Utikuma Region Study Area (URSA) – Part 2: Aspen Harvest and Recovery Study

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ABSTRACT

The Hydrology Ecology And Disturbance (HEAD-1 and HEAD-2) research programs in the Western Boreal Plains of North-Central Alberta, has provided objective delineation and determination of landscape units characterized by geology and climate. From these landscape indices can be developed that provide information on the scale at which forest, wetland, and aquatic systems are linked to their surroundings and the potential response of an area to particular disturbances. In collaboration with industry, government and NGO planners and ecologists this work establishes a hydrologic risk planning process that evaluates the ecological risk and monetary costs of forest harvest on forest succession and water quality and quantity.

RÉSUMÉ

Le programme de recherche sur l'hydrologie, l'écologie et les perturbations (HEAD-1 et HEAD-2) dans la région des Plaines boréales de l'Ouest, au centre-nord de l'Alberta, a permis de délimiter et de définir objectivement des éléments du paysage sur la base de leur géologie et de leur climat. À partir de ces éléments, il est possible d'élaborer des indices de paysage qui nous indiquent le niveau de lien entre la forêt, le milieu humide et les systèmes aquatiques et leur environnement immédiat et sur la façon dont un site pourrait réagir à des perturbations données. L'industrie, le gouvernement, ainsi que les planificateurs et écologistes des ONG disposent ainsi d'un processus commun de planification du risque hydrologique permettant d'évaluer le risque écologique et les coûts monétaires de l'exploitation forestière sur la succession forestière et sur la quantité d'eau et sa qualité.

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reclaimed mine landscapes. Specific deliverables of benefit to the Canadian forestry and oil sands industries arising from the project include the development of:

- 1) Quantifying the rate of hydrological recovery of regenerating aspen; and
- 2) Assessing how the water requirements of the regenerating stand are being met, and how this influences the eco-hydrological connections with surrounding wetlands.

Introduction

Work in this region in the Hydrology Ecology And Disturbance (HEAD-1 and HEAD-2) research programs has provided objective delineation and determination of landscape units characterized by the geology and climate of the Western Boreal Plain (WBP) (Fig. 1; Table 1). From these we have begun to develop landscape indices that provide information on the scale at which forest, wetland, and aquatic systems are linked to their surroundings and the potential response of an area to particular disturbances (Table 2). This will allow hydrologists and non-hydrologists to assess both the hydrologic impacts of Forest Management Practices (FMP) on harvested sites, and material storage and forest succession on

Given international concern of resource activities in this region, this research addresses national interests in the initial development of appropriate and defensible soil and hydrologic indicators for monitoring and assessing the success of oil sands reclamation and closure plans, and assessing, monitoring and mitigating cumulative impacts of regional land use in the WBF.

Important scientific advancement

- Initial vegetation succession quickly mitigated impacts of aspen harvested on fine-grained soils (Fig. 1; Table 2; Sutherland *et al.* 2014, Petrone *et al.* 2015, Sutherland *et al.* submitted).

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Fig. 1. Map of URSA showing location of detailed catchment ecohydrological studies and location of regional meteorological stations, deep piezometer nests and study lakes.

- Aspen forest lands showed greatly reduced evapotranspiration (ET) and interception (I), with some increase in soil moisture storage after harvesting (Chasmer *et al.* 2012, Hopkinson *et al.* 2013, Petrone *et al.* 2015).
 - Soil moisture increases were short-lived due to rapid redevelopment of leaf area as a result of high density regeneration of aspen through root suckering.
- Recovery of transpiration and I to near pre-harvest conditions occurred within three years. As a consequence, no major changes in direction of linkages from wetland to forest lands were observed.
- Overall, there was little difference in low and high stream-flow, water chemistry, and vegetation dynamics of adjacent wetlands between catchments with harvested or intact

aspen forest land (Devito *et al.* 2012).

- However, where road construction cut deeper to intersect depression and soil storage and was aligned perpendicular to slopes, water was channelled into adjacent wetlands and streams.
- Increased *I* of slash and evaporation, along with rapid aspen regeneration, compensated for a portion of the reduced ET following harvesting.
- Excess soil moisture was absorbed into surface depressions and deeper soil layers, resulting in increased groundwater recharge with little or no lateral flow to adjacent wetlands and aquatic systems.
- Climate cycles, primarily inter-annual variation in snow pack, can overwhelm the influence of aspen harvest in the WBP (Table 1; Carrera-Hernandez *et al.* 2011, Devito *et al.* 2012).
- During the harvest experiment substantial water table rises were observed in both the uncut and the harvested aspen forest lands (Carrera-Hernandez *et al.* 2011).
- Measures of root distribution and flow, and soil hydraulic lift show that wetlands can be additional water sources to adjacent forest lands influencing vegetation recovery (Redding and Devito 2010, Brown *et al.* 2013, Petrone *et al.* 2015).
- Following harvest, observations of suckering from forest lands (through riparian zones to wetlands) and independent measures of hydrologic lift indicate that rapid regenerative growth of aspen forest lands may tap water resources from adjacent wetlands.
- In contrast, root networks are disconnected in roads and deep cut linear disturbances, which limits additional water sources.
- Rapid regeneration creates conditions of higher water use efficiency (WUE) and returns stand ET to near (70 %) the pre-harvest rate within three years (Brown *et al.* 2013, Petrone *et al.* 2015).

Management/Operational Results

- In forest management plan (FMP) approvals, the Alberta Government Sustainable Resource Development (SRD) often sets approval conditions that “the revised FMP shall

Table 1. Watershed climatic and physiographic information for the URSA study area

Watershed Location Data	
Location (descriptive)	URSA is located north of Utikuma Lake, north-central Alberta (approximately 400 km north of Edmonton). The glacial landforms drain into the Wabasca and then the Peace River drainage. The small isolated catchments are located on a moraine, close to the regional topographic high.
Location (geographic)	56° 7' N, 115° 48' W to 55° 51' N, 115° 6' W
Biogeoclimatic zone(s)	Boreal Plains, Central mixed-wood, Utikuma uplands
Watershed area	The study watersheds loosely defined by gently sloping forested uplands, which are approximately seven m above the riparian, wetland and pond areas.
Elevation range (a.s.l.)	645–665 m
Precipitation (mean annual)	483 mm
Runoff (mean annual)	67 mm (range: 4 mm to 246 mm)
Temperature (mean annual)	1.2 °C

Table 2. Research design outline for the URSA upland harvest experiment

Research Design	
Study type	Catchment budgets and process hydro-meteorological studies
Treatments	Reference, pre-disturbance data was collected from both Ponds 40 and 43 from 1999 to 2006. The south-facing slope of Pond 40 was harvested in the winter of 2007, followed by the north-facing slope in the winter of 2008. Regeneration data are collected to the present.
Controls	Adjacent catchment - Pond 43
Study duration	1999 to present
Variables measured	Water and energy balance of reference and experimental (harvested) study catchments: Above and within the aspen canopy (eddy covariance measurements of water vapour and CO ₂); Energy balance and Penman-Monteith and Priestley-Taylor estimates of water vapour fluxes from various land covers (pond, peatland); Interception of precipitation from canopy, shrub and soil layers; Soil moisture content and tension; aspen hydraulic lift (isotopes and root excavation); Hill-slope and stream runoff; groundwater dynamics. Carbon and nitrogen in soil, water, and vegetation dynamics. Hydrogeology (deep and shallow piezometer nests), groundwater geochemical and isotopic (¹⁸ O and D) characteristics.

include an assessment of the effects of timber harvesting on water quality and quantity.” This research will assist in the challenge of providing more cost-effective and meaningful assessments of hydrologic impacts than currently exist using various simple models (e.g., WRENNs modelling).

- Similarly, Forest Products Association of Canada (FPAC) companies seeking Forest Stewardship Council (FSC) accreditation to secure national and international markets will use this information about hydrological linkages to maintain the ecologic integrity of harvested ecosystems.
- In collaboration with planners and ecologists from AIPac, FPAC, and staff at Ducks Unlimited Canada (DUC) and Alberta Geologic Survey (AGS), this work will establish a

hydrologic risk planning process that evaluates the ecological risk and monetary costs of forest harvest on forest succession and water quality and quantity.

- Resulting conceptual and predictive models, and landscape indices can be used to modify surficial geology (AGS) and vegetation map sheets, integrating them with current harvest scheduler and road optimizer programs to produce value-added hydrologic risk assessment layers and effective watershed planning units that include: a) least industry cost and ecological risk road network and spatial harvest scheduler; b) a risk assessment process that will identify hydrologic risk and associated best practices to avoid or mitigate effects from forest harvest as well as road construction; and, c) insight into long-term best management practices to minimize or remediate anthropogenic hydrologic impacts.
- Oil sands companies must reclaim mined areas to sustainable ecosystems that have equivalent capabilities to undisturbed areas.
 - The economic impact will be immediate, as reclamation activities are ongoing and operational decisions are already being made about tailings and overburden disposal. The ongoing ability of companies to continue to receive government approval for continued operation is partially contingent upon viable closure plans that include reclamation activities.
 - The environmental benefit could also be immediate if research suggests improved means to reconstruct viable landscapes.
- Comparing fluxes of water and CO₂ from reclaimed and regenerating stands of varying ages will help industry validate model predictions within the current climate regime and assess the capability of constructed soils to meet current (and future) climatic demands of the ecosystem.

There are numerous articles and summary reports published on these study catchments. Much of the research from the more recent specific Aspen Harvesting study is being written up and is to be submitted for publication.

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