Ecological Assessment of the Plant Communities of the Williams Lake Backlands

A REPORT

to

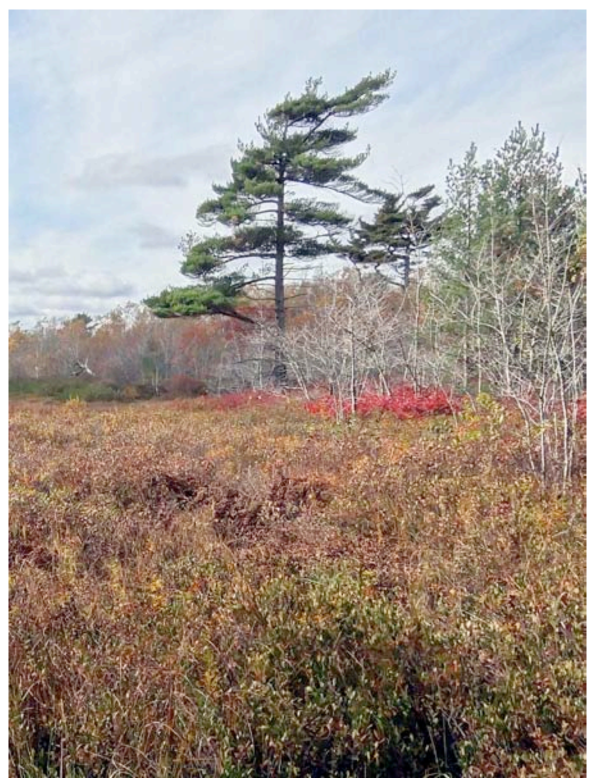
The Williams Lake Conservation Company

by

Nick Hill
Fern Hill Institute of Plant Conservation,
Berwick, Nova Scotia

David Patriquin
Professor of Biology (retired)
Dalhousie University, Halifax, Nova Scotia

February 12, 2014



ACKNOWLEDGMENTS

Our field studies were conducted between May 13 and November 8, 2013. Kathleen Hall of the Williams Lake Conservation Company facilitated our activities. Patricia Manuel (School of Planning, Dalhousie University), who has conducted research on the hydrology of the Williams Lake Backlands, contributed maps and accompanied us in the field on May 31st. She also gave us access to a report on vernal pools by her student, Huan Liu. We are grateful for feedback on various aspects of this study from Ellen Whitman, Sean Blaney, Sean Basquill, John Brazner, Marcos Zentilli, Kathryn Miller, Andrew Cutko, Burkhard Plache and Donna Crossland.

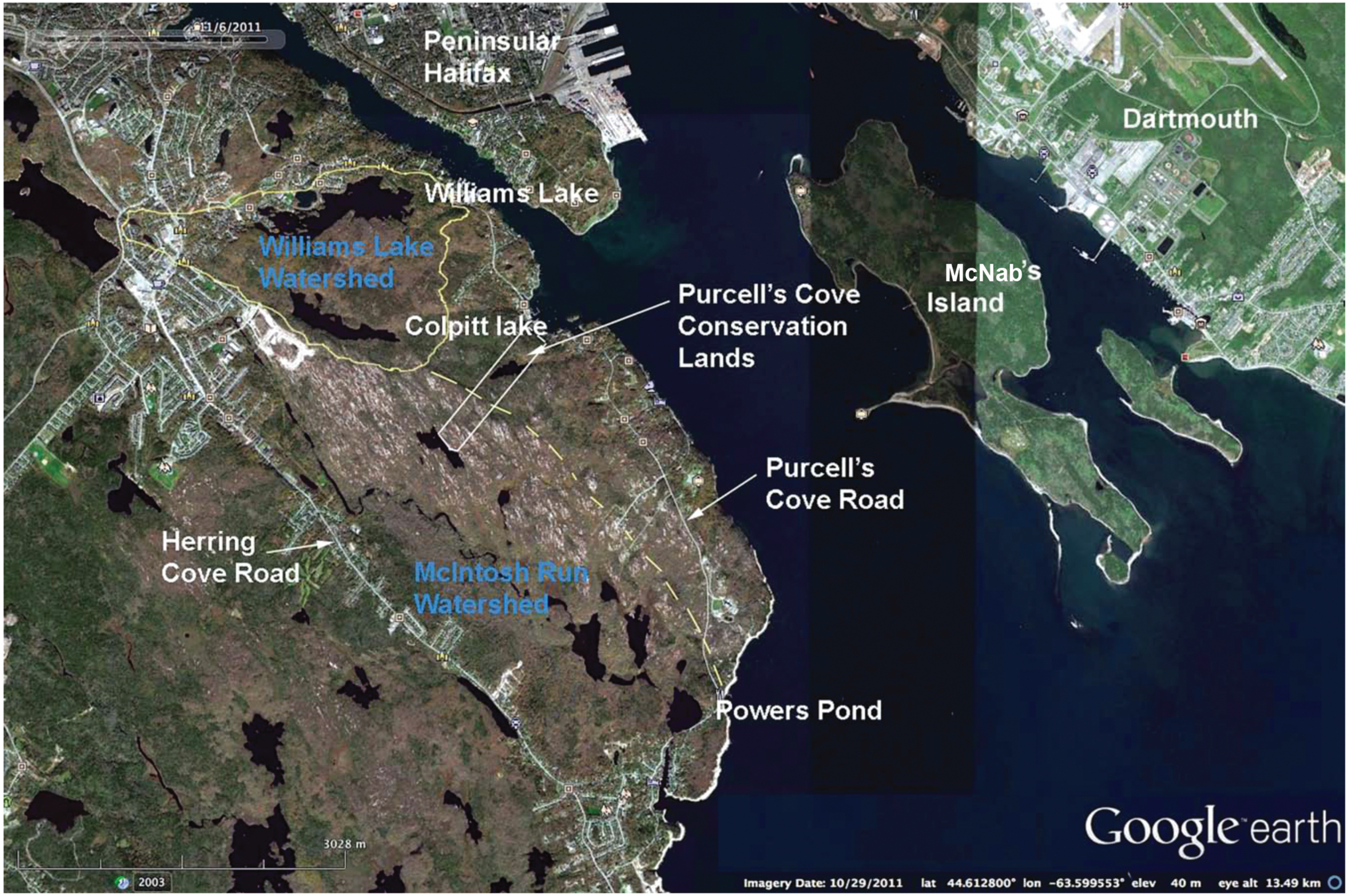


Fig. 1.1 Google Map showing Purcell's Backlands and major watersheds. The boundaries for the watersheds are approximate. Broken line marks eastern boundary of the McIntosh Run watershed.

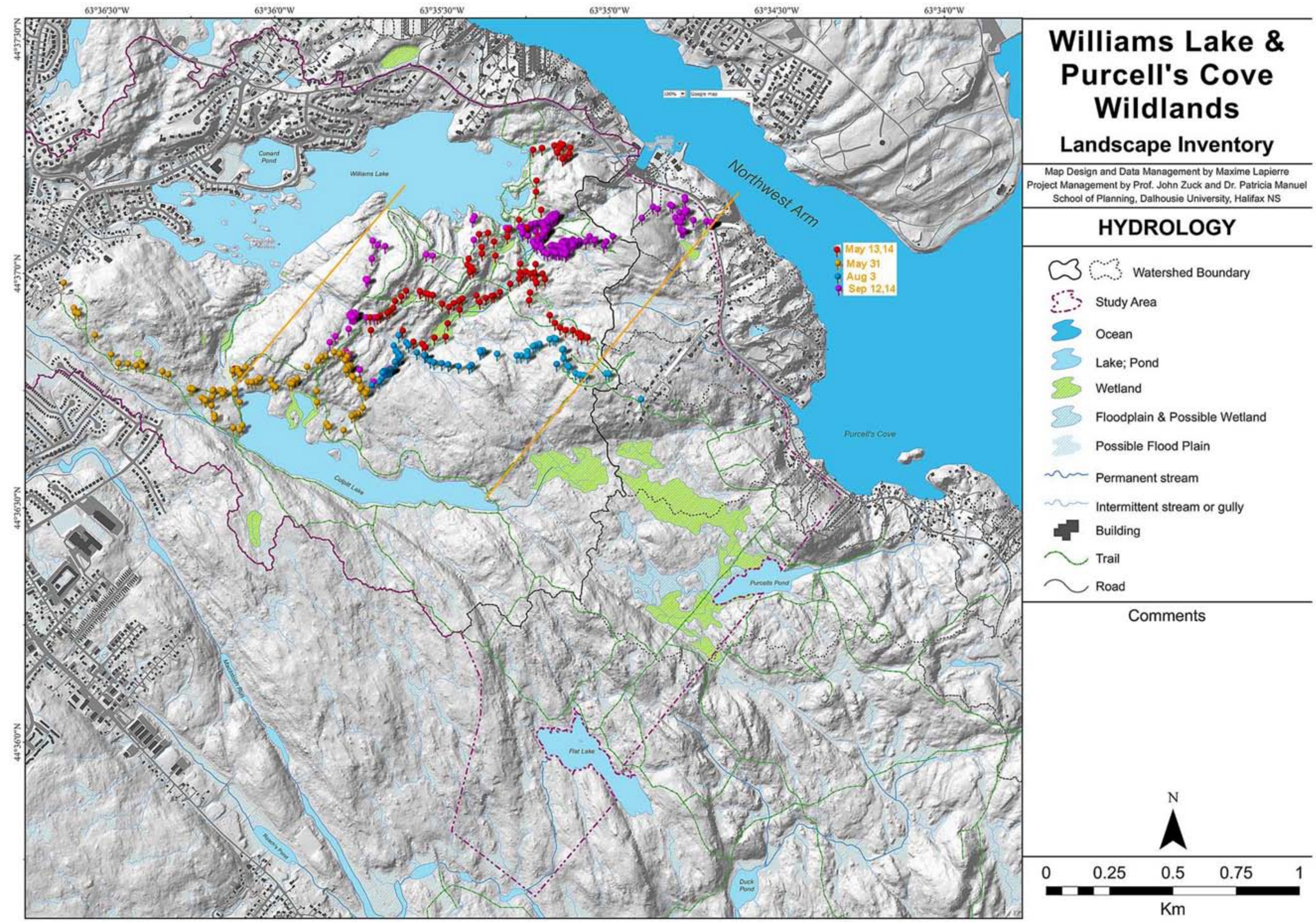


Fig. 2.1 Waypoints for the six surveys which included documentation of vernal pools.

The base map is courtesy of Professor Patricia Manuel, Dalhousie School of Planning. The waypoints were recorded for particular features including vernal pools, so are not exclusive for vernal pools.

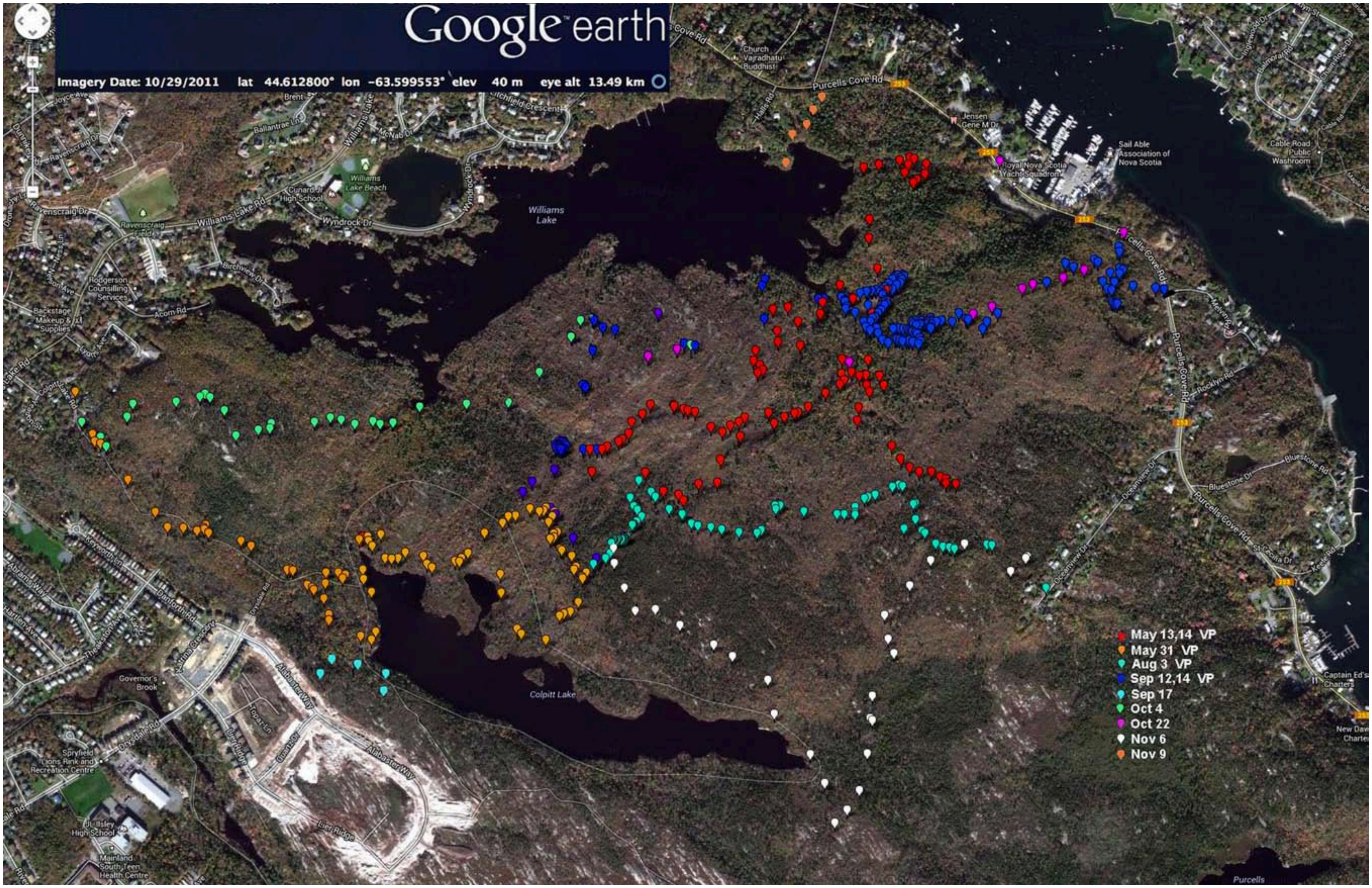


Fig. 2.2 Waypoints from all surveys on Google Satellite Map.

Fig. 3.1 Google Earth perspective of Williams Lake Backlands approached from the northeast.

Fig. 3.2 Some prominent features of the glacial landscape of the Williams Lake Backlands

A: Large erratic & D: boulder field, both in the area of Halifax Series bedrock;

B, C: whaleback in area of granite bedrock.

Fig. 3.3 Disturbance by fire, wind and pests in the WLB.

A, B: Barrens areas that burned in spring of 2012 and 2009 respectively.

C, D: Recent tip up (Red Oak) and snap (White Pine).

E, F: Red Pine southwest of Williams Lake killed by unidentified pest, F. borings in trunk of dead tree.

G. Healthy Red Pine by east side of Williams Lake.

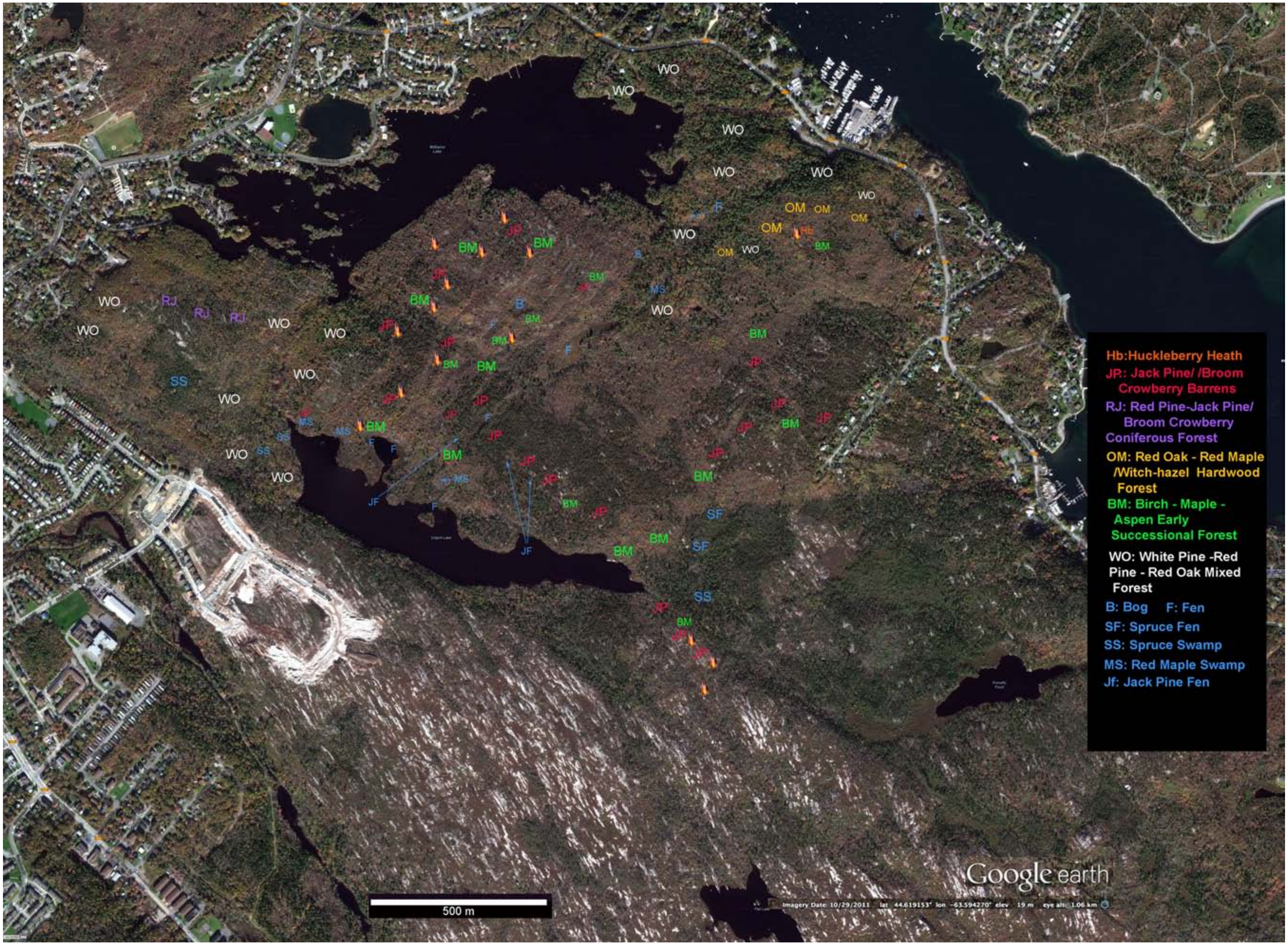


Fig. 3.4. Ground-truthed Wetlands & Upland Plant Communities (larger units).

Fig. 5.1 Upland Plant Communities. A: Broom Crowberry-Blueberry/Reindeer Lichen Barrens; Black Huckleberry (red) at border continues under Adjacent Birch-Maple-Aspen Early Successional Forest. B: Huckleberry Heath. C: Jack Pine/Broom Crowberry Barrens. D, E: Red Pine-Jack Pine/Broom Crowberry Coniferous Forest, Red Pines are partially or wholly dead.

Fig. 5.2 Upland plant communities.

A, B Birch-Maple-Aspen Early Successional Forest; stump sprouting in (B), photographed in fall 2013, followed spring 2012 fire.

C, D: Red Oak - Red Maple/Witchhazel Hardwood Forest, large Witch-hazel in (D).

Fig. 5.3 Upland Plant Communities: White Pine-Red Pine-Red Oak Mixed Forest.

A,B,C: Typical stands on better drained sites. D: Hemlocks close to Purcell's Cove Road.

E,F,G: In stream corridor of outflow stream from Williams Lake, E: Yellow Birch.

F: Large White Pine, Striped Maple in foreground, F: Hobblebush. H: Striped Maple and rock with Polypody Fern by "The Gully".

Fig 6.1

Google Earth Images of the drumlin on three dates.

The distinct brown (bare) patch appeared between June 18, 2007 & July 27, 2007. In the Oct 14, 2010 photo, reddish coloration Is associated with huckleberry which recovers quickly after fire.

WILLIAMS LAKE NORTH LANDCSAPES: Pine and Hemlock, Long-term residential.

WILLIAMS LAKE SOUTH LANDSCAPES: Rock Outcrops and Fire Dependent/Fire Adapted Plant Communities

Matchsticks: Fires may start in fine debris and dried vegetations of Broom-Crowberry (burned remains here) mixed with reindeer lichens and dead resinous Huckleberry leaves on rocky outcrops and moves by wind into communities with greater fuel loads

Fig. 6.2 Windblown rock ridges.

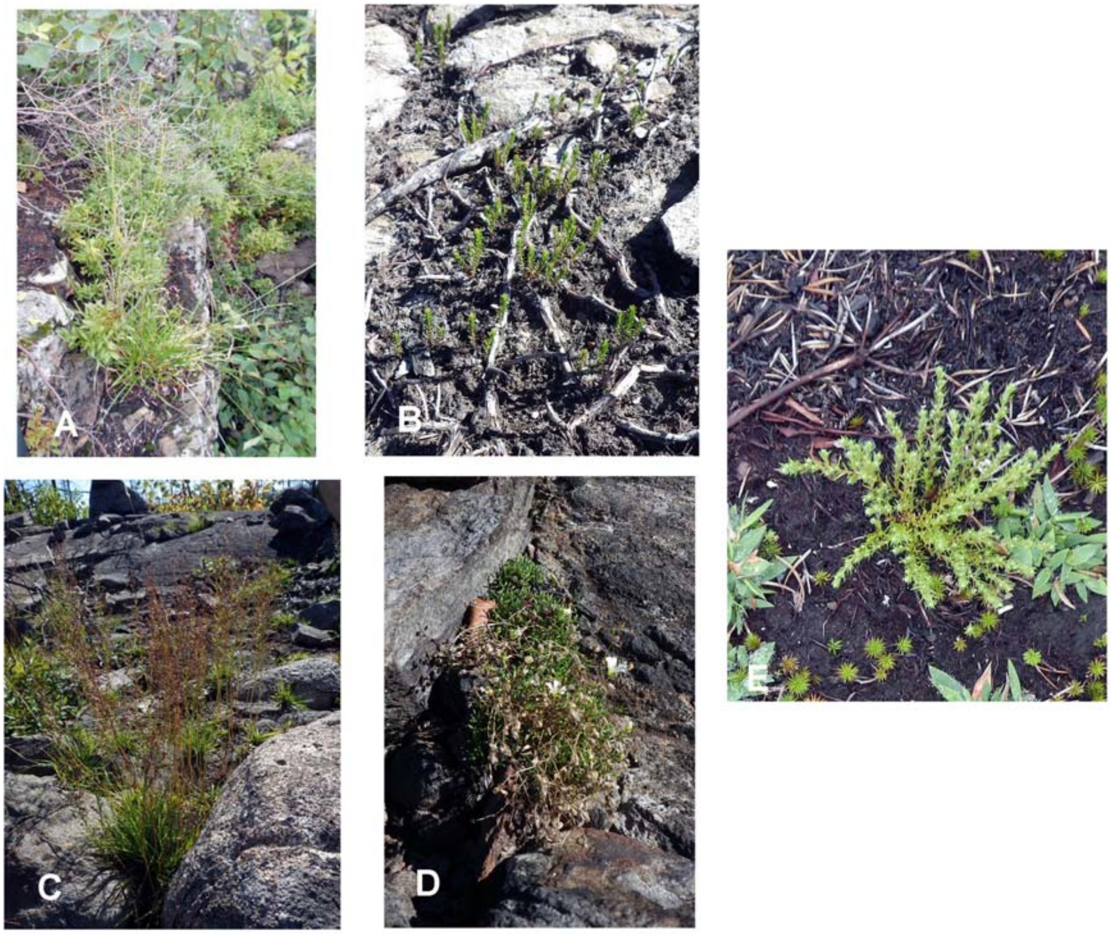


Fig. 6.3 Seedbankers establishing in fire-bared peat in an area burnt in 2012.
A Crowded Sedge, B Broom Crowberry, C Pinweed, D Mountain Sandwort,
E Golden Heather.

Serotinous Cones of Jack Pine
do not open unless the cones are heated.

The Backlands have a Serotiny Index >74% which is similar to fire shaped landscape of the New Jersey Pine Barrens.

Fire-Dependent to Fire-Adapted Species

High proportion serotinous Jack Pine population = Fire-Dependent reproduction

Deep-rhizomed Black Huckleberry and Bracken Fern = Fire-Adapted

Stump sprouting Paper Birch (midground)= Fire-Adapted

Fig. 6.4 Fire-Dependent to Fire-Adapted Species

Fig. 6.5 Stump-Sprouting Scrub Savannah

The fire frequency may be lower in an area of boulder mounds. Here, high vegetation cover gives no gaps to allow Jack Pine seedling regeneration.

Fig. 6.6 Fire-scarred pines.
Most damaged trunks are surrounded by Black Huckleberry

Fig. 6.7 Searching for a record of historical fires in a Jack Pine fen.

Fig. 6.8 Aging a Jack Pine at Site 1.

Dimensions of the disc were 8.35 by 6.7 cm for this approximately rectangular disc, average 7.5 cm (3”). Ring counts were my 42, 44, 45, 46 and 47, 44, 44, 40 (two observers), average 44.

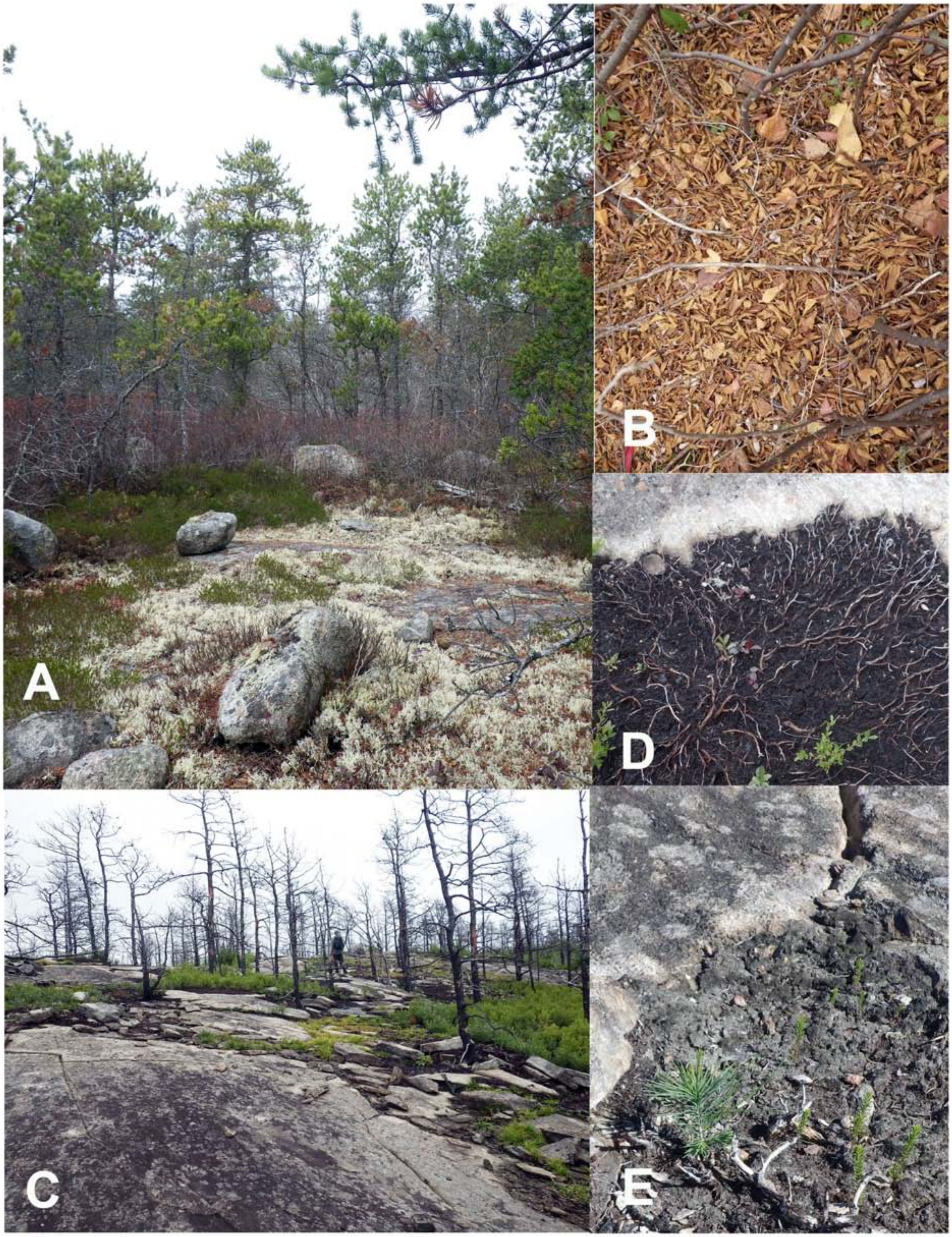


Fig. 6.9. Pre and Post-Fire scenes in Jack Pine/Broom Crowberry Barrens.

A. Jack Pine, probably 30-40 years age. Dead lower branches create ladder fuel. Reddish hue by trees is huckleberry with its last leaves on Nov 6, 2013. Lichens in the foreground form paper-like fire starter materials when dry. B. Twigs and resinous leaves accumulate as kindling under Huckleberry. C. Jack Pine barrens that burned May 21, 2012, viewed Sep.14, 2013. Huckleberry under the dead trees; some sedges can be seen closer to bare rock. Note charred areas on the rock surfaces once covered with lichens. D. Dead branches of broom crowberry after 2012 fire, viewed Sep.14, 2013; blueberry has spouted from rhizomes deeper in soil. E. Seedling of Broom Crowberry, and one seedling Jack Pine in area burnt in 2012 fire, viewed Oct 4, 2013.

WILLIAMS LAKE NORTH LANDCSAPES: Pine and Hemlock, Long-term residential.

WILLIAMS LAKE SOUTH LANDSCAPES: Rock Outcrops and Fire Dependent/Fire Adapted Plant Communities

Fig 7.1 Ridge and valley system overlooking south side of Williams Lake.

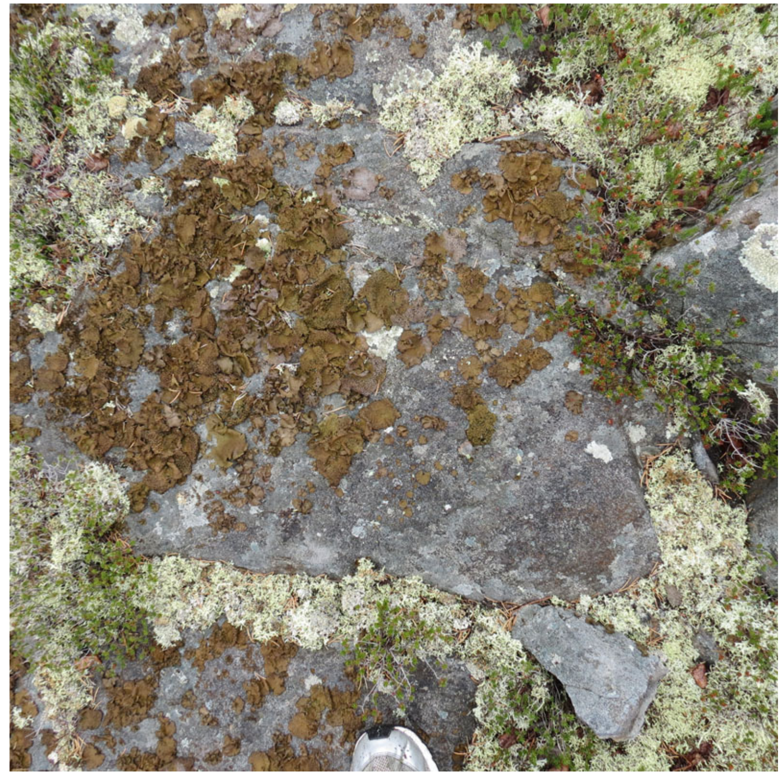


Fig. 7.2 Lichens on rock outcrop.

White lichens are "reindeer moss" (*Cladonia* spp.). Olive foliose lichens are Smooth Rock Tripe, U*mbillicaria mammulata*. Evergreen heath is Broom Crowberry.

Fig. 7.3 Glacial legacy.

Boulder fields support lichen and moss gardens that go through wetting and drying cycles. Featured here are two "reindeer mosses", *Cladonia boryi* (centre) and *Cladonia stellata* (right) as well as the Juniper Haircap Moss, *Polytrichum juniperinum* (centre). Fields are habitat for voles (e.g. Red-backed and Meadow Vole). We noted a vole here during our May 12, 2013 survey but study is needed to determine whether this HRM landscape supports the rare Rock Vole (*Microtus chrotorrhinus*) whose habitat is “hardwood forests on steep talus slopes” (Forbes et al. 2010).

Boulder Fields in the Williams Lake Backlands

Boulder accumulation. There was some standing water below Site G: 44.615518, -63.590688 (Aug. 25, 2012).

"Also intriguing were several lower lying areas where there were massive accumulations of large, angular boulders, most of them composed of the dark Meguma rock. I sent photos to two geologist friends and was referred to John Gosse of the Dalhousie Department of Earth Sciences. He commented:

> "They do look like small localized felsenmeer (sea-of-rocks) fields, but the slope suggests that there may be a different genesis. Without being there it is difficult to be certain, but these kinds of boulder zones are common in glaciated regions. They form either subglacially or, more commonly, along the sides of retreating ice margins. Specifically this looks like a lateral meltwater channel, formed along the side of an ice lobe, with the water flowing downslope. The meltwater stream would have removed the finer sediment and left the larger boulders alone. The angularity of the boulders is also interesting. This is typical in these situations, where the stream was short lived and did not have the energy to round the boulders' edges. On the other hand, boulders that are transported some distance by glaciers will also lose their angularity (depending on hardness and distance of course). That these boulders appear so angular suggests to me that they may not have been transported very far subglacially (though they were certainly covered by ice during the last major glaciation), and therefore may indicate a zone of the ice sheet that was cold-based (stuck to the substrate for most of its history, instead of sliding and transporting the boulders a long way)."

Accumulations of angular boudlers.
Site L: 44.614458, -63.596025 (Aug 25, 2012)

Fig. 7.4 Boulder Fields in Williams Lake Backlands.

The quoted text is from a report on a Halifax Field Naturalists Field Trip posted at
http://versicolor.ca/purcellsbacklands/HFNreport.html

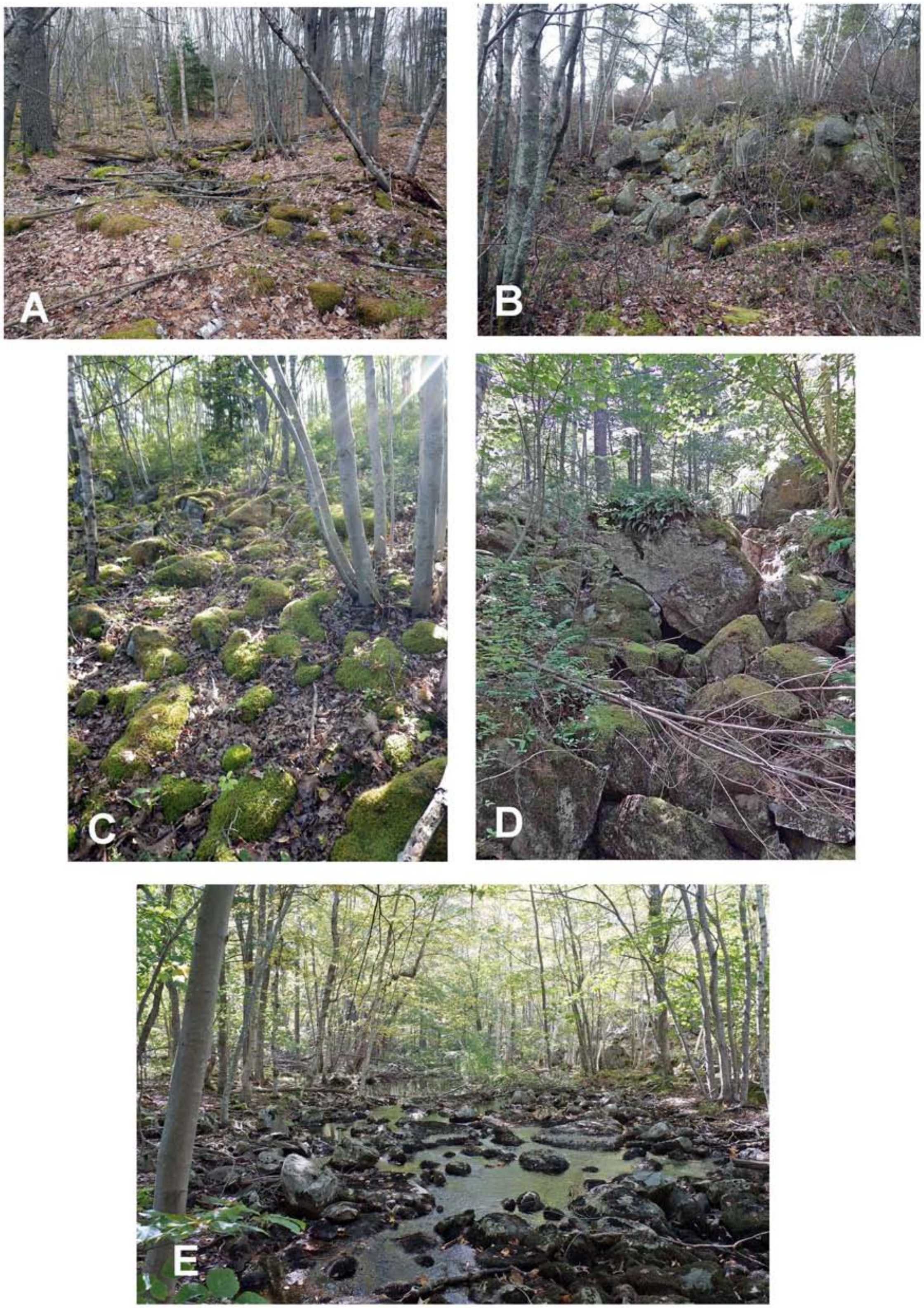


Fig. 7.5 Other types of boulder accumulations.
A, B, and C are in areas of granite bedrock, D and E in areas of Halifax Series bedrock.

1) (first at left) Mountain Holly stems in clumps in wash zone with Sphagnum growth at base of clump

2) (at right) Mountain Holly seedling setting up in zone of stream bared soil.

Landscape (at left) = Geomorphic position (two elevation grades: slope + transverse depression and a stream course.

Water flow (below) = bared soil (litter removed) and exposed roots and moss trim lines at left photo.

Fig. 7.6 Mountain Holly Washes.

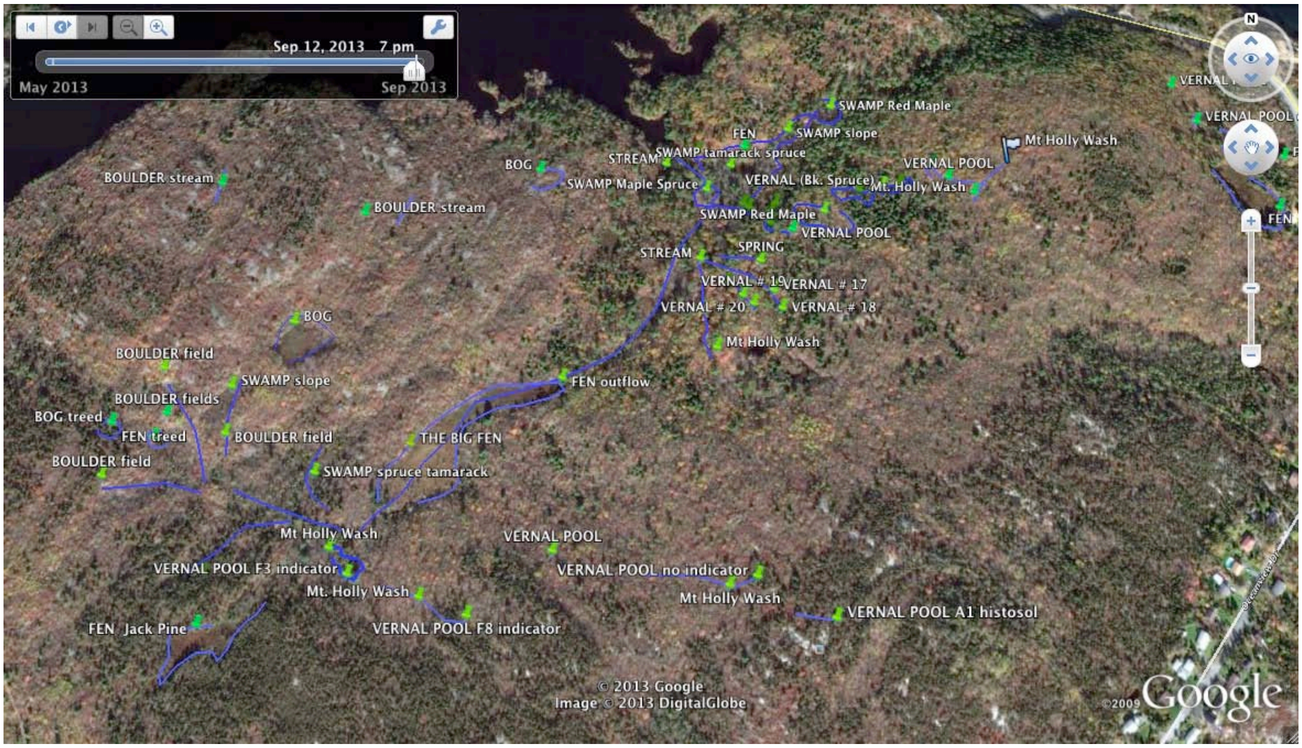


Fig. 7.7 Partial representation of water flows from the barrens into the water course that flows northeast along the contact zone between rocks of the South Mountain Batholith and the Halifax Formation and finally into Williams Lake. See next page for a larger version of this figure.

In the Williams Lake Backlands:

1. Water runs off into **boulder fields** (Fig. 7.7 at left) and into a network of Mountain Holly Washes* (central ridges on Fig. 7.7)
* Boulder fields and washes are essential conduits that recharge wetlands and groundwater BUT are not defined as wetlands.

2. Washes conduct water to **vernal pools** that are nodes where the flow pathway levels off. Vernal pools are wetlands, have dedicated hydric soil indicators, and they recharge **groundwater** and **springs** that maintain large organic based wetlands: **swamps** and **fens**.

3. **Bogs** (self-contained peatlands) are uncommon in this landscape where wetlands both store and discharge flow to **streams** that maintain **Colpitt Lake** and **Williams Lake**.

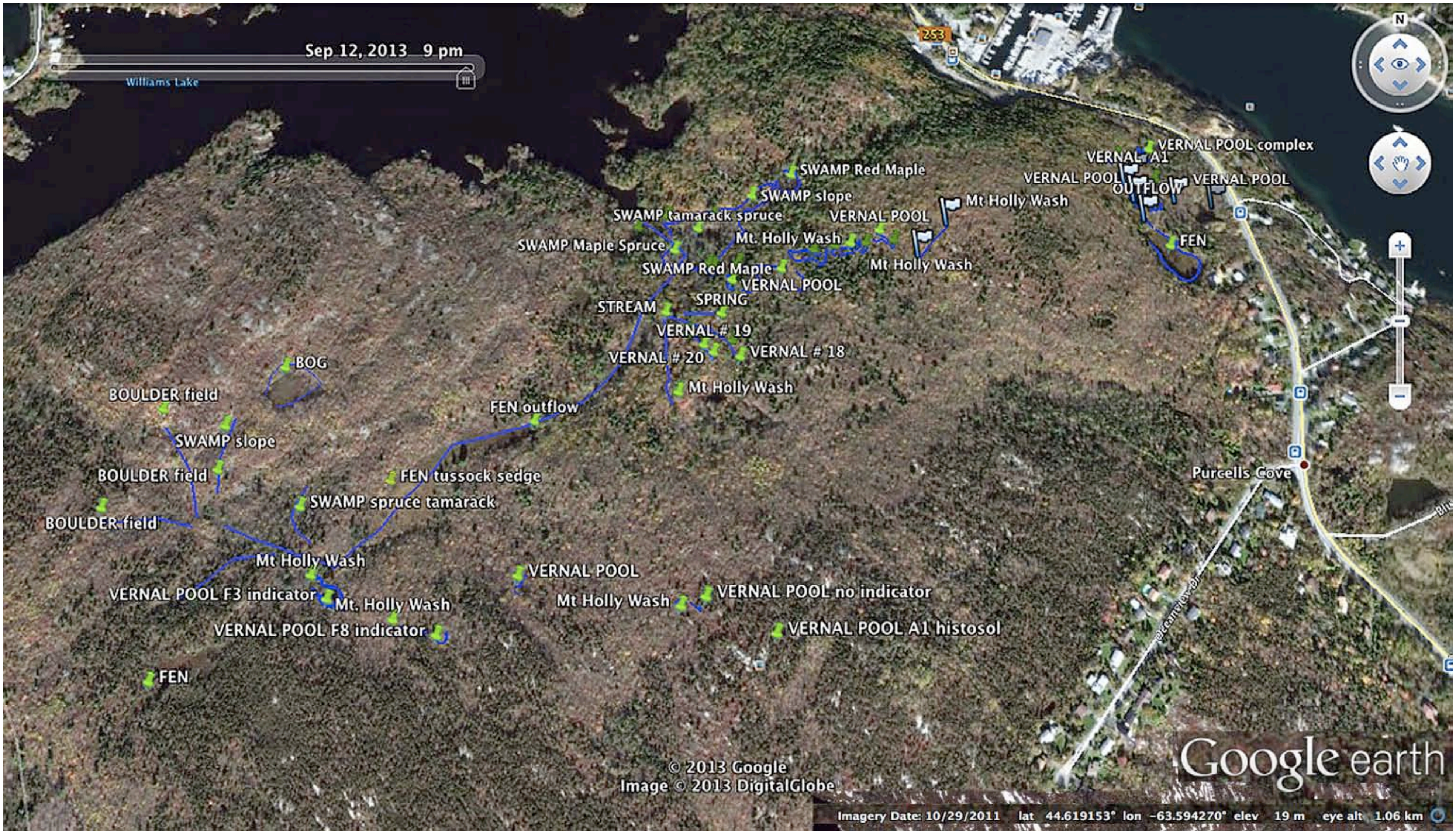


Fig. 7.7 Partial representation of water flows from the barrens into the water course that flows northeast along the contact zone between rocks of the South Mountain Batholith and the Halifax Formation and finally into Williams Lake.

Fig. 7.8 Springs
Much of the water passages in the backlands are below ground. Springs are an obvious example. This spring was found in May when a water flow disappeared from a plateau at a higher elevation and then it reappeared at a lower plateau (ca. 10-15m drop) emerging as a spring. The sphagnum indicates that this area is persistently moist.

Fig. 7.9 Vernal Pool

Soils were usually hydric as indicated by four indicators. The subsoil restrictive layer varies from rock (e.g. the case of A1 Histosol: peat on rock) to sandy soil (e.g. the A11 indicator) to clay silts where a particular indicator, F8: Redox Depressions, noted for use in closed depressions subject to ponding (ie. vernal pools) was observed.

Table 7.1 Plant species and soil wetland description for a vernal pond.

Plants	Hydric Soil	Soil Comment	Additional
Mt. Holly (FAC)	A1	Moist peat	Over rock
Red Maple (FAC)	A11	Depleted under dark surf.	--
Sheep Laurel (FAC)	F3	Depleted matrix	--
Paper Birch (FACU)	F8	Redox depressions	Indicator noted for vernal pools

INDICATOR	SOIL CORES
A1 = "HISTOSOLS include soils that have organic soil material of any thickness over rock or fragmental material that has interstices filled with organic..." Caution: organic as of peat muck of wetland origin.	
A11 = "Depleted below dark surface" 60% of chroma of 2 or less, 15cm thick, starting in upper 30cm **10YR 4/1** (a 35 m^2 vernal pool connected to others in a wash network)	
F8 =" Redox Depressions" For closed depressions subject to ponding 5% distinct to prominent redox 5cm thick, in upper 15cm matrix:redox = **2.5YR 7/3:2.5YR 6/6**	

Typical vernal pool at lower elevation also featuring Mountain Holly but standing water persisted into May and there is much evidence of hydrology: standing water, geomorphic postion, water-stained leaves (at right), sparsely vegetated surface.	
Goldthread (*Coptis trifolia,* Buttercup Family) is an indicator of these systems, so often occurring at their margins as at those of vernally flooded swamps. Goldthread= FAC (but FACW by USFWS).	
Sphagnum girgensohni and *S. palustre* were frequent members of these more typical vernal pools and they are also common in swamps at the Backlands.	

Fig. 7.10 Vernal Pools.

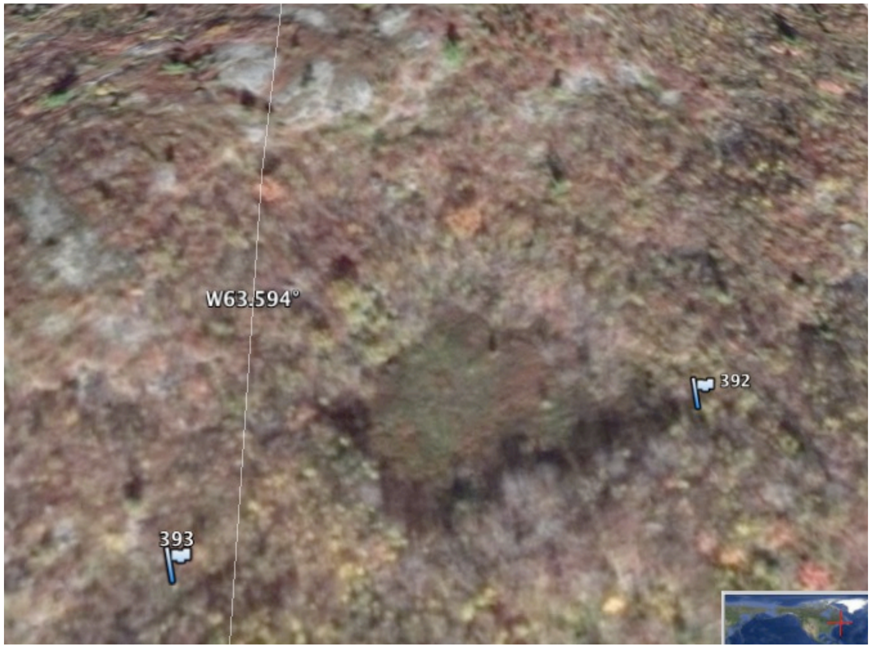


Fig. 7.11 Google image of a bog in the WLB (left) and some of its heath family plants.

The bog is a depression in this landscape and a rock wall surrounds the north and east bog edges There is a slope at the south edge and perhaps a small overflow toward the west which may or may not be functional. Because the supply of mineral nutrient is low, the plants colonizing bogs frequently have unusual nutrient strategies (e.g. insectivory in pitcher plants and sundews). Most of the vascular plant biomass of this bog is made up of evergreen shrubs of the Heath family including: Leatherleaf (the white flowerbells, mid photo below), Sheep Laurel and Bog Laurel and Labrador Tea. These plants are adapted to acidic conditions. Ericaceous mycorrhizal fungi give these plants exceptional mineral uptake abilities and evergreenness means they are more efficient at nutrient conservation. Note that nutrient and water availabilities increase at the bog margin (the "lagg" zone). Here grows the beautiful, deciduous heath family member, Rhodora. Its restriction to that zone may reflect a greater mineral nutrient requirement stemming from its mineral losses from the deciduous strategy.

Tussock Sedge, Sweet Gale
Red Maple and Tamarack
FEN

Black Spruce, Tamarack, Canada Holly and
Cinnamon Fern
SWAMP

Carex stricta

Myrica gale in flower

Fig. 7.12 Fen and Swamp

The FEN and SWAMP pictured above are part of the same wetland just above the waterfall gully above Williams Lake. The terrestrial landscape edge to the north of the fen is sloped and there is not much input of sediment and mineral nutrient from this edge. In contrast, the swamp portion of this wetland complex receives inflow from a more gradual slope and the swamp receives drainage from a larger watershed area. Notice that tree growth is sparse in the fen, relatable to greater constancy of waterlogging (less summer drawdown), and that the dominants include the tussock sedge (*Carex stricta*) and the nitrogen-fixing, Sweet Gale (*Myrica gale*).

Fig. 7.13 Canada Holly (red berried shrub) in a swamp in a wet period in the fall.
The presence of this relative of the Mountain Holly is found in richer wetlands.
The size of the dead black spruce is also indicative of a greater productivity site and the influence of dead wood inputs into swamp substrate was noted above.

Two divergent fens, the ‘Big Fen" and the "Jack Pine Fen" illustrate how variation in productivity influences the composition of the fens. Both are linear systems and are peatland flow pathways; both are more constrained by landscape sloping sides that is evident in swamps. The Big Fen is in the center of the Google Map (Fig. 7.7 above). The Jack Pine fen is the most southerly fen on the map.

Jack Pine fen is a narrow fen surrounded by Jack Pine upland. It is unusual in having Jack Pine established in the wet Tussock Sedge/Sphagnum moss matrix. The Jack Pine here and at other sites in the Backlands, has a high serotiny ratio that indicates that there have been recurrent **fires** in the landscape. Diversity was low in this ecosystem though the two typical fen species, Tussock Sedge and Sweet Gale, dominated the vegetation. Apart from scattered Jack Pines there was little additional plant diversity.

Fig. 7.14 The Big Fen.

This fen has the same dominants as noted in the entry fen (Fig. 7.12): the Tussock Sedge and Sweet Gale (both in photo top right). Leatherleaf (same photo, white bell) is abundant and this plant attracted both bumble bees and butterflies (Azure Blues and Coppers) in mid May. In September, the fen has fruit of the Large Cranberry and the Bog Rose (above) and colours of Red maples and Cinnamon Fern (top right).

Fig. 7.15 The Jack Pine Fen

Above: Fire-adapted/dependent Jack Pines in a wet Tussock Sedge Fen.
Below: the peat record reveals several layers of charcoal (see black stripes below right) that extend to the base of the metre long core which is laid out below at left.

Swamps
Swamps are the most common wetland in the central, lower elevation, drainage corridor (Fig. 7.7) for nutrient and sediment flow and deposition reasons elaborated above.

Like fens, there is a range of productivity and ecosystem types over the Backlands landscape. At lower fertility, as at lower watershed area positions closer to the headwaters of these small drainage systems (to the west of the central drainage that runs west to east), treed fens grade into swamps and both may be dominated by Black Spruce and Tamarack.

TREED BLACK SPRUCE FEN soils are A1 Histosols and peat is deep	BLACK SPRUCE SWAMP soils may be mucky and the mineral soil content can be felt as an greasiness

Fig. 7.16 Black Spruce fen and swamp.

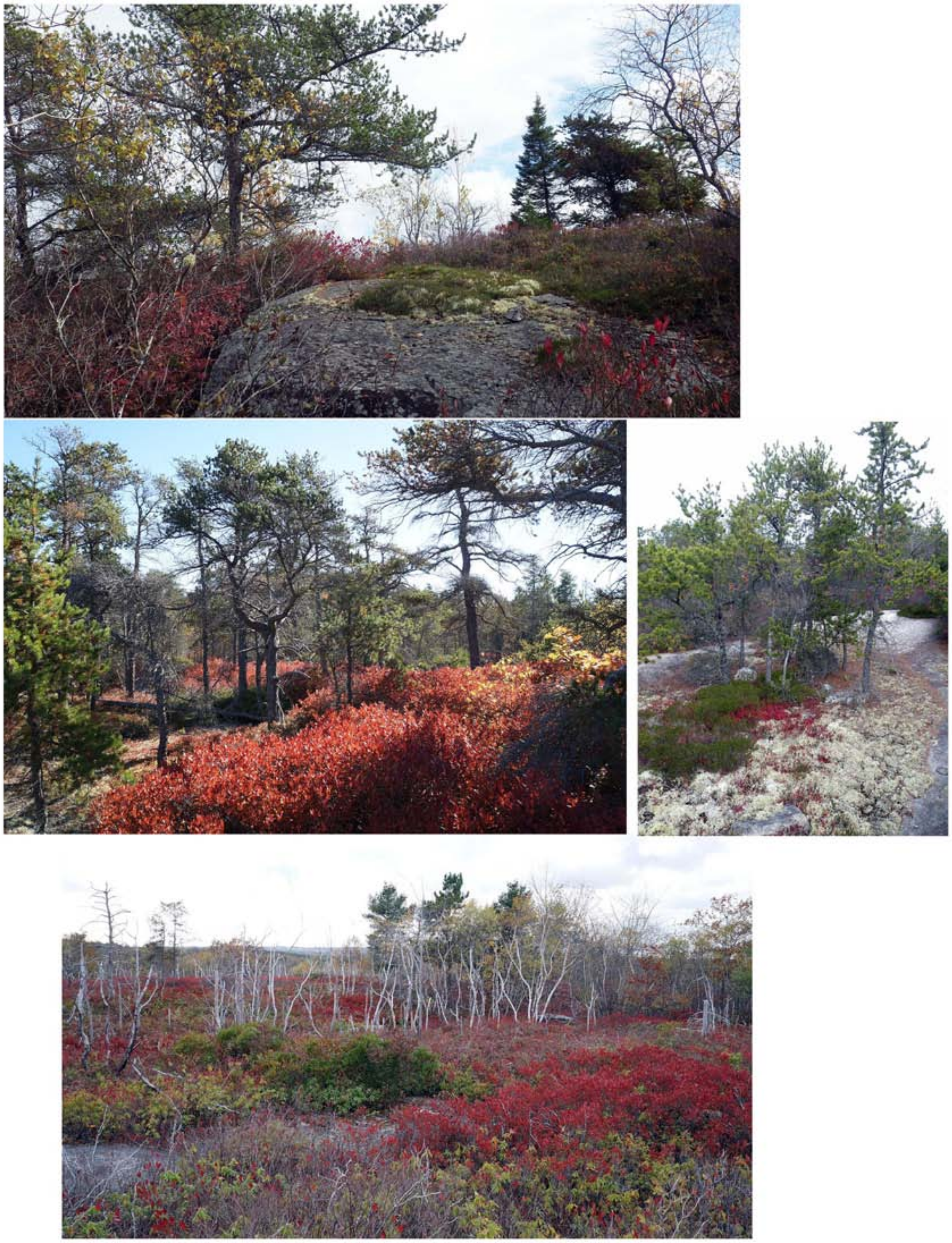
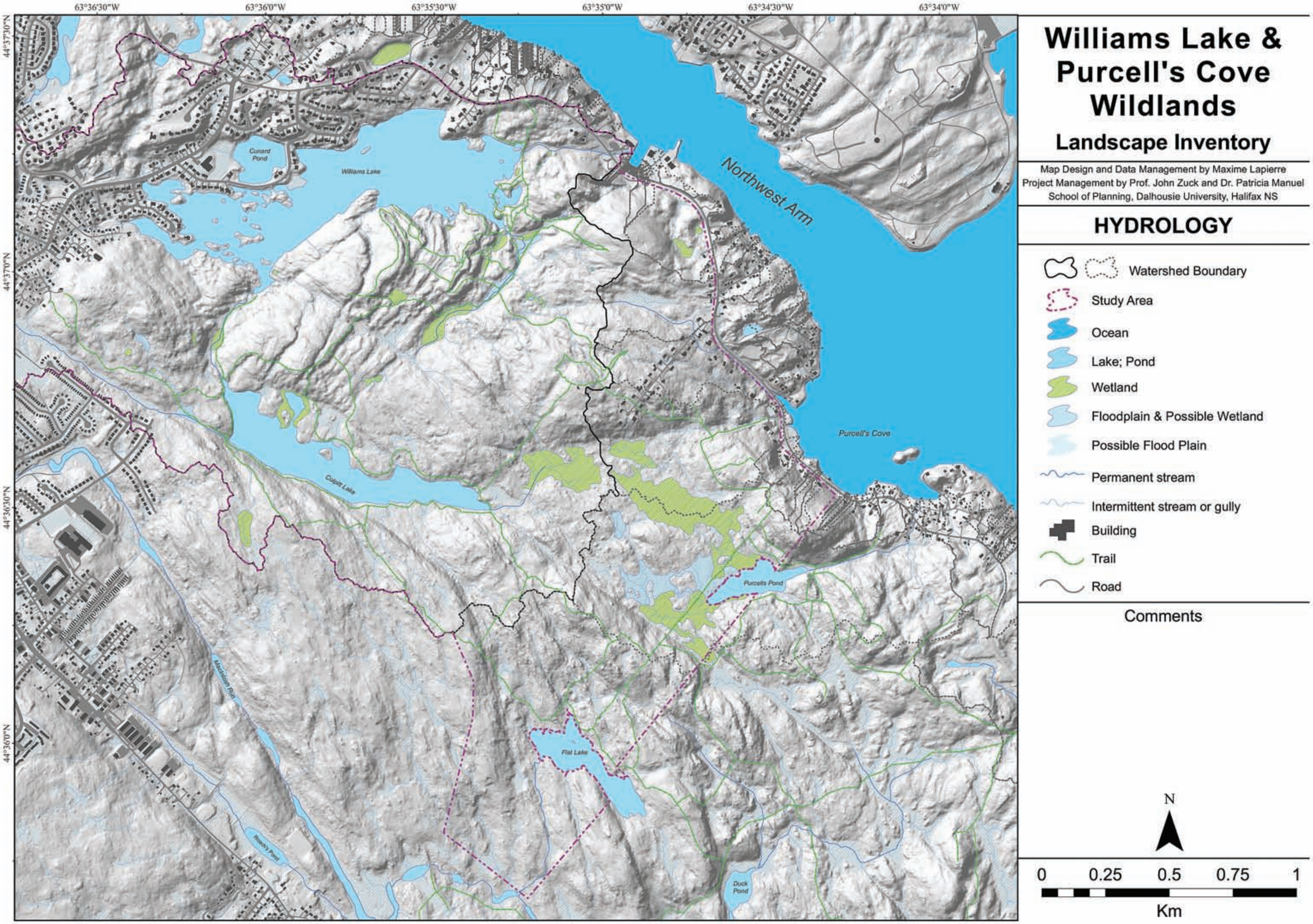
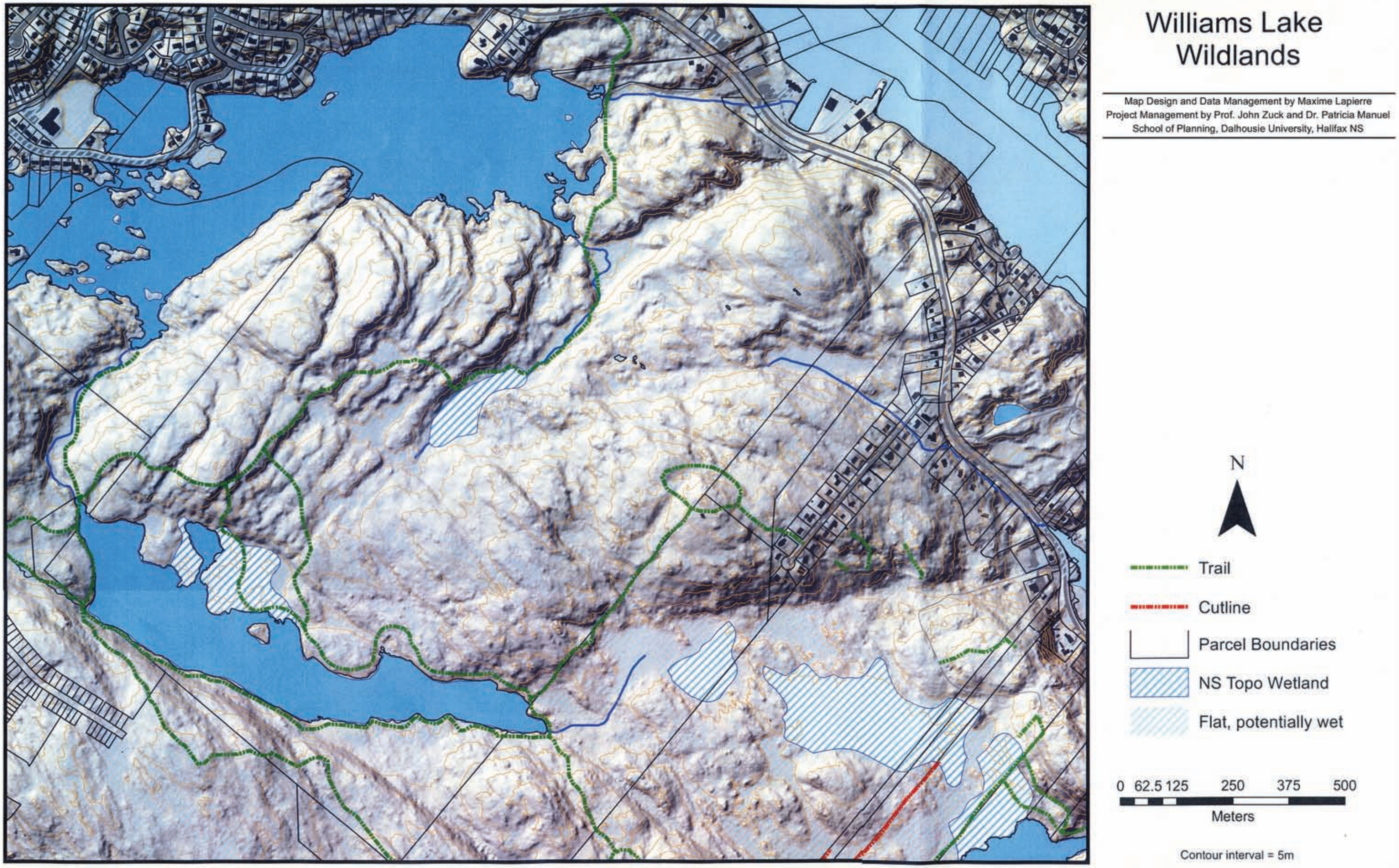


Fig.8.1 Fall in the Jack Pine/Broom Crowberry barrens (top 3 pics) and heathland on top of the drumlin that burned in 2007.

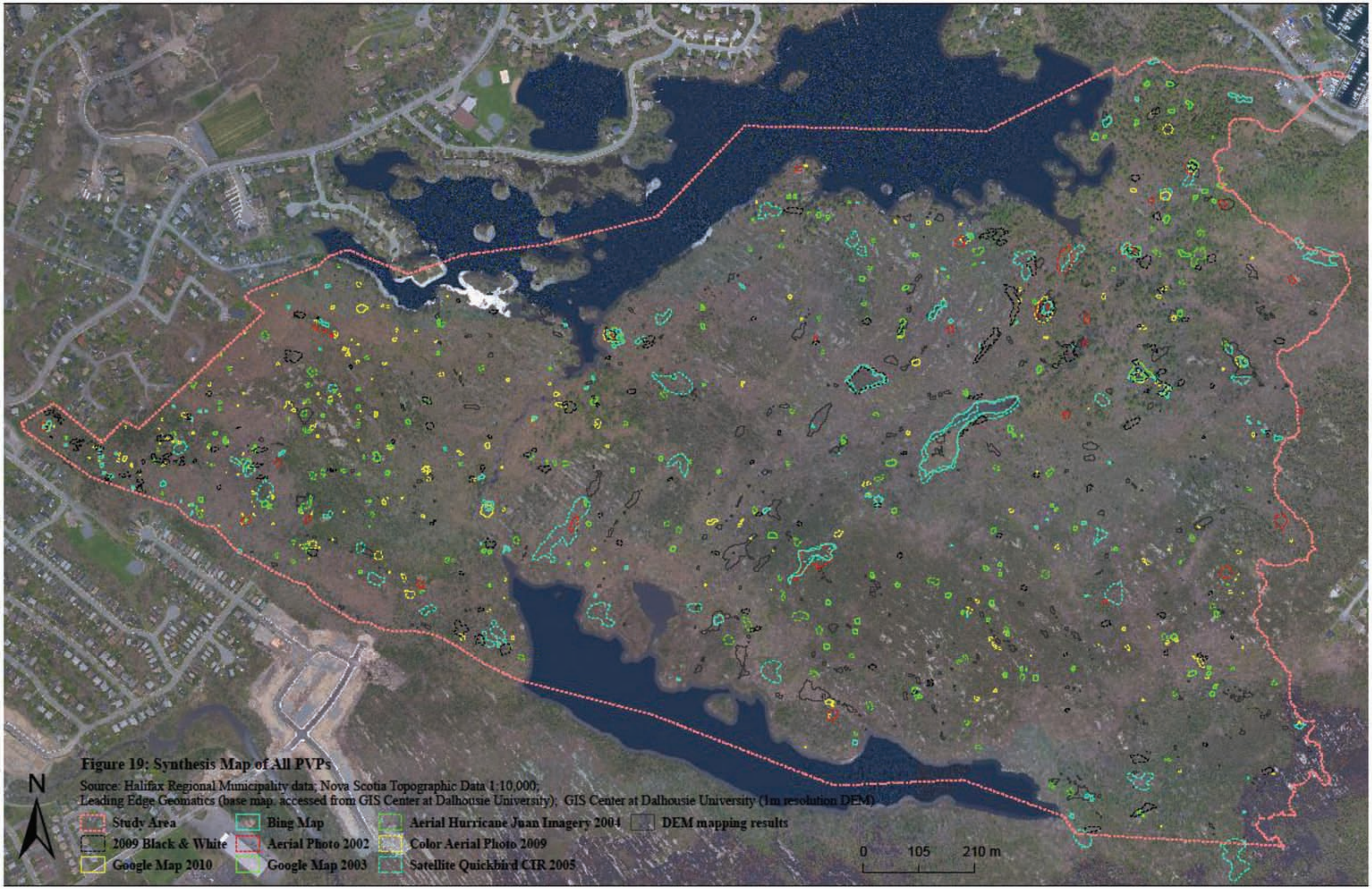
Losing such areas would be a conservation loss on a North American scale but the loss to aesthetics, recreation and ecological services would be ours alone.



Appendix A Map 1 in *Ecological Assessment of the Plant Communities of the Williams Lake Backlands* REPORT to Williams Lake Conservation Co., Dec. 2013. Courtesy of Prof. Patricia Manuel, School of Planning, Dalhousie Univerity.

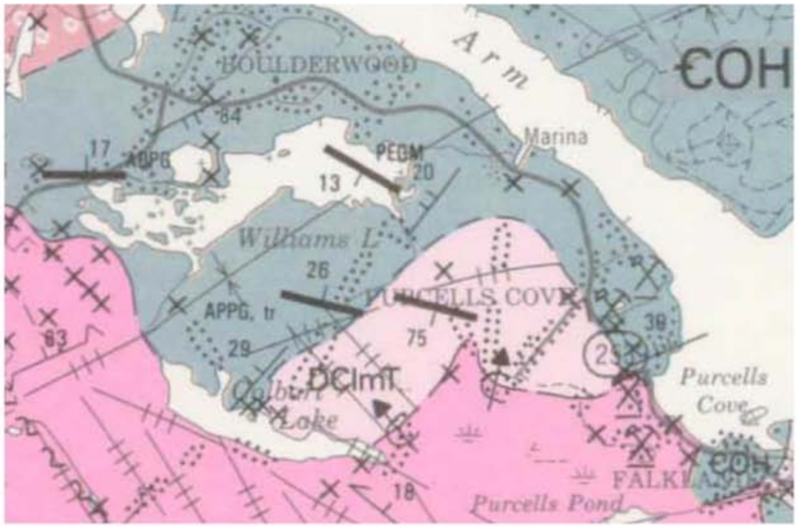


Appendix A Map 2 in *Ecological Assessment of the Plant Communities of the Williams Lake Backlands* REPORT to Williams Lake Conservation Co., Dec. 2013. Courtesy of Prof. Patricia Manuel, School of Planning, Dalhousie Univerity.

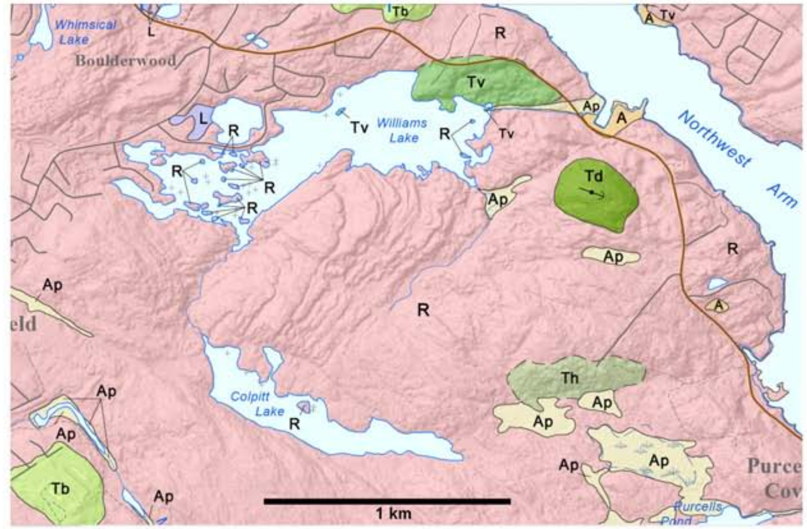


Appendix A Map 3: H. Liu's Synthesis Map of All Potential Vernal Ponds. In *Ecological Assessment of the Plant Communities of the Williams Lake Backlands:* REPORT to Williams Lake Conservation Co., Dec. 2013. Courtesy of Prof. Patricia Manuel, School of Planning, Dalhousie Univerity.

BEDROCK GEOLOGY



SURFICIAL GEOLOGY



DEVONO-CARBONIFEROUS

DClmHX	HALIFAX PENINSULA LEUCOMONZOGRANITE: light- to whitish-grey, pinkish- to orangish-grey, medium- to predominantly coarse-grained, megacrystic (5-›50%), biotite (‹4-6%), muscovite (trace-2%), cordierite (trace-›4%)
DClmT	TANTALLON LEUCOMONZOGRANITE: light- to medium-buff-orange, pink, red, light- to medium-whitish grey, fine- to medium-grained, equigranular and aplitic to porphyritic, biotite (trace-6%), muscovite- (1-4%), cordierite (0-3%), large alkali feldspar phenocrysts ›2.5cm (0-5%)

CAMBRO-ORDIVICIAN

MEGUMA GROUP (after Faribault, 1908)

€OH	HALIFAX FORMATION: finely laminated black slates and siltstones

CENOZOIC

QUATERNARY

HOLOCENE (postglacial)

A	***Anthropogenic*** Artificial or geological material that has been disrupted and redistributed by human activity; texture highly variable. Note that many areas of residential communities and till veneer are mapped as the original material because of the sporadic and shallow nature of the modification.
Ap	***Alluvial*** Gravel, sand, silt, minor clay and organic deposits. Deposited by active streams and rivers in channels and floodplains. Thickness estimated from 1-10 m.
Ml	***Marine littoral*** Boulders, cobbles, sand and organic deposits. Coarser material predominant where drumlins form headlands; finer material forms beaches, barrier bars and spits. Sediments deposited or reworked in the littoral zone (i.e. foreshore and backshore) by wave action, longshore drift and eolian processes. Thickness estimated from 1-5 m.
L	***Lacustrine*** Sand, silt, clay and organic deposits. Sediments deposited from suspension in freshwater lakes, ponds and wetlands; includes shoreline material deposited or reworked by wave action. May be underlain by till or glaciolacustrine material (sand, silt and clay with some dropstones). Thickness estimated from 1-5 m.

PLEISTOCENE (last glaciation)

Th	***Hummocky till*** Beaver River Till is a diamicton with loose, sandy matrix and locally derived clasts. Surface topography is irregular with small mounds of till deposits. Sediments derived from subglacial erosion and meltout processes. These deposits may represent areas occupied by stagnant ice. Thickness estimated from 1–10 m.
Tb	***Till blanket*** Beaver River Till is a diamicton with sandy matrix and locally derived clasts. Sediments deposited by ice and derived from subglacial erosion. Thickness estimated from 5-10 m (thick enough to mask irregularities of the underlying bedrock).
Tv	***Till veneer*** Beaver River Till is a diamicton with sandy matrix and locally derived clasts. Sediments deposited by ice and derived from subglacial erosion. Thickness estimated from 0.5-5 m. Some areas include exposed bedrock and thicker till deposits (>5 m) of locally derived till.
Td	***Drumlins*** Elongate landforms with long axes parallel to ice flow, composed of up to three tills: a core of Hartlen Till (observed only at coastal sections), overlain by Lawrencetown Till, and in some areas, overlain by Beaver River Till (described above). Hartlen Till is a diamicton with dark grey, compacted, clayey silt matrix, and predominantly locally derived and lesser distally derived clasts. Lawrencetown Till is a diamicton with brownish-red, compacted, clayey silt matrix, and predominantly distally derived clasts. Thicknesses of drumlins are affected by the surface relief of the landforms they are sitting on. In some instances depth to bedrock (determined from water well data, cf. Kennedy *et al.*, 2009) exceeds the surface relief, suggesting material filled a preglacial topographic low or paleovalley. These thicknesses may exceed 30 m.

PALEOZOIC

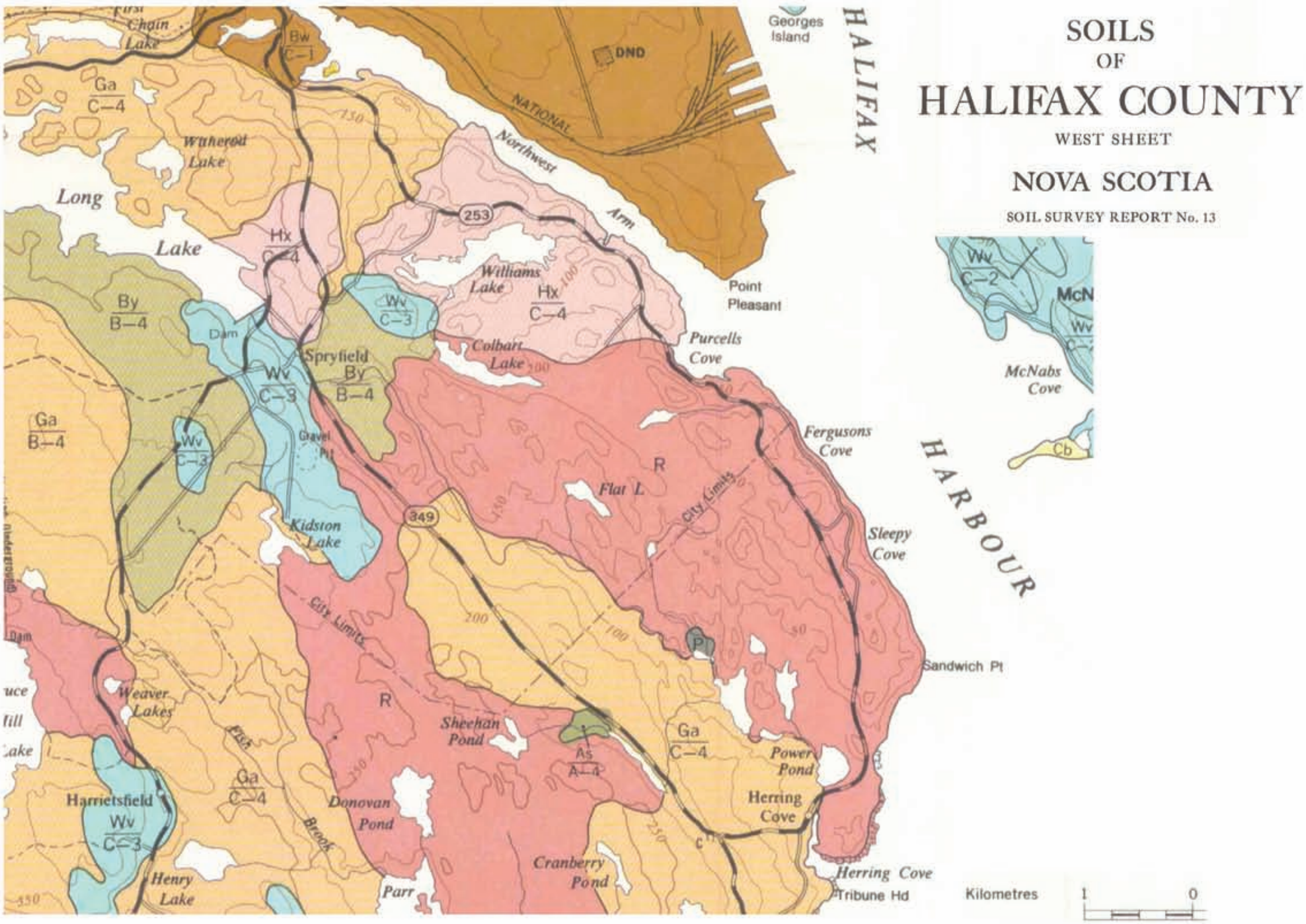
R	***Bedrock*** Bedrock exposed at surface or beneath shallow soil. It may include minor fluvial, lacustrine and till deposits. Exposed surface is glacially scoured with ice movement features, such as striae, which are indicated by symbols where identified. Obvious 'strike ridges' seen on the LiDAR hillshade image represent more durable rocks within individual formations.

Sources:

Nova Scotia Department of Mines and Energy Map 87-6
Geological Map of Halifax and Sambro
MA Macdonald and RJ Horne 1987

Nova Scotia Department of Natural Resources - Mineral Resources Branch
Surficial Geology Map, Part of the Herring Cove Claim
D. J. Utting Open File Map ME 2011-011

Apendix A Map 4. Bedrock and surficial geology in the Williams Lake area.



LEGEND

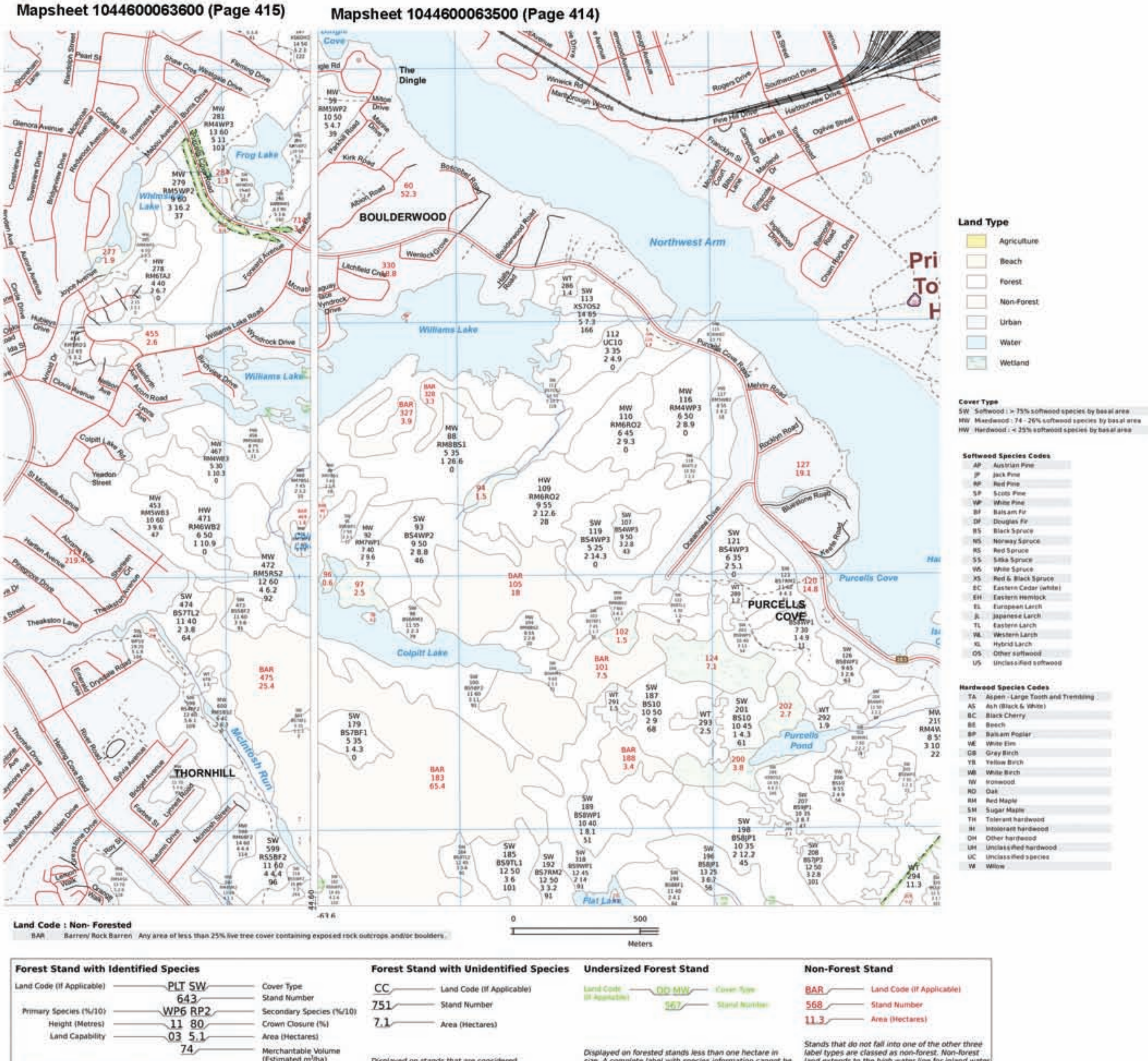
MAP COLOUR AND SYMBOL	SOIL SERIES OR LAND TYPE	DESCRIPTION OF SURFACE AND SUBSOIL	PARENT MATERIAL	TOPOGRAPHY	DRAINAGE
By	**BAYSWATER**	Grayish-brown sandy loam over dark yellowish brown sandy loam; mottled	Yellowish-brown coarse sandy loam till	Gently undulating to gently rolling	Imperfect drainage
Ga	**GIBRALTAR**	Brown sandy loam over strong-brown sandy loam	Pale-brown coarse sandy loam till derived from granite	Gently undulating to gently rolling	Good to excessive drainage
Hx	**HALIFAX**	Brown sandy loam over yellowish sandy loam	Olive to yellowish-brown stony sandy loam till derived from quartzite	Gently undulating to gently rolling	Good to excessive drainage
R	**ROCKLAND**		Areas where at least 60 per cent of the land is exposed bed-rock or the till is extremely stony	Variable	Variable
Wv	**WOLFVILLE**	Dark reddish brown loam to sandy clay loam over strong-brown loam to sandy clay loam	Reddish-brown loam to sandy clay loam till derived from shale and sandstone	Gently undulating to gently rolling	Good drainage

Appendix A Map 5: Soils, in *Ecological Assessment of the Plant Communities of the Williams Lake Backlands* REPORT to Williams Lake Conservation Co., Dec. 2013.

Source:MacDougall, J.I., &Cann, D. B., &Hilchey, J.D. (1963). Soil Survey of Halifax County Nova Scotia (Report No. 13).

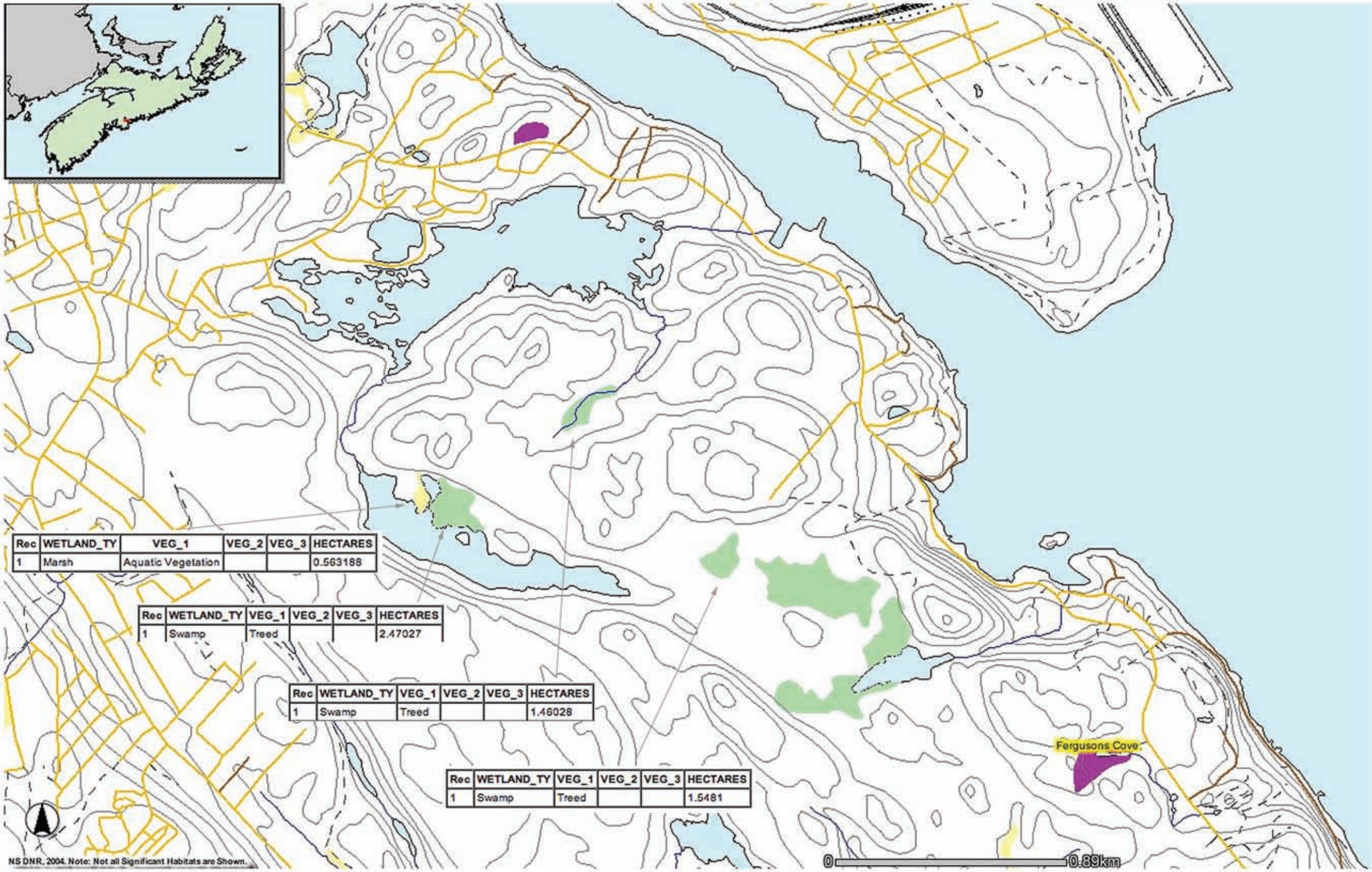
Nova Scotia DNR Forest Cover Type Map

Mapsheet 1044600063600 (Page 415) **Mapsheet 1044600063500 (Page 414)**



Accessed at http://novascotia.ca/natr/forestry/gis/webmaps.asp 1 Dec. 2013

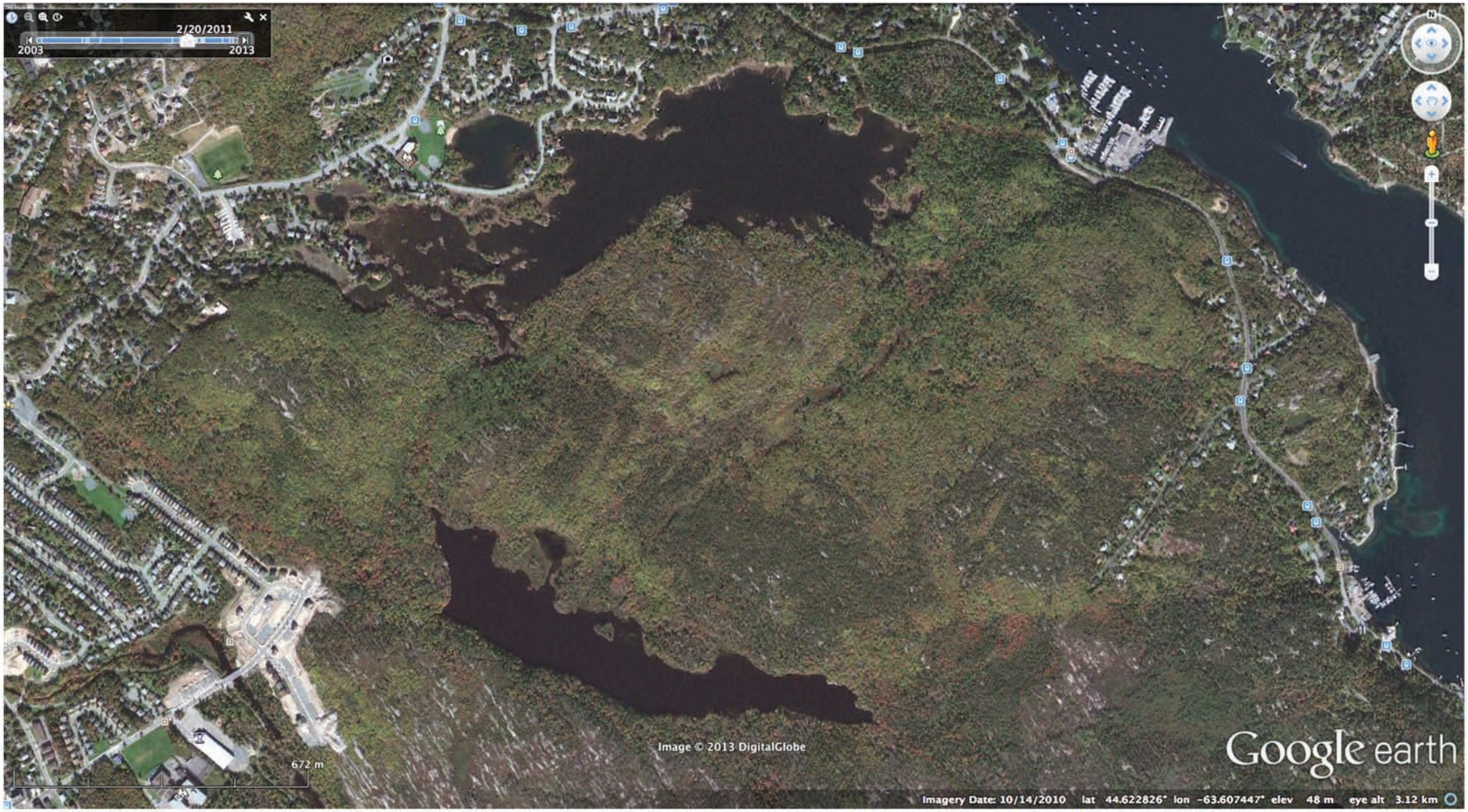
Appendix A Map 6 N.S. Forest Cover Map; in *Ecological Assessment of the Plant Communities of the Williams Lake Backlands:* REPORT to Williams Lake Conservation Co., Dec. 2013.



Appendix A Map 7. DNR mapped wetlands, in *Ecological Assessment of the Plant Communities of the Williams Lake Backlands* REPORT to Williams Lake Conservation Co., Dec. 2013.

Source: N.S. Natural Resources Map Viewer at http://gis4.natr.gov.ns.ca/website/nssighabnew/viewer.htm Accessed 2 Dec. 2013

Appendix A Map 8: Google Earth Map of Oct. 29, 2011, prepared for *Ecological Assessment of the Plant Communitiesof the Williams Lake Backlands*: REPORT to Williams Lake Conservation Co., Dec. 2013



Appendix A Map 9: Google Earth Map of Oct. 14, 2010 prepared for *Ecological Assessment of the Plant Communitiesof the Williams Lake Backlands*: REPORT to Williams Lake Conservation Co., Dec. 2013

Appendix A Map10:Google Earth Map of Apr. 29, 2011, prepared for *Ecological Assessment of the Plant Communitiesof the Williams Lake Backlands*: REPORT to Williams Lake Conservation Co., Dec. 2013