

## Wapiti River Basin Land Cover Change Assessment

### Introduction

Different types of land cover evapo-transpire at different rates under the same temperature and moisture conditions. Because of this, long-term flow supply to water bodies can change due to these land cover changes. The most common forms of land cover change are changes between forested areas (conifer and deciduous), natural grasslands, agricultural crops, wetlands, and urban areas. Over large areas in the Wapiti River basin, the bulk of the land cover changes have been the conversion of forest and natural grasslands to agricultural land.

It is generally established that grasslands produce more runoff than forested areas, conifer forests produce more runoff than deciduous forests, and forests produce more runoff than agricultural land. However, quantifying these changes in a reliable manner in a specific area is difficult to do in practice because there is a lack of sufficient data to distinguish between changes in flow due to climate cycles and trends from changes in land cover. Most studies that have been carried out focus on particular watersheds in a small region. Recently however, Tran and O'Neill (2013) conducted an analysis of 180,000 catchments in the Upper Mississippi River Basin (49 million km<sup>2</sup>) to estimate the relationship between streamflow and a large range of land cover types. Using the results of this work, it is possible to quantify the change in annual runoff from a watershed due to a change in land cover.

### Land Cover Change Assessment

Figure 1 shows the natural Ecoregions in Alberta along with the current land cover for British Columbia from the USGS 1 km land cover dataset. Large scale land cover change in British Columbia's portion of the Wapiti River watershed has been relatively negligible compared with development within Alberta as can be seen in Figure 2, which uses Alberta's 30 metre land cover dataset to show how most of the land in the Wapiti Watershed north of the Wapiti River has been developed for agriculture. Table 1 summarizes the natural (pre-disturbance) distribution of various land cover types across each of the major sub-watersheds of the Wapiti River. Table 2 summarizes the current land cover types for the same sub-watersheds. Table 3 summarizes the change in land cover for each sub-watershed.

The dominant land disturbances in the Wapiti River watershed have been the creation of crop and pasture lands mostly in the Bear, Beaverlodge, and Redwillow watersheds (Table 3). There has also been some urban development, mainly the city of Grande Prairie in the Bear watershed, and minor increases in bare land across the region. These increases have been matched by decreases in forests (both conifer and deciduous), wetlands, and natural grasslands.

Tran and O'Neill (2013) developed an equation to estimate mean annual flow volume changes due to changes in land cover such that they could be applied to other watersheds. This equation can be re-written as:

$$\Delta Q = \exp \left[ \sum_{i=1}^n k_i \left( \frac{LC_{post_i} - LC_{pre_i}}{A} \right) \right] - 1 \quad (7)$$

Where,  $\Delta Q$  is the fractional change in mean annual flow,  $A$  is the watershed area,  $k_i$  is a coefficient for land cover type ' $i$ ',  $LC_{pre_i}$  is the pre-development area for land cover type ' $i$ ', and  $LC_{post_i}$  is the post-development area for land cover type ' $i$ '. For example, a  $\Delta Q$  value of 0.1 would mean a 10% increase in mean annual flow while a value of -0.2 would mean a 20% decrease in mean annual flow. Land cover coefficients (Table 4) were taken from the standardized coefficients reported in Tran and O'Neill (2013).

## Results

Table 5 shows the estimated changes in mean annual runoff due to land cover change in each sub-basin of the Wapiti River. Because 80% of the Wapiti River's flow originates in the Upper Wapiti watershed, where land use change has been minimal, the significant land use change in the lower watersheds do not translate to significant changes in flow in the Wapiti River main stem (a 2% reduction from natural land use conditions) despite much higher changes in several lower tributaries: -13% in the Beaverlodge River, -6.2% in the Redwillow River, and -21.7% in the Bear River. These three watersheds represent 37% of the Wapiti River watershed area, and 78% of the land disturbance, but only produce 12% of the river's flow.

## Conclusions

The lower tributaries of the Wapiti River (Redwillow, Beaverlodge, and Bear Rivers) have undergone significant land use change, primarily due to agricultural development. The approach developed by Tran and O'Neill (2013) was applied to the Wapiti River Basin to estimate how much river flows in the Wapiti River may have changed due to this land development. Although flows in these tributaries are estimated to have decreased by 5 to 20% due to this development, overall flows in the Wapiti River mainstem are estimated to have decreased by less than 2% due to land development because most of the river's water originates in watersheds that have experienced minimal land cover change.

## References

Tran, L.T., and O'Neill, R.V., 2013, Detecting the effects of land use/land cover on mean annual streamflow in the Upper Mississippi River Basin, USA, *Journal of Hydrology*, 499, p 82-90.

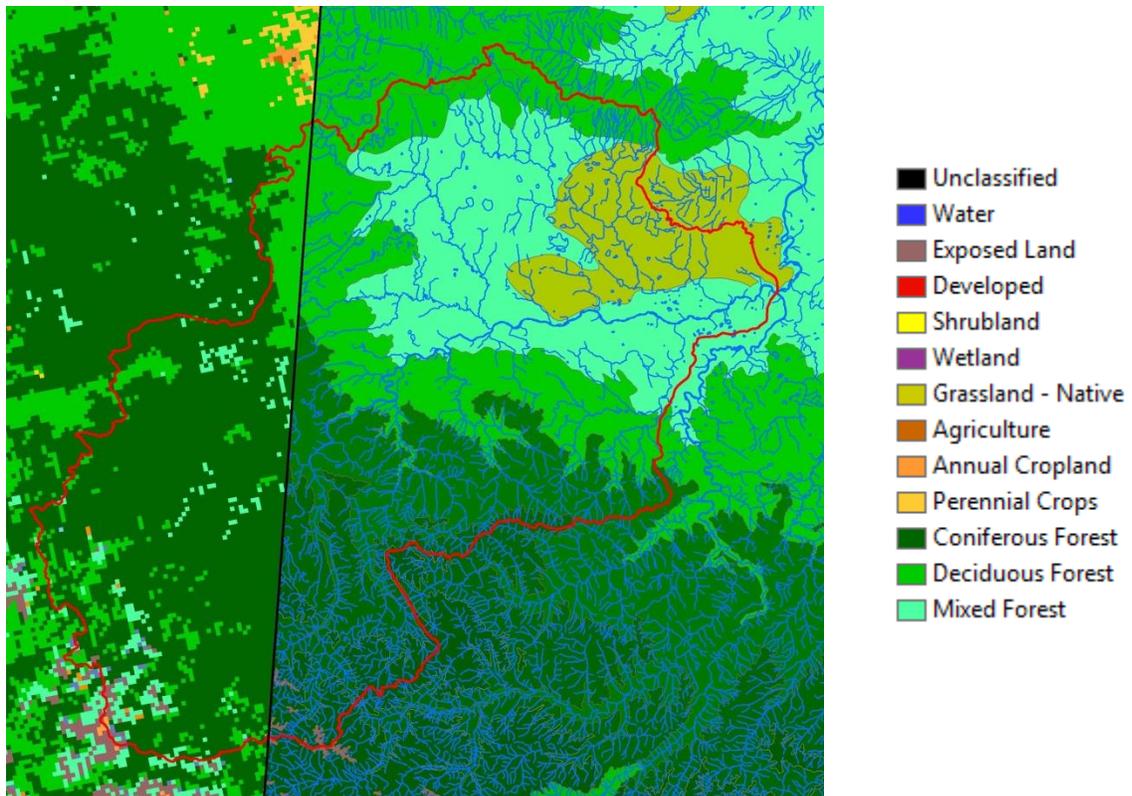


Figure 1 – Wapiti River Watershed Natural Ecoregions in Alberta and current land cover classification from USGS 1 km landcover dataset. In the British Columbia portion of the watershed, land cover is still in a near natural state.

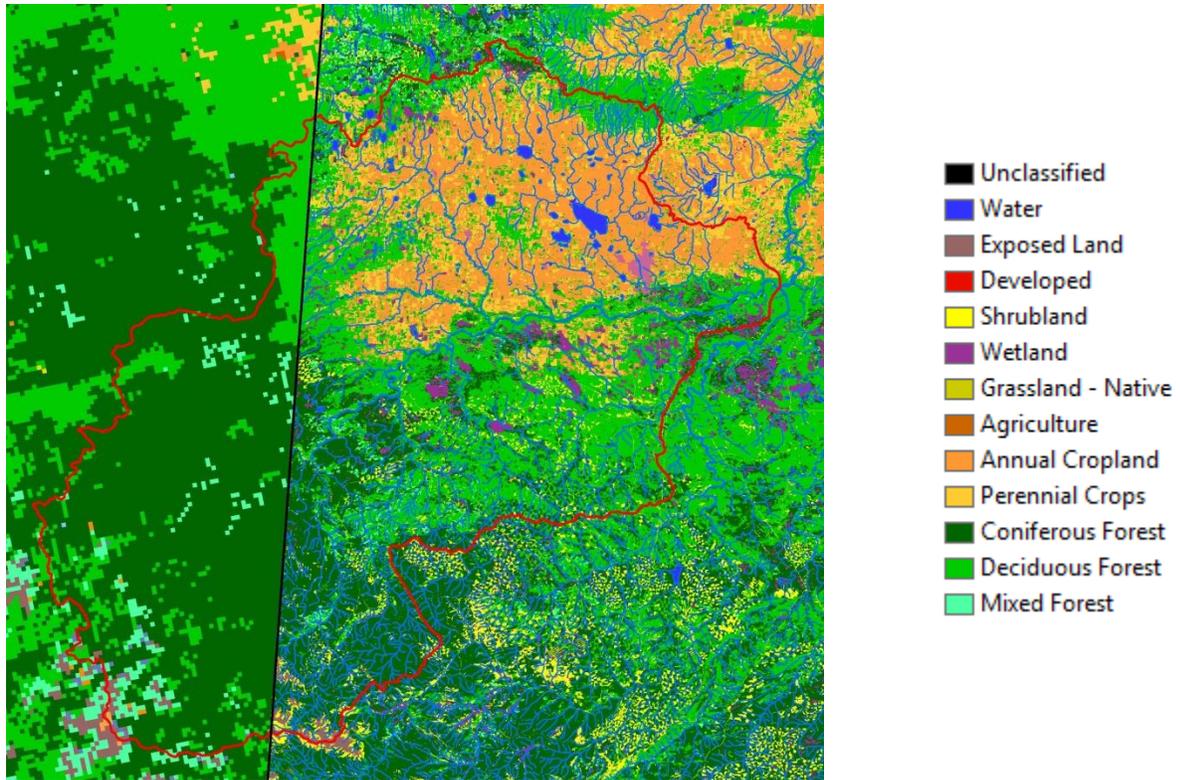


Figure 2 – Wapiti River Watershed Landcover Map. Alberta data is from 30 m resolution Alberta landcover dataset. British Columbia data is from USGA 1 km resolution dataset.



Table 4 – Land cover coefficients from Tran and O’Neill (2013). Coefficients have been multiplied by 100 to reflect the form of equation 7.

Land Cover Type	Coefficient, k
Conifer	0.3
Deciduous	0.49
Grassland	0.66
Wetland	-0.12
Bare	0.66
Crop	0.07
Pasture	0.13
Urban	0.01

Table 5 – Estimated changes in flow by sub-watershed due to land cover change

Flow (m <sup>3</sup> /s)	Upper Wapiti	Pinto	Beaverlodge	Redwillow	Wapiti to Grande Prairie	Wapiti to Big Mountain	Big Mountain	Bear	Total
Natural Flow	79.15	2.28	2.76	7.04	1.28	0.67	3.88	4.60	101.65
Change (%)	0.3%	0.7%	-13.0%	-6.2%	-13.9%	-10.3%	-2.0%	-21.7%	-1.82%
Current Flow	79.40	2.30	2.40	6.60	1.10	0.60	3.80	3.60	99.80