1. Description of Scotty Creek research basin and current infrastructure

1.1 Geography

Scotty Creek basin is located roughly 40 km south of Fort Simpson, NWT, in the Liard River watershed (Figure 1). The estimated size of Scotty Creek basin, based on the gauged stream outlet is 140 km^2. Discharge (and stage) from the basin has been monitored since 1996 by the Water Survey of Canada, and has been analyzed in several studies (e.g. Connon et al. 2014). The climate is described as dry-continental, with long winters and short summers. Air temperature records indicate that the climate of the region is warming over the past several decades.

The land cover of Scotty Creek basin is primarily described as forested uplands and lowland peatlands, which include tree plateaus (underlain by permafrost), bogs and fens. A 4-m land cover classification was completed over Scotty Creek basin (Chasmer et al. 2014). According to this classification (Figure 2), the land cover composition is approximately 48% uplands, 20% treed plateaus, 19% bog, and 12% fen.

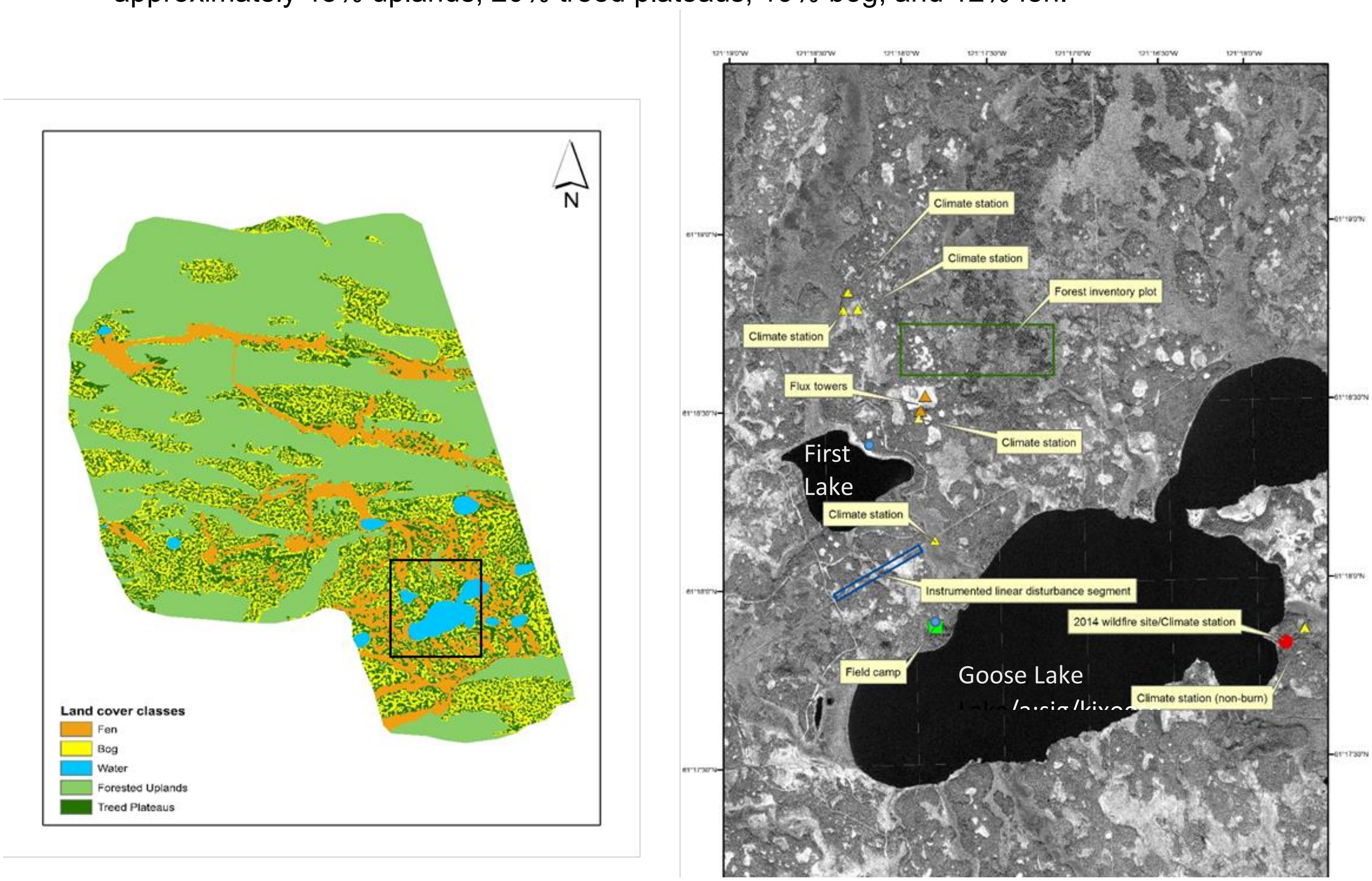

Figure 2 (a) Scotty Creek basin land cover classification and (b) sub-section of the basin where science activities are concentrated. Note that the map of installed science instruments is not comprehensive (e.g. water level recorders, and soil moisture and soil temperature monitoring stations not shown).

The primary focus of research efforts in the basin is on the lowland peatlands, specifically located in a sub-area around Goose Lake (Figure 2). This sub-area has relatively minimal topographic variability. Treed-plateaus (*Black spruce*) are underlain by permafrost and are elevated approximately 1-2 m relative to surrounding features. Permafrost thaw results in the loss of tree cover and the conversion of plateaus to bogs. The rate of thaw has accelerated since the commencement of field activities in 1999. The surfaces of permafrost plateaus consist of dense layers of organic material, such as mosses and lichens. Fens and bogs are considered wetlands, as they are perennially saturated. Bogs and fens are generally tree-less, although some sparse tree coverage (*Tamarack*) and shrubs and sedges can be observed along the periphery of fens. For further reference, the biophysical features, soil properties and permafrost characteristics, and the hydrological roles of the three main land cover types in this sub-area are documented in detail in Scotty Creek science publications (A1).

A grid of both seismic lines and winter roads exists through the basin (i.e. linear disturbances). These deforested disturbances are approximately 6-10 m wide, with a topographic depression relative to the surrounding features. The linear disturbances are considered permafrost-free areas. The total length of linear disturbances in the basin is 133 km for a density of 0.95 km/km^2. A significant amount of work has been done to study the implications of linear disturbances a this site (e.g. Braverman and Quinton, 2016; Williams et al. 2013).

A wildfire occurred in an area along the south side of Goose Lake in summer 2014 (Figure 2a). Field-work has been conducted at this site, along with a paired unburned site, since 2015. The purpose of this work is to study the wildfire impacts to soil hydrology, snow melt, surface energy budgets, permafrost thaw, and biogeochemical properties.

1.2 Current infrastructure

Automated science infrastructure has been installed in the sub-area of Scotty Creek basin (Figure 2b). This includes numerous climate stations, which record: incoming/outgoing shortwave and longwave radiation, soil moisture, soil temperature, wind speed, air temperature, relative humidity and snow depth in a localized area (SR50). Most of these stations are also equipped with a tipping-bucket rain gauge (with the exception of the most northerly station), while there are also two shielded gauges, a Pluvio and a Geonor located near Goose Lake field camp and near First Lake to address undercatch and poor data quality in some tipping bucket rain gauges (Blue markers in Figure 2b). The climate stations are strategically distributed among land cover types for use in characterizing surface energy balances. Additional end-of-season snow surveys are performed annually along transects traversing all land-cover types and border features.

Automated soil moisture and soil thermistor sensors are placed at multiple sites in addition to the climate stations. A large number of water level recorders are distributed throughout the basin for use in delineating flow cascades and hydrologic connectivity, these are indicated as red diamonds in figure 3. Additional water level recorders are placed along the NE-SW seismic line running between Goose and First Lakes, in the northerly region of the study site, and some additional waterlevel records are available for previous years, providing boundary and initial conditions for various parts of the landscape. The water level records report the water level fluctuations in wetland features – bogs and fens – as well as some confined Taliks.

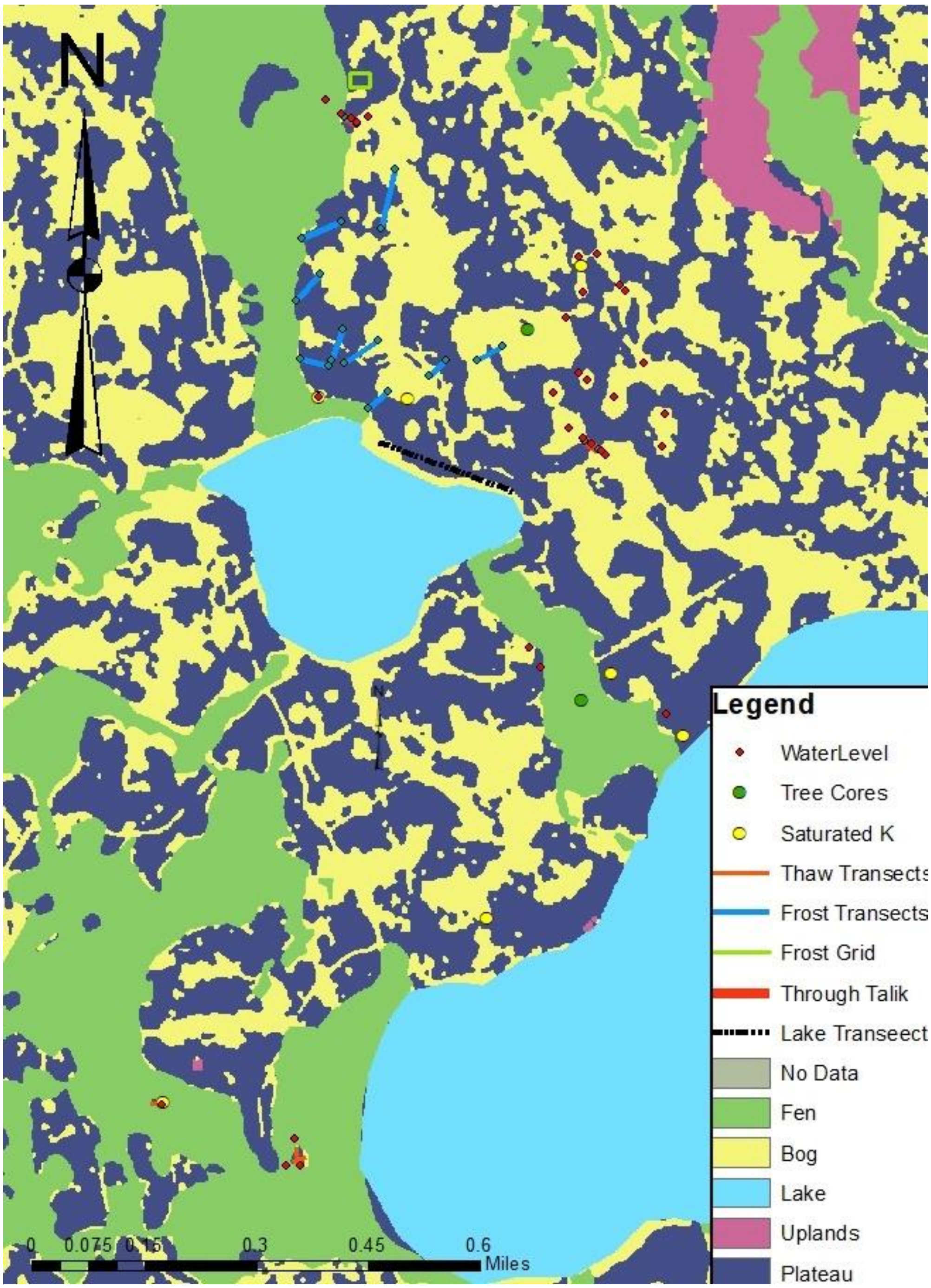

Figure 3

The position and evolution of the frost table has been recorded at 3 m intervals along all of the transects shown in blue in Figure 3 throughout the thaw season for multiple years. Additional transects have been established (shown in red) in features which demonstrate accelerated thaw rates. Measurements of the active layer thickness in different land cover regions have been made across the landscape (not shown in figure). The edges of various wetland features have been especially monitored for frost table and permafrost evolution, with an additional lake transect and short transects surrounding bogs and fens. Hydraulic conductivity of thawed soil has been measured at the yellow markers in figure 3, as well as the hydraulic conductivity of the permafrost was measured at the seismic line.

Carbon flux towers are located in the basin, at landscape and wetland sites (Figure 2b). These are operated by the Atmospheric Biogeosciences at High Latitudes research group, based at Université de Montréal (http://www.atmosbios.com/).

High-resolution DEM data is available for the area shown in Figure 2a), which extends slightly beyond the watershed boundaries for the Scotty Creek gauging station.

Appendix 1: Selected recent Scotty Creek science publications

For a complete list, refer to https://www.scottycreek.com/site/info?p=publications

Helbig, M., L.E. Chasmer, A.R. Desai, N. Nljun, W.L. Quinton, and O. Sonnentag (In Press). Direct and indirect climate change effects on carbon dioxide fluxes in a thawing boreal forest-wetland landscape. Global Change Biology. doi: 10.1111/gcb.13638

Helbig, M., L.E. Chasmer, A.R., N. Nljun, W.L. Quinton, C.C. Treat, and O. Sonnentag (In Press). The positive net radiative greenhouse gas forcing of increasing methane emissions from a thawing boreal forest-wetland landscape. Global Change Biology. doi: 10.1111/gcb.13520

Merchant, M.A., J.R. Adams, A.A. Berg, J.L. Baltzer, W.L. Quinton, and L.E. Chasmer (2017). The contribution of C-band SAR data and polarimetric decompositions to subarctic Boreal peatland mapping. IEEE Journal of Selected Topics in Applied Earth Observation and Remote Sensing. 10(4): 1467-1482. doi: 10.1109/JSTARS.2016.2621043

Mohammed, A., R.A. Schincariol, W.L. Quinton, R.M. Nagare, and G.N. Flerchinger (2017). On the use of mulching to mitigate permafrost degradation due to linear disturbances in sub-arctic peatlands. Ecological Engineering. 102: 207-223. doi: 10.1016/j.ecoleng.2017.02.020

Braverman, M. and W. Quinton (2016). Hydrological impacts of seismic lines in the wetland-dominated zone of thawing, discontinuous permafrost, Northwest Territories, Canada. Hydrological Processes. 30(15): 2617-2627. doi: 10.1002/hyp.10695.

Gordon, J., W. Quinton, B. Branfireun, D., and Olefeldt (2016). Methylmercury production along a wetland cascade ecotone within a thawing permafrost plateau, Northwest Territories, Canada. Hydrological Processes. 30(20): 3627-3638. doi: 10.1002/hyp.10911

Helbig, M., K. Wischnewski, N. Kljun, L.E. Chasmer, W.L. Quinton, M. Detto, and O. Sonnentag (2016). Regional atmospheric cooling and wetting effect of permafrost thaw-induced boreal forest loss. Global Change Biology. 22(12): 4048-4066. doi: 10.1111/gcb.13348.

Helbig M, K. Wischnewski, E., G.H. Gosselin, S.C. Biraud, I. Bogoev, W.S. Chan, E.S. Euskirchen, A.J. Glenn, P.M. Marsh, W.L. Quinton, and O. Sonnentag (2016). Addressing a systematic bias in carbon dioxide flux measurements with the EC150 and the IRGASON open-path gas analyzers. Agricultural & Forest Meteorology. 228: 349-359. doi: 10.1016/j.agrformet.2016.07.018

Kurylyk, B.L., M. Hayashi, W.L. Quinton, J.M. McKenzie, and C.I. Voss (2016). Influence of vertical and lateral heat transfer on permafrost thaw, peatland landscape transition, and groundwater flow. Water Resources Research. 52(2). doi: 10.1002/2015WR018057

Sniderhan, A.E, and J.L. Baltzer (2016). Growth dynamics of Black Spruce (Picea mariana) in a rapidly thawing discontinuous permafrost peatland. Journal of Geophysical Research-Biogeosciences. 121(12): 2988-3000. doi: 10.1002/2016JG003528

Connon, R., W. Quinton, J. Craig, J. Hanisch, and O. Sonnentag (2015). The hydrology of interconnected bog complexes in discontinuous permafrost terrains. Hydrological Processes. 29(18): 3831-3847. doi: 10.1002/hyp.10604

DeBeer, C., H.S. Wheater, W.L. Quinton, S.K. Carey, R.E. Stewart, M.D. MacKay, P. Marsh (2015). The Changing Cold Regions Network: Observation, Diagnosis, and Prediction of Environmental Change in the Saskatchewan and Mackenzie River Basins, Canada. Science China: Earth Sciences. Special Issue: Watershed science: bridge the new advancements in hydrological science with good management of river basins. X. Li, G. Zhang, C. He, T. Yue (eds.). Vol. 57, No. 1, p. 1-16.

Patankar, R., W. Quinton, M. Hayashi, and J. Baltzer (2015). Sap flow responses to seasonal thaw and permafrost degradation in a subarctic boreal peatland. Trees. 29(1): 129-142. doi: 10.1007/s00468-014-1097-8

Baltzer, J.L., T. Veness, L.E. Chasmer, A.E. Sniderhan, and W.L. Quinton (2014). Forests on thawing permafrost: fragmentation, edge effects, and net forest loss. Global Change Biology. 20(3): 824-834. doi: 10.1111/gcb.12349.

Chasmer, L, C. Hopkinson, T. Veness, W. Quinton, and J. Baltzer (2014). A decision-tree classification for low-lying complex land cover types within the zone of discontinuous permafrost. Remote Sensing of Environment, 143:73-84.

Connon, R., W.L. Quinton, M. Hayashi, and J.R Craig (2014). The effect of permafrost thaw on rising stream flows in the lower Liard River valley, NWT, Canada. Hydrological Processes. 28(14): 4163–4178. doi: 10.1002/hyp.10206

Mohammed, A., R. A. Schincariol, R. M. Nagare, and W. L. Quinton (2014). Reproducing Field-Scale Active Layer Thaw in the Lab. Vadose Zone Journal. 13(8). doi:10.2136/vzj 20 14.01.0008

Baltzer, J.L., R. Patankar, A. Downey, and W. Quinton (2013). Impacts of seasonal thaw and permafrost degradation on Picea mariana root function in a subarctic boreal peatland. Proceedings of XI International Workshop on Sap Flow. 991: 141-148.

Patankar, R, W. Quinton, and J.L. Baltzer (2013). Permafrost-driven differences in habitat quality determine plant responses to gall-inducing mite herbivory. Journal of Ecology. 101(4): 1042-1052. doi: 10.1111/1365-2745.12101

Quinton, W.L., and J.L. Baltzer (2013). The active-layer hydrology of a peat plateau with thawing permafrost (Scotty Creek, Canada). Hydrogeology Journal. 21(1): 201-220. doi: 10.1007/s10040-012-0935-2

Quinton, W.L. and J.L. Baltzer (2013). Changing surface water systems in the discontinuous permafrost zone: implications to stream flow. Cold and Mountain Region Hydrological Systems Under Climate Change: Towards Improved Projections. IAHS Publication. 360, 85-92.

Williams, T.J., W.L. Quinton, and J.L. Baltzer (2013). Linear disturbances on discontinuous permafrost: implications for thaw-induced changes to land cover and drainage patterns. Environmental Research Letters. 8: 025006. doi: 10.1088/1748-9326/8/2/025006

Williams, T.J., and W.L. Quinton (2013). Modelling Incoming Radiation on a Linear Disturbance and its Impact on the Ground Thermal Regime in Discontinuous Permafrost. Hydrological Processes. 27(13): 1854–1865. doi: 10.1002/hyp.9792