.
4. Devito, K. and C. Mendoza. 2006. Maintenance and dynamics of natural wetlands in western boreal forest: Synthesis of current understanding from the Utikuma Research Study Area. Cumulative Environmental Management Association. Alberta, Canada. Pg. 84.
5. Thompson, C., Devito, K. J., & Mendoza, C. A. (2018). Hydrologic impact of aspen harvesting within the subhumid Boreal Plains of Alberta. Hydrological Processes, 32(26), 3924–3937. https://doi.org/10.1002/hyp.13301
6. Webster, K. L., Beall, F. D., Creed, I. F., & Kreutzweiser, D. P. (2015a). Impacts and prognosis of natural resource development on water and wetlands in Canada's boreal zone. In Environmental Reviews (Vol. 23, Issue 1, pp. 78–131). National Research Council of Canada. https://doi.org/10.1139/er-2014-0063
7. Locky, D. (2010). Early stand-level assessment of forest harvesting in western Boreal Peatlands [Research Note Series]. Athabasca University. https://auspace.athabascau.ca/bitstream/handle/2149/2430/Locky%20SFMN%20RN%20En57%202010%20Peatland.pdf?sequence=1&isAllowed=y
8. Marcotte, P., Roy, V., Plamondon, A. P., & Auger, I. (2008). Ten-year water table recovery after clearcutting and draining boreal forested wetlands of eastern Canada. Hydrological Processes, 22(20), 4163–4172. https://doi.org/10.1002/hyp.7020
9. Mahaney, W. M., Wardrop, D. H., & Brooks, R. P. (2005). Impacts of sedimentation and nitrogen enrichment on wetland plant community development. Plant Ecology, 175(2). https://doi.org/10.1007/s11258-005-0011-2
10. Devito, K.J., Creed, I.F., Gan, T., Mendoza, C., Petrone, R., Silins, U., Smerdon, B., 2005. A framework for broad-scale classification of hydrologic response units on the Boreal Plain: is topography the last thing to consider? Hydrol. Process. 19, 1705–1714. https://doi.org/10.1002/hyp.5881
11. Gleason, R. A., Euliss, N. H., Hubbard, D. E., & Duffy, W. G. (2003). Effects of sediment load on emergence of aquatic invertebrates and plants from wetland soil egg and seed banks. Wetlands, 23(1). https://doi.org/10.1672/0277-5212(2003)023[0026:EOSLOE]2.0.CO;2
12. Thompson, D. K., & Waddington, J. M. (2008). Sphagnum under pressure: towards an ecohydrological approach to examining Sphagnum productivity . Ecohydrology, 1(4), 299–308. https://doi.org/10.1002/eco.31
13. Pothier, D., Prévost, M., & Auger, I. (2003). Using the shelterwood method to mitigate water table rise after forest harvesting.