Ecological Assessment of the Plant Communities of the Williams Lake Backlands

A REPORT

to

The Williams Lake Conservation Company

by

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WILLIAMS LAKE
CONSERVATION COMPANY

www.williamslakecc.org

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Halifax Regional Council provided funding to the Williams Lake Conservation Company in order to obtain a survey of the plant communities in the William's Lake Backlands. While the survey focused on these lands, many of the findings apply to the larger Purcell's Cove Backlands. It is noteworthy that the authors advance some novel perspectives on the ecological values of the area. The issues of fire management and wetland protection require attention and discussion by the larger community.

The funding from the municipality covered approximately two-thirds of the costs of carbon-dating a charcoal sample, one day of time for a specialist to document wetland mosses, travel costs and a portion of the hours put in by Nick Hill. The larger portion of his time was contributed as was the time put in by David Patriquin.

The survey has been reviewed by the executive of the Williams Lake Conservation Company and approved at a meeting held January 28, 2014.

Kathleen J Hall

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.

SUMMARY

The Williams Lake Backlands (WLB), covering approximately 200 ha, are the larger, undeveloped part of the Williams Lake Watershed which includes Colpitt Lake and Williams Lake. The WLB are part of "Purcell's Cove Backlands" (approximately the 1350 ha) which include the land between Purcell's Cove Road and Herring Cove Road from Williams Lake at the northwest end to Powers Pond at the southeast end. Lying only two kilometers from peninsular Halifax, the WLB are near pristine wilderness. We traversed various routes through the WLB on twelve separate days between May 13 and Nov. 8, 2013 to document plant communities and wetlands for the Williams Lake Conservation Company, a volunteer organization concerned with stewardship of the Williams Lake watershed.

The WLB present a mosaic of landscapes and plant communities associated with high variability on a fairly small scale in the topography, depth of soil/till, drainage and surface water storage and in the ages since disturbance of the associated plant communities. That variability in turn is related to the presence of glacially scoured hard granite outcrops of South Mountain Batholith, outcroppings of highly folded and metamorphosed Halifax Group black slates and siltstones of the Meguma Supergroup, a contact zone between the two rock types, and glacial till. Overall, the plant communities are those of nutrient-poor, acidic environments and of fire-, wind-, and pest-driven disturbance regimes within a moist temperate, coastal region. Exotic (non-native) species are found only close to roads and houses at the edge of the WLB. These are "old process" plant communities with a high degree of ecological integrity.

The fire dependent/fire adapted nature of the vegetation and carbon dating of charcoal from a core in a Jack Pine fen indicate that fires in the WLB are part of a long-term fire regime that predates European settlement. Indeed, the whole of the Purcell's Cove Backlands is one of the most fire-susceptible landscapes in Nova Scotia, the droughty, windswept high barrens acting as matchsticks. One result is the presence of an old process, fire dependent Jack Pine/Broom Crowberry Barrens community that is nationally unique to Nova Scotia, globally rare and of high conservation significance. In the northeastern U.S., this community transitions to the fire-dependent Pitch Pine/Broom Crowberry community which is well recognized as of high conservation value. The largest single patch of Jack Pine/Broom Crowberry Barrens within the Purcell's Backlands occurs within the WLB, and overall, the Jack Pine/Broom Crowberry Barrens in the Purcell's Cove Backlands are amongst if not the best, representatives of this community in Nova Scotia.

The water regime in the WLB has features of dryland systems, with intermittent stream courses probably accounting for a majority of the water flow. Critical components such as Mountain Holly washes, vernal pools and boulder fields are not currently protected under Nova Scotia wetland and stream course regulations but are vital to maintenance of the larger wetlands and water quality of both surface and groundwater in the area.

The undisturbed nature of this wilderness area, its mosaic of habitats with wetlands, lakes, streams, forest and barrens, and its location by the coast in the most urbanized area of the province make the WLB and the larger Purcell's Cove Backlands significant habitat for both breeding and migratory birds.

It is suggested that conserving the WLB and the larger Purcell's Cove Backlands as natural systems reduces fire risk to adjacent communities compared to allowing more intrusions into the backlands. Implementing strategies such as those promoted in the northeastern U.S. for living compatibly with fire-structured pitch pine ecosystems would enhance both fire protection for neighbouring communities and conservation of biodiversity in our backlands.

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Photos posted online: http://versicolor.ca/wlbphotos

1. Introduction

In 2013, we conducted a survey of plants species and their habitats in the "Williams Lake Backlands" (WLB) in response to a request by the Williams Lake Conservation Company. Their interest was several-fold: (i) to contribute to their understanding of the Williams Lake Watershed & how it influences water quality of Williams Lake; (ii) to characterize the area in relation to efforts to see it formally protected & (iii) to document wetlands and other features that should be protected in the event some of the area is developed.

The WLB, approximately 200 ha in area, are part of the larger "Purcell's Cove Backlands" (approximately 1350 ha) which include the land between Purcells Cove Road and Herring Cove Road from Williams Lake at the northwest end to Powers Pond at the southeast end (Fig. 1.1).

There are two lakes within the Williams Lake watershed, Colpitt Lake and Williams Lake. The outflow from Colpitt Lake empties into Williams Lake. The northern shore of Williams Lake hosts moderate density housing which lies within the watershed. To date most of the new developments above and to the west of Colpitt Lake are outside of the watershed. Otherwise the large undeveloped area is urban wilderness.

Existing documentation includes:

- A detailed LIDAR-based hydrology map of the specific area prepared by Prof. Patricia Manual and colleagues at the School of Planning, Dalhousie University (Appendix A, Maps 1, 2)
- A report on "Vernal Pool Mapping in the Williams Lake Watershed, Halifax supporting small wetland identification in advance of development" by Huan Liu, conducted under the supervision of Dr. Patricia Manuel (Appendix A, Map 3; Liu, 2012).
- Nova Scotia Dept. of Natural Resources Geological and Surficial Geology Maps (Appendix A Map 4)
- Agriculture Canada Soils Map (Appendix A Map 5)
- DNR Forest Cover and Wetland Maps (Nova Scotia Dept. of Natural Resources) (Appendix A Map 6)
- A report on birds in the WLB was prepared for the Williams Lake Conservation Company by Fulton Lavender (2012).

The Purcell's Cove Conservation Lands, established under the aegis of the Nova Scotia Nature Trust, is the only formally protected area within the Purcell's Cove Backlands. This 35 ha area lies approximately 700 m southeast of the Williams Lake watershed (Fig. 1.1). A species list for that area was updated in 2012 (HFN, 2012). A photo-essay documenting recovery of vegetation in the Purcell's Cove Backlands over a year and a half after the Spryfield Fire of 2009 is also available (Beazley and Patriquin, 2010).

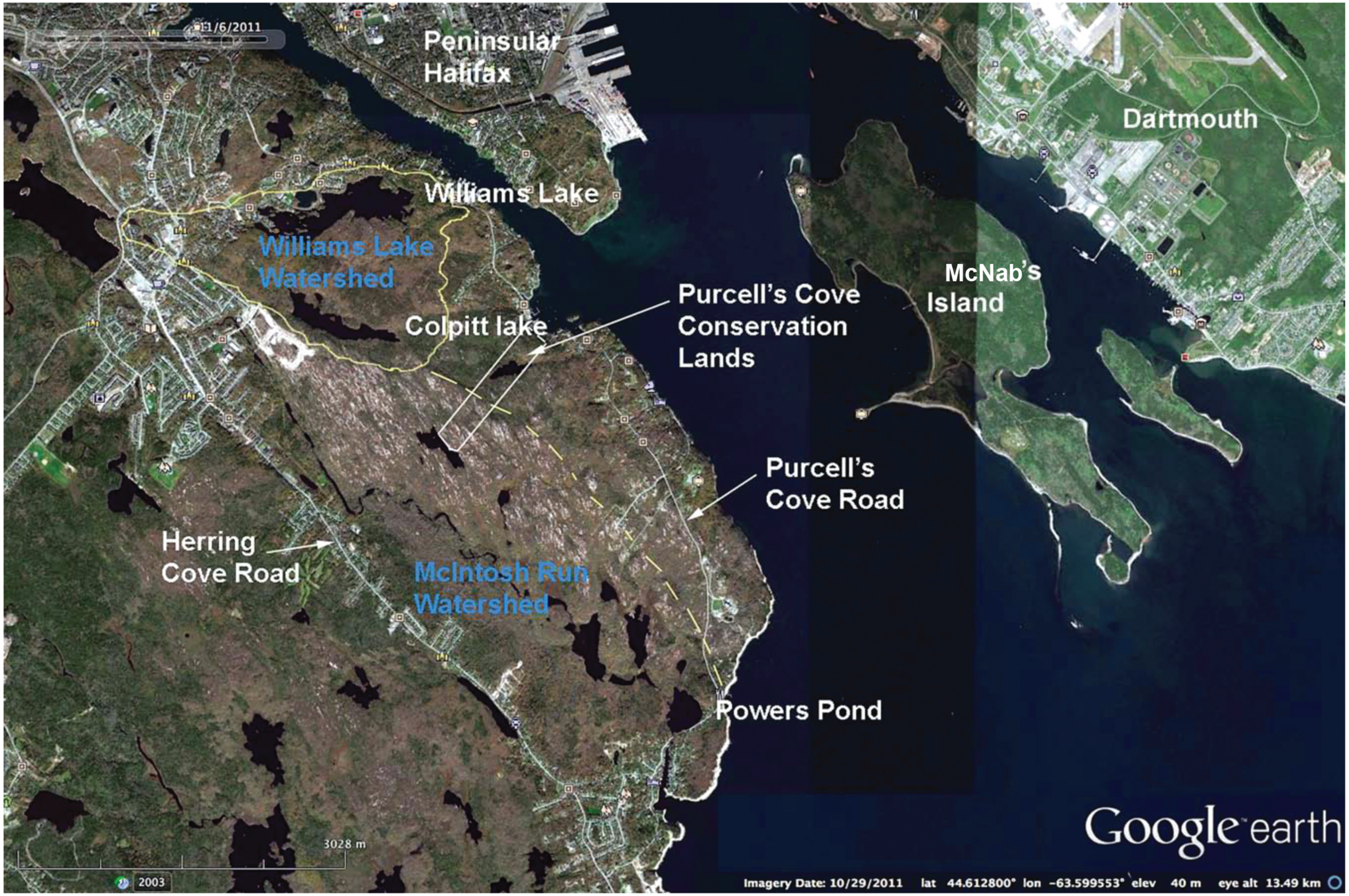

Fig. 1.1 Google Map showing Purcell's Backlands and major watersheds. The boundaries for the watersheds are approximate. Broken line marks eastern boundary of the McIntosh Run watershed.

2. Methods

We conducted surveys in the WLB on a total of eleven days between May 13 and Nov 8, 2013 (Fig. 2.1, 2.2). The surveys were of necessity semi-formal and largely qualitative, given the broad objectives, the limited time, funds and, except for the work of Prof. Patricia Manuel & colleagues on topography and hydrological features, the exploratory context of this study.

On May 13, 14, 31 our focus was on watercourses and wetlands which we wished to view while water levels were still relatively high. We entered via Purcell's Cove Road (May 12, 13) and Colpitt Lake Road (May 31), on the latter occasion with Patricia Manuel. (Dr. Manuel, a member of the Williams Lake Conservation Company and Professor at Dalhousie's School of Planning has conducted hydrological research in the area.) On Aug. 3rd we followed a route from Oceanview Drive almost due west to reach a "Jack Pine fen" close to Colpitt Lake which we had viewed on May 31; that route took us across higher barrens and lightly forested areas on granitic bedrock. On Sep. 12th, we followed a route from Purcell's Cove Road in the vicinity of Melvin Road across the drumlin by the SE side of Williams Lake, down into wetlands by Williams Lake. The initial part of this route lies within the "Purcell's Cove Watershed" (Appendix A, Map 1); the rest of it lies within the Williams Lake Watershed (as did all other sites that we visited). The route took us through upland hardwood forest and heathland as well as through lower lying moist forest and wetlands. On September 14th, we were accompanied by Tom Neily who would document sphagnum mosses, as well as some other mosses and lichens. We re-visited several of the larger or more interesting wetlands identified in previous excursions and we also went into the recently burnt barrens/high areas by the south side of Williams Lake.

On each of the surveys cited above, we documented the GPS location of every vernal pool/wetland encountered, the occurrence of stained leaves and plant species (particularly those diagnostic of wetlands) and, for many sites, the soil type (histosol or not) and depth to bedrock (sampled with an auger). Other relevant features such as the general topography of the surrounding area were noted. Approximately 20 wetlands were formally delineated. Other habitat types and associated vascular plant species, topographic features etc. were noted. Several thousand geo-referenced photos were taken for reference purpose. At two sites in the "Jack Pine Fen" close to Colpitt Lake, successive blocks of peat were removed from the surface down to the bedrock, and examined for the presence of charcoaled wood. One sample was sent to the Beta Analytic in Miami for carbon dating.

Additional surveys were made on May 20, Sep. 17, Oct. 4 & 22 and Nov. 6 & 8 (Fig. 2.2) by David P. to document vegetation in major landscape types identified on a Google Map that we hadn't covered previously and to obtain additional photo documentation.

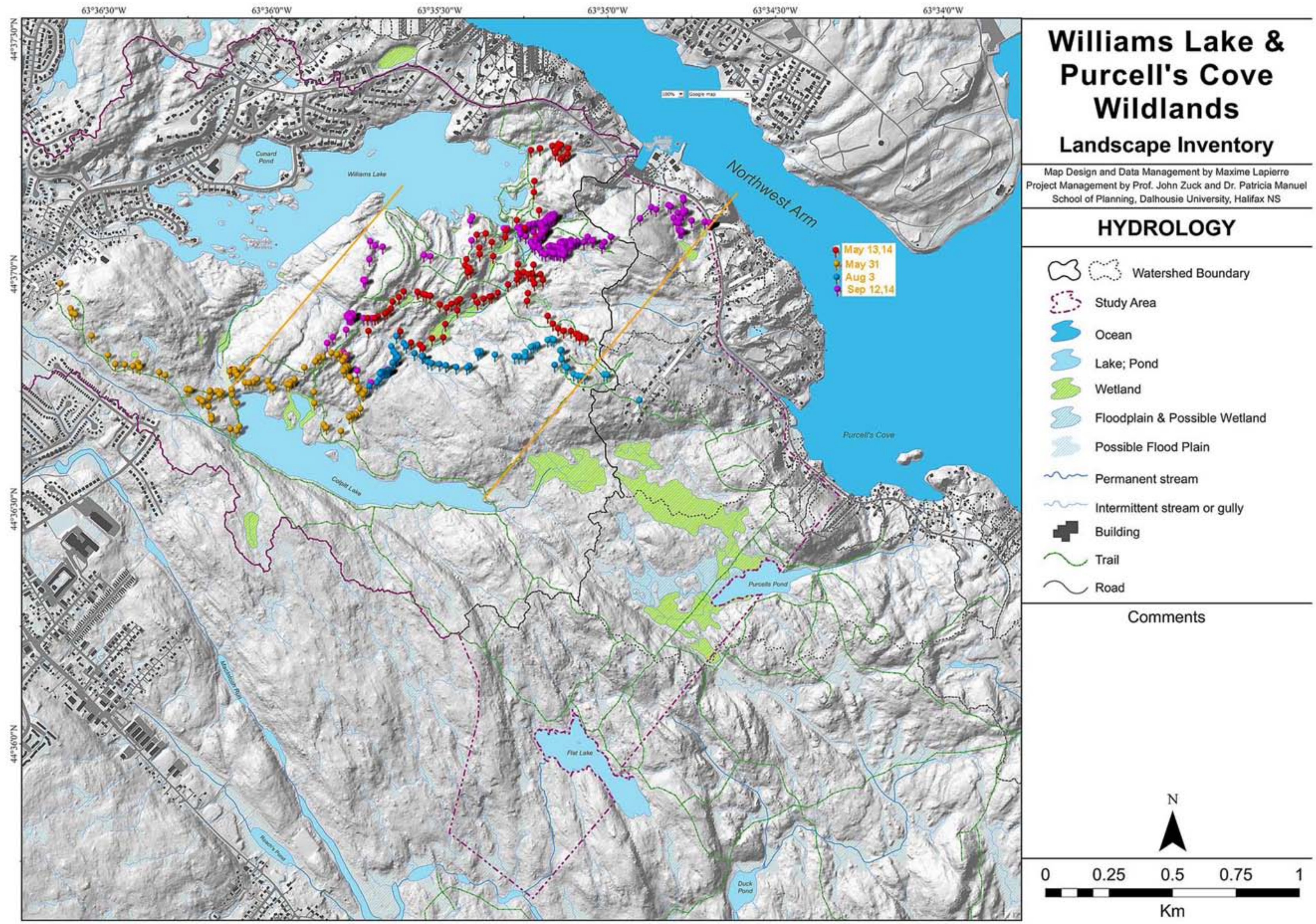

Fig. 2.1 Waypoints for the six surveys which included documentation of vernal pools.
The base map is courtesy of Professor Patricia Manuel, Dalhousie School of Planning. The waypoints were recorded for particular features including vernal pools, so are not exclusive for vernal pools.

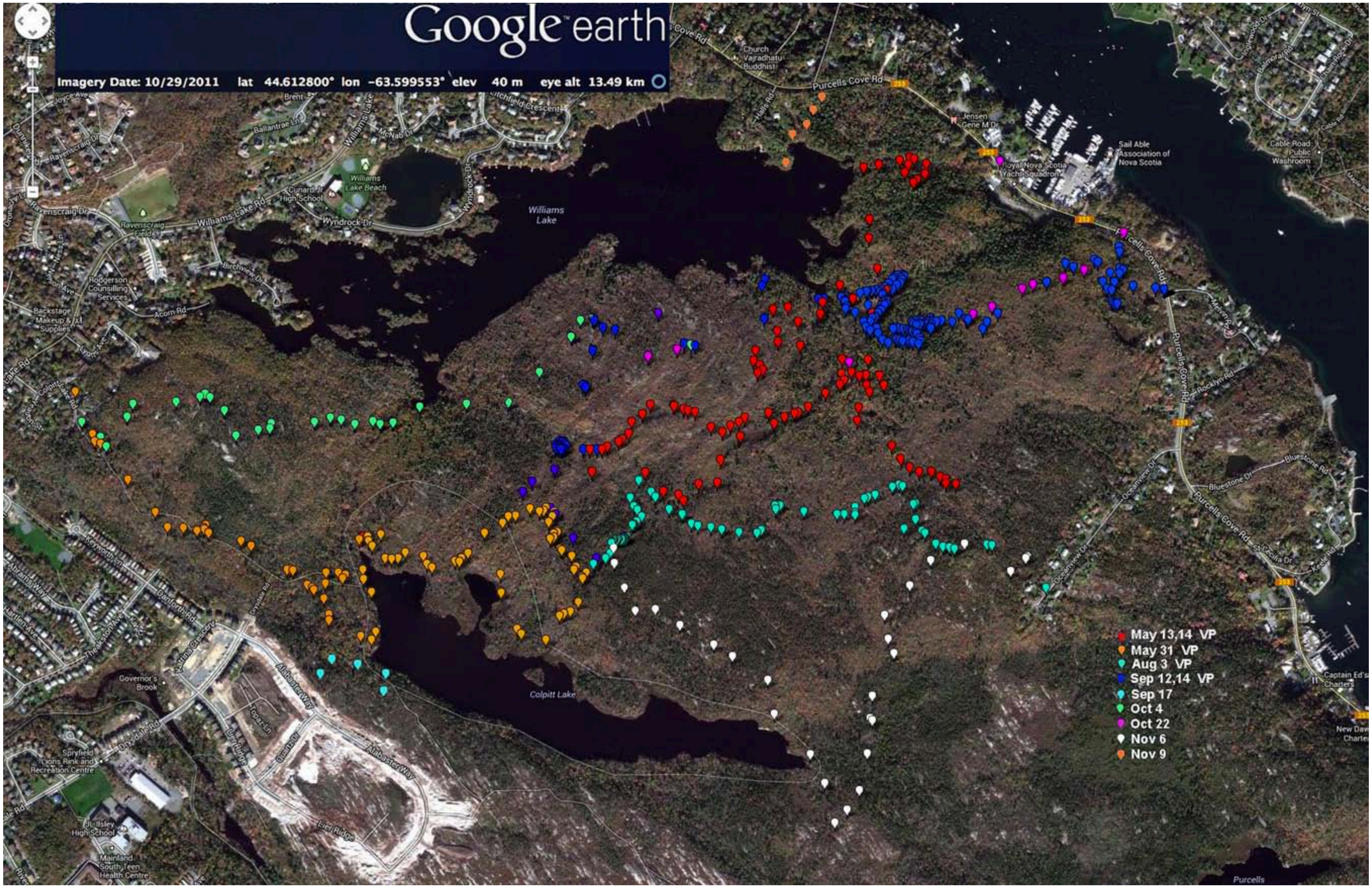

Fig. 2.2 Waypoints from all surveys on Google Satellite Map.

3. The Landscape-Vegetation Mosaic

The Williams Lake Backlands present a mosaic of landscapes and plant communities (Fig. 3.1). The mosaic pattern is associated with high variability on a fairly small scale in the topography, depth of soil/till, drainage and surface water storage and in the ages since disturbance of the associated plant communities. That variability in turn is related to the distribution of glacially scoured hard granite outcrops of South Mountain Batholith, outcrops of highly folded and metamorphosed Halifax Group black slates and siltstones of the Meguma Supergroup, a contact zone between the two rock types, and deposition of glacial till (Appendix A Map 4).

A set of hydrologically connected wetlands flowing into Williams Lake and a smaller set flowing into Colpitt Lake occur along the NE/SW oriented contact zone between rocks of the South Mountain Batholith and the Halifax Formation. Erratic blocks, whalebacks and boulder fields are prominent features of the glacially scoured landscape (Fig. 3.2). Some boulder fields are partially covered with plant litter, mosses, lichens and vascular plants, others are entirely bare except for a few lichens. The latter (bare boulder fields) may be restricted to the Halifax Series black slates.

The more extreme topographic variation occurs in the area of Halifax Group rocks between Williams Lake and Colpitt Lake where successive NE/SW oriented folds of the Halifax formation are crossed by NW/SE oriented glacially scoured ridges and valleys, which reveal the flow direction of ice during the last glaciation (Fig. 3.1).

A distinctive feature is a drumlin that occurs east of Williams Lake behind the Royal Nova Scotia Yacht Squadron (Fig. 3.1), a positive landform with a smooth surface, made of thick glacial till accumulated with a SE elongation, parallel to the ice flow. The drumlin is characterized by tall, healthy trees.

Most soil within the watershed is well-drained brownish stony sandy loam (Appendix A Map 5).

The major disturbances are fire, wind, and pests and diseases (Fig. 3.3). A large fire in 1964 is said by local residents to have burned most of the vegetation in the study area, leaving only larger pines intact. More restricted fires have occurred since then. Hurricane Juan (Sep. 29, 2003) caused a lot of windfall between Purcell's Cove Road and the dam at Williams Lake, sporadically elsewhere. Small scale tip-ups and wind snaps occur every year. An example of pest disturbance: our surveys revealed severe pest damage and dieback of many red pines to the southwest of Williams lake, but as yet the infestation seems not to have spread to red pines at the eastern side of Williams Lake. The pines boles of dead trees are intensively bored. We have not identified the causative agent.

Overall, the plant communities are those of nutrient-poor, acidic environments and of fire and wind-driven disturbance regimes within a moist temperate, coastal region. They include species from the Boreal, Acadian and Atlantic Coastal Plain elements (*sensu* Roland and Smith, 1969) of the Nova Scotia flora.

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.

Distribution of plant communities across the landscape

In Section 5 of this document, we classify the upland* plant communities into seven Vegetation Types based on the vegetation and habitat, ordered in a sequence from drier to more moist. In Section 7, the wetlands and other sites of water storage or channeling are classified into seven types based on the water regime, soil characteristics and vegetation, following the general principles of wetland classification.

Table 3.1 Our classification of upland plant communities, wetlands and other sites of water storage or channeling in the WLB.

Upland Vegetation Types	**Wetlands & Other Sites of Water Storage or Channeling**
1. Broom Crowberry - Blueberry/Reindeer Lichen Barrens	1. Vernal Pools
2. Huckleberry Heath	2. Swamp/Vernal Pool complexes
3. Jack Pine/Broom Crowberry Barrens	3. Shrub Swamps
4. Red Pine-Jack Pine/Broom Crowberry Coniferous Forest	4. Treed Swamps
5. Birch-Maple-Aspen Early Successional Forest	5. Fens
6. Red Oak-Red Maple/Witch-hazel Hardwood Forest	6. Lakeshore Fens
7. White Pine -Red Pine - Red Oak Mixed Forest	7. Bogs

Two community or habitat types don't fit neatly into the Upland/Wetland classification: boulder fields and washes. Both are important in water movement and are discussed together with wetlands in Section 7.

In the WLB, upland and lowland terrains (and associated plant communities) are distributed in a mosaic of small to large patches ranging in size from a few square meters or less to several or more hectares. Even the larger units are not uniform. For example, there are some large outcrop barrens, which have the driest soils, and some large wetlands but each hosts pockets of the other: small depressions in the barrens can host wetland plant communities, and rock outcrops in a wetland can host upland communities.

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*In ecological parlance, the distinction between "upland" and "lowland" or "wetland" refers to soil water regimes rather than to vertical positions, although the latter generally lie below the former on a small scale if not on a larger scale. In the Canadian Wetland Classification System (National Wetlands Working Group, 1997), upland and wetland are defined as follows:

> Upland: Terrain not affected by high water table or excess surface water, or if affected, only for short periods such that hydrophytic vegetation or aquatic processes do not exist.
>
> Wetland: Terrain affected by water table at, near or above the land surface and which is saturated for sufficient time to promote wetland or aquatic processes.

Google Earth and Google Map images can aid in the visualization of the mosaic nature of the WLB. Images taken in the fall are particularly useful because there is a wider range of colors associated with different vegetation types than in images taken at other times of year. The default image currently on Google Maps for the WLB area was taken on Oct 29, 2011 (Appendix A Map 8).

In Fig. 3.4 we labeled the larger units of upland vegetation and wetlands visible on the Google Earth image where we had ground-truthed them. Not labeled but showing prominently as southeast oriented streaks in this image are the rock outcrops which support the Broom Crowberry-Blueberry/Reindeer Lichen Barrens. The reddish hues are associated with Huckleberry. The largest trees, which cast distinct shadows, are White Pines. Conifers, including White, Red and Jack Pines and Red and Black spruce stand out as dark green. Needles of Tamaracks are orange colored in the fall before they drop, but Tamaracks do not occur in large aggregations in the WLB. Leaves of Wire and Paper birches and Red Maples have dropped by the end of October, and these landscapes tend to have reddish hues associated with huckleberry. An Oct 14th, 2010 image shows such areas as green associated with the overstory, mostly small, trees (Appendix A Map 9). Oaks retain their leaves for a longer period and show up in the Oct 29th imagery as light green to orange. Winter imagery shows the conifers (except for Tamarack which is deciduous) more clearly (Appendix A Map 10). Fig. 3.1 is a 3D perspective of the area from Google Earth.

In Fig. 3.4, fire icons are placed where there have been fires within the last 7 years. All are in high barrens or heaths. These windblown, droughty areas are the “matchsticks” of the backlands, discussed in Section 6.

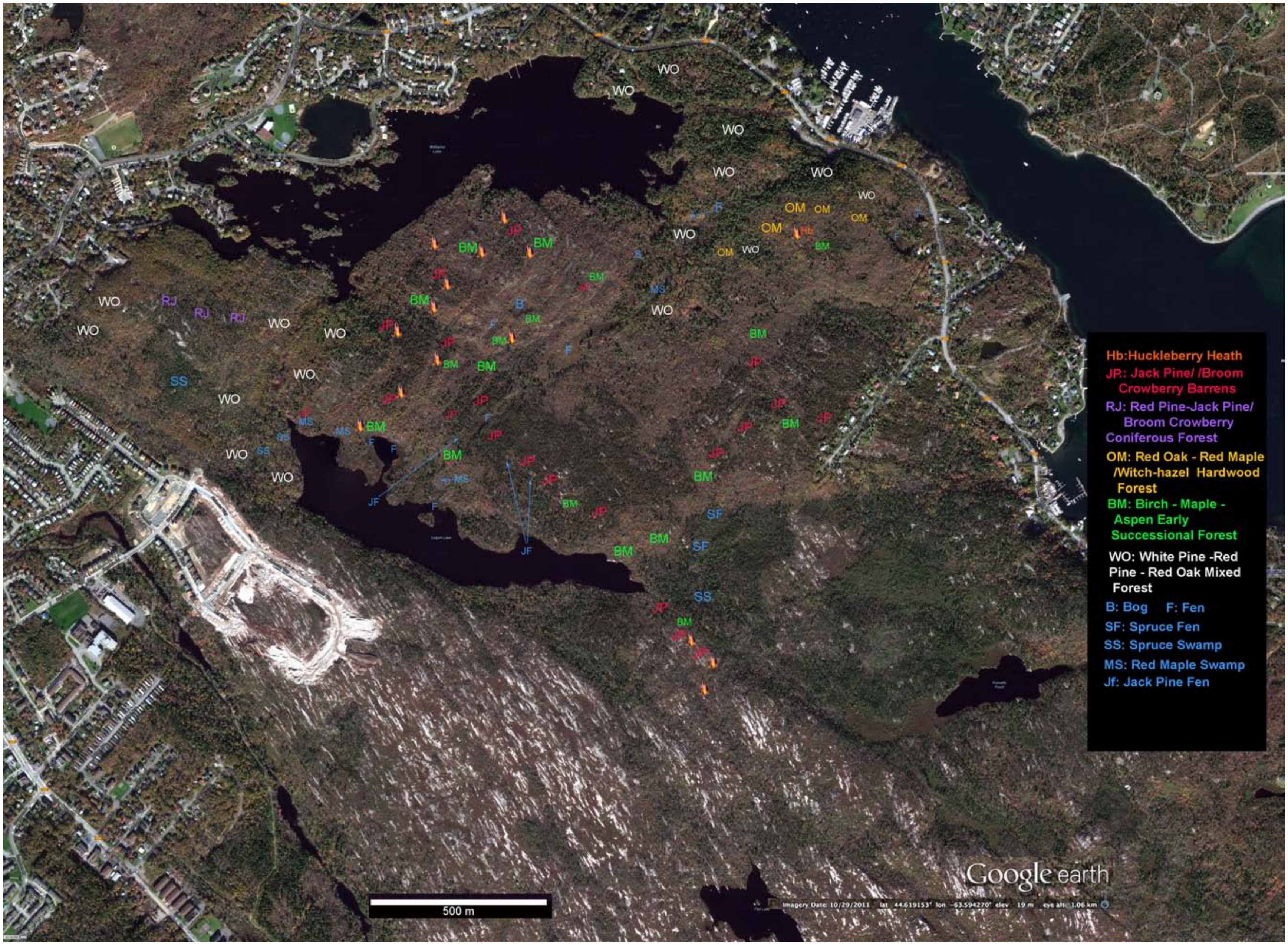

Fig. 3.4. Ground-truthed Wetlands & Upland Plant Communities (larger units).

4. Plant Species

Vascular plant species sighted on our surveys are listed in Table 4.1A, together with their S Ranks**.** Three of the 112 species had S-Ranks lower than S4**:** Mountain Sandwort (S2), Golden Heather (S2) and Lesser Brown Sedge (S2/S3); all were found on the recently burnt barrens. Tom Neily accompanied us on Sep. 14 to look at mosses with a focus on wetlands (Table 2B). All were fairly typical species with S4-S5 rankings. We did not attempt to document lichens. The lichen flora is likely very similar to that documented for the Purcell's Cove Conservation Lands by Francis Anderson (cited in HFN, 2012). "Reindeer Lichen" cited Section 5 refers to species of *Cladina* (e.g., *C. rangifera, C. stellaris*).

Table 4.1 Vascular Plant and Bryophytes/Liverworts sighted in the WLB May 13 to Nov 8, 2013. S-Ranks refer to the conservation status of the species in Nova Scotia. S5=Secure, S4=Apparently Secure S3=Vulnerable S2=Imperiled (S1=Critically Imperiled). See NatureServe Explorer (http://www.natureserve.org/explorer/ranking.htm) for more detailed explanation of the S-Ranks.

A. Vascular Plants

Species	Common Name	Growth Habit	S Rank
Abies balsamea	Balsam-Fir	Tree-conif	S5
Acer pensylvanicum	Striped Maple	Tree-decid	S5
Acer rubrum	Red Maple	Tree-decid	S5
Alnus incana	Speckled Alder	Shrub	S5
Alnus viridis	green alder	Shrub	S5
Amelanchier laevis	Shadbush / Indian Pear/ Serviceberry	Tree-decid	S5
Aralia hispida	Bristly Sarsaparilla	Forb/Herb	S5
Aralia nudicaulis	Wild Sarsaparilla	Forb/Herb	S5
Berberis thunbergii	Japanese barberry	Shrub	Exotic
Betula alleghaniensis	Yellow Birch	Tree-decid	S5
Betula papyrifera	White or Paper Birch	Tree-decid	S5
Betula populifolia	Paper Birch	Tree-decid	S5
Brachyelytrum erectum	Bearded Shorthusk	Graminoid	SNA
Calamagrostis canadensis	Bluejoint Reed Grass	Graminoid	S5
Calamagrostis pickeringii	Pickering's Reed Grass	Graminoid	S4/S5
Carex adusta	Lesser Brown Sedge, Crowded Sedge, Burnt Sedge, Carex brûlé	Graminoid	S2/S3
Carex communis	Fibrous-Root Sedge	Graminoid	S5
Carex debilis	White-edged Sedge	Graminoid	S5
Carex echinata	Star Sedge	Graminoid	S5
Carex folliculata	Northern Long Sedge	Graminoid	S5

Carex magellanica	Boreal Bog Sedge	Graminoid	S5
Carex scoparia	Broom Sedge	Graminoid	S5
Carex stricta	Tussock Sedge	Graminoid	S5
Carex trisperma	Three-seeded Sedge	Graminoid	S5
Carex umbellata	Umbellate Sedge	Graminoid	S4
Chamaedaphne calyculata	Leatherleaf	Shrub	S5
Coptis trifolia	Gold-thread	Forb/Herb	S5
Corema conradii	Broom-crowberry	Sub-shrub	S4
Cornus canadensis	Bunchberry	Forb/Herb	S5
Danthonia compressa	Flattened oatgrass	Graminoid	S5
Dennstaedtia punctilobula	Hayscented Fern	Fern/LVP	S5
Dicanthelium depauperatum	Starved Panicgrass	Graminoid	S4/S5
Dichanthelium acuminatum	Woolly Panic Grass	Graminoid	
Drosera rotundifolia	Round-leaved Sundew	Forb/Herb	S5
Dryopteris intermedia	Evergreen Wood Fern	Fern/LVP	S5
Dulichium arundinaceum	Threeway Sedge	Graminoid	S5
Epigaea repens	Mayflower	Forb/Herb	S5
Equisetum arvense	Horsetail	Fern/LVP	
Eriophorum virginicum	Tawny Cottongrass	Graminoid	S5
Eurybia radula	Low Rough Aster	Forb/Herb	
Fagus grandifolia	American beech	Tree	S5
Gaultheria hispidula	Creeping Snowberry	Forb/Herb	S5
Gaultheria procumbens	Wintergreen, Teaberry	Forb/Herb	S5
Gaylusaccia baccata	Huckleberry, Black Huckleberry	Shrub	S5
Glyceria canadensis	Canada Manna Grass	Graminoid	S5
Glyceria obtusa	Atlantic Manna Grass	Graminoid	S4
Hamamelis virginiana	Witch-hazel	Shrub	S5
Hudsonia ericoides	Golden Heather	Sub-shrub	*S2*
Ilex glabra	Inkberry	Shrub	S5
Ilex verticillata	Canada Holly	Shrub	S5
Iris versicolor	Harlequin Blue Flag	Forb/Herb	S5
Juncus canadensis	Canada Rush	Graminoid	S5
Juncus pelocarpus	Brown-Fruited Rush	Graminoid	S5

Juniperus communis	Common Juniper	Shrub	S5
Kalmia angustifolia	Sheep Laurel, Lambkill	Shrub	S5
Kalmia polifolia	Bog Laurel	Sub-shrub	*S5*
Larix laricina	Eastern Larch, Tamarack	Tree-conif	S5
Lechea intermedia	Large-pod Pinweed	Forb/Herb	S4
Lonicera canadensis	American fly honeysuckle	Shrub	S5
Luzula luzuloides	Forest Woodrush	Graminoid	S5
Lycopodium obscurum	Tree Clubmoss	Fern/LVP	S4/S5
Maianthemum canadense	Wild Lily of the Valley	Forb/Herb	S5
Melampyrum lineare	Cow-wheat	Forb/Herb	S5
Michella repens	Partridgeberry / Twinberry	Forb/Herb	S5
Minuartia groenlandica	Mountain Sandwort	Forb/Herb	S2
Monotropa uniflora	Indian Pipe	Forb/Herb	S5
Myrica gale	Sweet Gale	Shrub	S5
Myrica pensylvanica	Bayberry	Shrub	S5
Nemopanthus mucronata	Mountain Holly	Shrub	S5
Oclemena acuminata	Whorled Wood Aster	Forb/Herb	S5
Oclemena nemoralis	Bog Aster	Forb/Herb	S5
Osmunda cinnamomea	Cinnamon Fern	Fern/LVP	S5
Osmunda regalis	Royal Fern	Fern/LVP	S5
Photinia melanocarpa	Black chokeberry	Shrub	S5
Picea mariana	Black Spruce	Tree	S5
Picea rubens	Red Spruce	Tree	S5
Pinus banksiana	Jack Pine	Tree	S5
Pinus resinosa	Red Pine	Tree	S5
Pinus strobus	White Pine	Tree	S5
Polygonum cuspidatum	Japanese knotweed	Shrub	Exotic
Polypodium virginianum	Rock Polypody	Fern/LVP	S5
Populus grandidentata	Big-toothed Aspen	Tree	S5
Populus tremuloides	Trembling Aspen	Tree	S5
Prenanthes trifoliolata	Three-leaved Rattlesnakeroot	Forb/Herb	S5
Prunus pensylvanica	Pin Cherry	Shrub	S5
Pteridium aquilinum	Bracken Fern	Fern/LVP	S5
Quercus rubra	Red Oak	Tree	S5
Rhododendron	Labrador Tea	Shrub	S5

groenlandicum			
Rhodora canadense	Rhodora	Shrub	S5
Rhyncospora alba	White Beakrush	Graminoid	S5
Rosa nitida	Shining Rose	Shrub	S4
Rosa virginiana	Virginia Rose	Shrub	S5
Rubus hispidus	Dewberry	Sub-shrub	S5
Salix bebbiana	Bebb's Willow	Shrub	S5
Sarracenia purpurea	Pitcher Plant	Forb/Herb	S5
Scirpus cyperinus	Common Woolly Bulrush	Forb/Herb	S5
Solidago canadensis	Canada Goldenrod	Forb/Herb	S5
Solidago puberula	Downy Goldenrod	Forb/Herb	S5
Solidago rugosa	Rough-stemmed Goldenrod	Forb/Herb	S5
Sorbus americana	American Mountain Ash	Tree	S5
Thelypteris simulata	Bog Fern	Fern/LVP	S4/S5
Toxicodendron radicans	Poison ivy	Vine	S4
Trientalis borealis	Starflower	Forb/Herb	S5
Tsuga canadensis	Hemlock	Tree-conif	S5
Utricularia vulgaris	Common Bladderwort	Forb/Herb	S5
Vaccinium angustifolium	Early Low Blueberry	Shrub	S5
Vaccinium macrocarpon	Large Cranberry	Sub-shrub	S5
Vaccinium myrtilloides	Velvet-leaf Blueberry	Shrub	S5
Vaccinium oxycoccus	Small Cranberry	Sub-shrub	S5
Vaccinium vitis-idaea	Mountain Cranberry	Sub-shrub	S5
Viburnum lantanoides	Hobblebush	Shrub	S5
Viburnum nudum	Northern Wild Raisin, Witherod	Shrub	S5

B. Mosses and Liverworts

Identified by Tom Neily

Species	Common Name	S-Rank
Andreaea rupestris	Black Rock Moss	S5
Bazzania trilobata	Three-lobed Whipwort	S?
Dicranum flagellare	Whip Broom Moss	S5
Dicranum montanum	Mountain Broom Moss	S5
Dicranum polysetum	Wavy-leaved Broom Moss	S5
Dicranum scoparium	Common Broom Moss	S5
Dicranum viride	Green Broom Moss	S5
Diphyscium foliosum	a Moss	S4S5

Diplophyllum albicans	White Earwort	S?
Gymnocolea inflata	Inflated Notchwort	S?
Hypnum imponens	Pellucid Plait Moss	S5
Lepidozia reptans	Creeping Fingerwort	S?
Leucobryum glaucum	White Pincushion Moss	S5
Mnium hornum	Swan's-neck Leafy Moss	S4S5
Odontoschisma denudatum	Matchstick Flapwort	S?
Plagiothecium laetum	Bright Silk Moss	S5
Pleurozium schreberi	Red-stemmed Feather Moss	S5
Polytrichum commune	Common Haircap Moss	S5
Polytrichum juniperinum	Juniper Haircap Moss	S5
Polytrichum piliferum	Bristly Haircap Moss	S5
Sphagnum austinii	Austin's Peat Moss	SNR
Sphagnum fallax	Flat-top Peat Moss	S5
Sphagnum girgensohnii	Green Peat Moss	S5
Sphagnum palustre	Blunt-leaved Peat Moss	S5
Sphagnum papillosum	Papillose Peat Moss	S5
Sphagnum pylaesii	Simple Peatmoss	S4?
Sphagnum russowii	Russow's Peat Moss	S5

The vascular plant flora that we documented overlaps almost entirely with the 84 species of vascular plants flora documented for the Purcell's Cove Conservation Lands (PCCL), recognizing that wetland graminoids have not been documented for the PCCL. We could expect that another half dozen to a dozen vascular plant species could be added to the WLB list over time. The moss list would be expanded considerably with more detailed study.

The total number of vascular plant species documented for the WLB (112), given that it supports diverse habitats and plant communities, is not impressive but reflects a high stress environment associated with repeated fires, acidity/low nutrient status and limited soil development. Such environments, however, often harbour rarities that cannot compete in more nutrient-rich environments (Grime, 1977, 1979: Hill and Keddy, 1992) and this is true of the WLB, where we found Mountain Sandwort (S2), Golden Heather (S2) and Lesser Brown Sedge (S2/S3). All three occur in barrens communities (A1) and in small exposed barren type areas within community types A2, A3 and A4. In our study we observed Mountain Sandwort and Golden Heather only in recently burnt barrens. Mountain Sandwort (S2) and Golden Heather (S2) are commonly reported for barrens elsewhere in Nova Scotia, Lesser Brown Sedge less so but that could reflect in part, identification limitations. These species are essentially absent from other community types in Nova Scotia except sandy pine barrens.

Broom Crowberry, a signature species for three of the community types is likewise found on both rock barrens and sand barrens. This Atlantic Coastal Plain species has S4 status in Nova Scotia, but is precarious outside of Nova Scotia and is losing ground within Nova Scotia. It was either never present or is extirpated in New Brunswick, imperiled (S2) in the Magdallen Islands of Quebec and in P.E.I. has S3S4 status in Maine and S1 (at risk) to S3 (sensitive) status for other U.S. states where it occurs (Massachusetts, New Jersey, New York). However, threats to Broom Crowberry habitats cited by the Center for Plant Conservation in the U.S. apply also to Nova Scotian habitats. These include shoreline erosion, deer browsing, trampling, fire suppression, development and invasion by Scot's Pine (CPC n.d.; Catling and Carbyn, 2004). The Annapolis heathlands, dominated by Broom Crowberry, have been reduced to less than 3% of their pre-colonial area of approximately 200 km^2 (Carbyn et al., 2006).

The two exotic species (Japanese Knotweed and Japanese Barberry) were found only close to Purcell's Cove Road. The absence of exotic species otherwise attests to high ecological integrity of the WLB, i.e. they are not overly impacted by human disturbance (LaPaix et al., 2009).

5. Upland Plant Communities

The upland plant communities of the WLB are classified into seven Vegetation Types (VTs, or BVTs for Backland Vegetation Types), described below. Species are cited by their common names. (See Appendix B for the Latin names.) The classification is our own but for the forest types, we identify analogues or near analogues to Nova Scotia Forest Vegetation Types (NSFVTs) elaborated by Neily et al. (2011) for stands of at least 40 years old. The names cite the most common vegetation, with a dash (-) between species of the same strata or growth habit, and a slash separating species of differing strata or growth habits, plus a higher level descriptor, e.g., forest or barren. They are ordered (1, 2 ,3…) from droughty to more consistently moist conditions. The species cited under each BVT are the more common ones.

The plant species of these upland communities are xerophytic (tolerating frequent or extended drought) to mesophytic (living in moderately moist soils and tolerating only occasional shortages of water) the former prominent in this landscape only in the barrens habitats.

UPLAND PLANT VEGETATION TYPES OF THE WILLIAMS LAKE BACKLANDS

1. Broom Crowberry-Blueberry/Lichen Barrens

The term "barren" is defined in the Collins Dictionary of Botany (Bailey, 2006) as:

> A COMMUNITY of relatively sparsely distributed plants that cover less than half the ground area. Such communities are typical of some fairly level parts of the Arctic tundra, often on sandy and serpentine soils. Barrens often have few trees and are dominated by a single species such as mountain avens (*Dryas octopetala*). The plants are often small and stunted compared to individuals of the same species from less infertile habitats, and they often contain groups of specialized endemic species.

Broom Crowberry (*Corema conradii),* a dwarf evergreen, needled, ericaceous shrub is the signature species of this community which occurs on rock outcrops, the woody species growing in thin soils and around crevices, and lichens extending onto bare rock. It is important to distinguish this species from Black Crowberry (*Empetrum nigrum*), and Red Crowberry (*Empetrum rubrum*) which also occur in Nova Scotia but not in the WLB. Other species include the perennials Lowbush Blueberry, Pinweed, Carex brûlé (or Crowded Sedge), Golden Heather, Teaberry, Three-toothed Cinquefoil and the annuals Mountain Sandwort, two panic grasses and the Hidden Sedge. Reindeer and rock tripe lichens and mosses, without vascular plants, often cover the most exposed rock. Reindeer lichens also occur mixed with Broom Crowberry. Huckleberry typically occurs towards the edges where there is more soil and moisture retention, with Broom Crowberry extending into its inner fringes.

This VT corresponds roughly to Coastal Barrens Dwarf Heath of Porter (2013) and the Low-shrub Coastal Communities of Cameron and Soren Bondrup-Nielsen (2013) with the notable distinction that Black Crowberry is entirely absent from the WLB, and probably from all of the Purcell's Cove Backlands (Halifax Field Naturalists, 2012; Beazley and Patriquin, 2010) because of the extreme droughtiness of these barrens. Where these two species occur in close juxtaposition on a micro-scale in the Polly's Cove area, Broom Crowberry occurs in the drier, well drained area of a rock face, while Black Crowberry may sit in a slight depression in the same rock face (Nova Scotia Wild Flora Society: *Corema conradii*, n.d.). On inland barrens in southwest Nova Scotia, the *Corema conradii* community is "confined to the tops of knolls and ridges, all boulder-strewn and excessively well drained" (Strang, 1972).

2. Huckleberry Heath

"Heath" refers to land with poor, well drained soil dominated by shrubs of the heath family (Ericaceae). In the WLB, heath dominated by Huckleberry occurs where soil depth and moisture retention rise above levels in the Broom Crowberry-Blueberry/Lichen VT, but are not sufficient for trees and/or tree growth is restricted by repeated fire. Typically this community borders the Broom Crowberry-Blueberry/Lichen Barrens and extends over a few to tens of meters or occurs in large patches on fairly level but high ground in the midst of otherwise forested landscape. Common associated species include Lowbush Blueberry, Lambkill, Teaberry, and on deeper soils, Bayberry and Wild Raisin. In patches where drainage is impeded, Huckleberry is replaced by Rhodora and/or Leatherleaf. This Vegetation Type corresponds roughly to the High Shrub Coastal Heathland of Cameron and Soren Bondrup-Nielsen (2013).

3. Jack Pine/Broom Crowberry Barrens

In this VT, Jack Pine occurs (i) as single or a few gnarled trees growing in cracks on rock barrens, (ii) in smallish (10-50 m across) treed patches with Jack Pine alone or dominated by Jack Pine and (iii) in more contiguous, larger patches interrupted by rock barrens or wetlands. Tree canopy cover ranges from less than 10% percent to about 60%. Big-toothed Aspen is the most common other tree in most mixed stands, followed by Red Maple, Wire & Paper Birch, Red & Black spruce. (Additionally, Jack Pines occur singly and in clusters in the Red Pine/Jack Pine/Broom Crowberry VT, and isolated Jack Pines occur in the Birch/Maple/Aspen VT, usually adjacent to their occurrence on Jack Pine/Broom Crowberry Barrens.) Broom Crowberry and Huckleberry are the most common associated shrubs, the Broom Crowberry occurring in edge areas on shallower soils, often with Reindeer Lichen, while Huckleberry occurs on deeper soils, growing tallest (to circa 1.5 m) where there is more exposure to the sun. Sheep Laurel may also occur, and in wet pockets, Huckleberry is replaced by one or more of Leatherleaf, Rhodora, Inkberry.

The composition and site conditions for this VT are very similar to those for NSFVT OW1 (Jack Pine/Huckleberry/Black crowberry/Reindeer lichen), except that the latter cites Black Crowberry as characteristic, and Broom Crowberry occurring only occasionally. As well, the more fire-sensitive species listed under OW1 such as Hemlock and *Bazzania trilobata* (a liverwort) are not found in Jack Pine/Broom Crowberry Barrens in the WLB. Under the Canadian National Vegetation Classification system, many details of which are not yet publicly available, it corresponds to Subassociation A301b *Corema conradii*, in the Association A301 Jack Pine/Black Huckleberry – Black Crowberry/Three-toothed cinquefoil/reindeer Lichen

Woodland (S.Basquill, Nova Scotia Dept. Natural Resources, personal communication).

4. Red Pine-Jack Pine/Broom Crowberry Coniferous Woodland
This VT occurs on higher and sloping land with rock outcrops to the south of Williams Lake towards its western end. Red Pine, Jack Pine, Black Spruce, Big-toothed Aspen and Red Maple are the prevalent trees, with some Paper and Wire Birch, Tamarack, Red Oak and Mountain Ash forming a largely open canopy forest. In a few smallish areas, Jack Pine is the sole tree species.

Broom Crowberry forms a fringe around trees extending into the rock outcrops, displaced by Huckleberry where there is more soil. Other species include Wild Raisin, Bayberry, Lambkill, Ground Juniper, Lowbush Blueberry, Teaberry, Trailing Arbutus, goldenrods and in wet areas, Mountain Holly and Wooly Sedge. There are some large mats of reindeer lichen in quasi-shaded as well as exposed areas. The larger rock outcrops have smooth surfaces and are mildly sloping; they appear to be popular with mountain bikers, whose activities have largely bared the surfaces.

Many of the Red Pines were entirely dead, with more living or partially living specimens towards the east; the dead plants had been heavily bored. It seems this infestation has not yet affected red pines on land bordering the east and south east sides on Williams Lake.

This vegetation type approximates FECNS VT OW4 (Red pine-White pine/Broom crowberry/Grey reindeer lichen) with the notable difference that deciduous species are more abundant than described for OW4.

5. Paper Birch–Red Maple–Big-toothed Aspen Early Successional Forest
This early successional shade-intolerant hardwood forest occurs in patches and large sweeps throughout the area. It occupies most of the valleys in the set of NW/SE oriented glacially scoured ridges and valleys by Williams Lake. Paper and Wire Birches, Red Maple, Red Oak occur mostly as stump sprouts (in clumps). Some areas have prolific Big-toothed aspen which spouts from its extensive roots. There are scattered pines and spruces (Red and/or Black Spruce), few Balsam Firs. Lambkill and Huckleberry cover much of the ground between trees. Bracken Fern and Teaberry are common. This VT corresponds closely to NSFVT IH6 (Paper Birch – Red maple/Sarsaparilla – bracken).

6. Red Oak–Red Maple/Witch-hazel Hardwood Forest
This VT occurs in higher/better drained patches within the White Pine - Red Pine - Red Oak Mixed Forest VT, most significantly around and on the summit of the drumlin southeast of Williams Lake. Witch-hazel and some Shadbush form a subcanopy at 3-5 m height below Red Oak and Red Maple, Paper Birch, occasional White Pines and Spruce (Red and/or Black). Balsam Fir occurs in the shrub layer only. Lambkill and Huckleberry are common shrubs. Bracken Fern is common. This VT corresponds closely to the NSFVT IH2 of the same name (Red oak – Red maple/Witch-hazel).

7. White Pine-Red Pine-Red Oak Mixed Forest
Mixed, mid succession forest occurs around the eastern end of Williams Lake up to Purcell's Cove Road and extends as a finger-like projection along the major water course to the southeast of Williams Lake; also along the watercourse from Colpitt Lake to Williams Lake, and at the northwest end of Colpitt Lake. White Pine and Red Oak are the most consistently present large trees, with Red Maple, Red Pine, Black Spruce, Red Spruce, Paper Birch, Wire Birch commonly present. Balsam Fir occurs mostly in understory. Yellow Birch is common and clustered in certain areas, notably along the outflow streams from Colpitt and Williams Lakes.

Hemlock occurs at the northwest end of Williams Lake, but not elsewhere in our study area, likely reflecting the limit of the 1966 fire as Hemlock is very slow to recover after fire. Overall trees are larger in that area as well (e.g., dbh of 40 cm for a red maple, 55 cm for a Hemlock), but none would rank as a "Big Tree".

Red Pine becomes more common progressing south from the dam on western Williams lake and then west along lake on higher well drained land. Distinct fire scars were observed on most of the larger (60-95 cm dbh, (diameter at breast height) White and Red pines in that same sweep. Common large shrubs/small trees include Shadbush, Witch Hazel, Hobblebush (mostly along the outflow streams from Colpitt and Williams lakes), Striped Maple, Mountain Holly, Canada Holly, Wild Raisin. Low shrubs include Huckleberry, Lowbush Blueberry, Sweetfern (occasional), Teaberry, Trailing Arbutus, Creeping Snowberry. Common herbaceous species include Bunchberry, Sarsaparilla, Partridge Berry, Indian Pipe, Goldthread, Wild Lily of the Valley, asters and goldenrods, Balsam Fir (mostly as small understory trees). Bracken Fern is common on drier ground, Cinnamon Fern on wetter ground.

There are the elements of older forest structure in the forest by Williams Lake that was mostly burnt over in 1966, including snags, fallen dead in various stages of decomposition and multiage age tree populations.

This VT shares characteristics of NSFVTs SP3 (Red Pine-White pine/Bracken-Mayflower) and SP4 (White pine/Blueberry/Bracken).

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".

6. Role of Fire in Structuring the Plant Communities

The fire dependent/fire adapted nature of the vegetation and evidence from cores in a Jack Pine fen indicate that the fires in the WLB are part of a long-term fire regime that likely predates European settlement. Indeed, the whole of the Purcell's Cove Backlands is probably one of the most fire susceptible landscapes in Nova Scotia. One result is the presence of fire-dependent Jack Pine/Broom Crowberry Barrens which are of conservation significance. The "fire story" has important implications in part because there is a common perception that fires in the backlands only began with European settlement. In this section, we elaborate on these concepts and the evidence for them.

6.1 Fire in Nova Scotian forests

Estimation of the natural frequency of forest fires in Nova Scotia has proved controversial, in part because of its bearing on forest management practices. Clearcutting is said to emulate the effects of frequent stand-replacing disturbances, notably fires in the boreal forest. Thus there is interest in the extent to which fires (or extensive hurricane blowdown which is often followed by fires) have structured Nova Scotian forests - such forests would be considered naturally suitable for clearcutting or "even-aged management", as opposed to selective harvesting or "uneven-aged" or "multi-aged management" which is considered more akin to natural processes in the "Acadian Forest".

There is general agreement that the frequency of fires in Nova Scotia increased very significantly over natural levels after the arrival of the Europeans.* It remained high until the mid to latter 20th century, when effective fire control and a much lower incidence of deliberately set fires reduced the frequency to low levels and possibly even below the natural frequency in some areas (Wein and Moore, 1979). Estimates (or opinions) of fire frequency in the mixed forest and tolerant hardwoods in which wind-driven gap dynamics constitute the major disturbance vary from several centuries to over 1000 years (Loo and Ives, 2003; Mossler et al., 2003).

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*The extent to which native peoples in Nova Scotia made regular use of fire as a land management tool in Nova Scotia is not yet clear (Wein and Moore, 1979; Loo and Ives, 2003; Mossler et al., 2003; Ponomarenko, 2006).

It is the estimation of the proportion of our forests which were subject to large scale, stand-replacing disturbances (mostly fire) in pre-European times that is controversial. Personnel in the Nova Scotia Dept of Natural Resources have estimated the proportion as follows:

> Fifty-one percent of the forested area evolved from infrequent and/or gap natural disturbance regimes and developed uneven-aged softwood forests of red spruce, eastern hemlock, and white pine or uneven-aged hardwood forests of sugar maple, yellow birch, and beech. **Forty-three percent of the forested area developed from frequent natural disturbance regimes giving rise to predominantly even-aged forests of balsam fir, jack pine, red pine, black spruce, and red maple.** The remaining six percent of the land area has site and climatic conditions that produce treeless barrens, wetlands, and rocklands, and krummholz. (Neily et al., 2008, bolding ours).

Others contend that the majority of the 43% of forest considered to be developed from frequent natural disturbance regimes has been made more fire susceptible by the post-European fire regime and clearcutting which has caused forests to be younger, with finer fuels, more fire prone in structure, with more resinous (coniferous) species.

> The pre-settlement forests of northeastern North America probably consisted of forest types that were much less prone to fire (Mott 1975; Anderson 1980; Anderson et al. 1986; Green 1987;Warner et al. 1991). Fires in these types of forests were probably restricted largely to surface fires, causing much less canopy mortality. For instance, the shade-tolerant hardwood forests characteristic of much of the Maritimes are not prone to crown fire disturbance. The present forest with its high percentage of a single conifer species is far more prone to destructive crown fires… The degree to which a steady-state, climax forest dominated the pre-European settlement forest of the Maritimes and the role of large-scale or catastrophic disturbances in interrupting the development of such OG forests will continue to be a matter of controversy and debate. Nevertheless, it is evident that the forest-disturbance interrelationships we see today are probably the result of the transformation of long-lived, disease-resistant, windfirm, less fire-prone pre-European settlement climax forests to shorter-lived, disease-, wind-, and fire-prone early successional forests. (Mossler et al., 2003)

From this perspective, it is argued that we should manage those forests to favour more longer lived, shade tolerant species and forests that are more resilient, more biodiverse and better adapted to our climate and to climatic warming than forests maintained by clearcutting (Bancroft and Crossland, 2008; Mossler et al., 2003).

There is agreement, however, between disparate camps that Jack Pine communities in areas such as the WLB are naturally fire structured while recognizing that human intervention increased the frequency above natural frequencies (Neily et al., 2008; Anon 2005):

> "Throughout Nova Scotia Loucks (1962) noted the presence of fire origin species such as jack, red and white pine, red maple, wire and Paper Birch, and red oak in his forest districts. Although he acknowledges that the occurrence of fire and its frequency has probably increased since European settlement the conditions conducive to fire are a product of the topography, soils and climate and that these conditions exist mainly in the lowland ecodistricts and western ecoregion. Fernow (1912) states "approximately one-fourth of the present forest area of the Province is semi-barren of commercial trees. This condition has been brought about by repeated fires in situations possessing naturally the coarser soils. Johnson (1986) states that "although most settlers tried to be careful with fire, burning only at what they considered to be safe times, fires often got out of control and burnt extensive areas". In the Atlantic Coastal ecoregion fires have been common but they appear to have been started by settlers to extend their pasture land (Loucks 1962). However, **the presence of Jack Pine in several places on the Canso peninsula, and on Isle de Madame, suggests that the constant winds may create a droughtiness that is conducive to fire.**" (From Neily et al., 2008; bolding ours.)
>
> "In my view, there are only a handful of site types in Nova Scotia where geomorphology, soils, climate, etc., create the conditions that permit the frequent, stand-replacing disturbance of ecological processes and hence produce a non-climatic climax or non-subclimax (eg. edaphic climax) vegetation. Some examples are: **Jack Pine on Target Hill and a few other prominent granitic knobs in Halifax County**; the pines on the sand plains of Annapolis Valley; black spruce-Jack Pine on the sand plain near Oxford; and balsam fir-Paper Birch on exposed spur ends in the steep-sided canyons of northern Cape Breton Island." (From Anon, 2005; bolding ours.)

FIRE TERMINOLOGY

Selected terms from Stacey et al., 2012**. European Glossary for Wildfires and Forest Fires** http://www.fire.uni-freiburg.de/literature/EUFOFINET-Fire-Glossary.pdf

Fire dependent ecosystem
An ecosystem which requires periodic fires in order to maintain the character, diversity and vigour of its intrinsic plant and animal communities. A fire dependent ecosystem will often be composed of pyrophile species (species that are able to survive wildfires and/or to regenerate after wildfires through germination stimulated by fire, stumps sprouts or aerial re-growth (i.e. broadleaved trees).

Fire dependent species
Plant and animal species which require regular fires in order to trigger or facilitate regeneration mechanisms, or to regulate competition from other species. Without fires, these species would become extinct.

Fire resistant plant
A plant species which has morphological or seasonal growth characteristics that give it a high probability of surviving a wildfire. Heat-insulating bark, seasonal dormancy, and the ability to regenerate through stump sprouts or aerial re-growth (broadleaved) are specific examples of fire resistant characteristics. [Sometimes used interchangeably with **Fire tolerant**.]

Fire sensitive ecosystem
An ecosystem with a low resilience to fire. Fire sensitive ecosystems will struggle to recover from the passage of a wildfire.

Fire sensitive species
Species with a relatively high probability of being killed or scarred if a wildfire occurs. Specific examples include trees with thin bark or highly flammable foliage, or animal species that are unable to evade the heat of a wildfire.

Fire regime
The pattern of fire occurrence, fire frequency, fire seasons, fire size, fire intensity, and fire type that is characteristic of a particular geographical area and/or vegetation type.

Fire types There are three different schemes for classifying fire type:

1. Classification of a fire or section of fire according to the fuel level within which it occurs. For example, aerial, crown, understory, surface and ground fires.
2. Classification of a section of fire according to its position along the fire perimeter. For example, head, tail and flank fires.
3. Classification of a fire or section of fire according to the visual characteristics it displays. For example, smouldering, creeping, backing, running, torching, spotting, crowning, fire whirl, convection driven fire etc.

Aerial fuels
Any fuel found at a height of more than 3.5 metres above the ground surface.

Crown Fire/Crowning
When a fire burns freely in the upper foliage of trees and shrubs. There are three different types of crown fires:

- **Active Crown Fire** – A fire that advances as a wall of flame engulfing all surface and aerial fuels.
- **Independent Crown Fire** - A fire that advances through aerial fuels only.
- **Intermittent Crown Fire** - A surface= fire involving torching behaviour but without sustained crowning activity. Rate of spread is controlled by the surface fire.

Ground fire
A fire burning below the surface fuel layer.

Surface fire
A fire that burns within the surface fuel layer.

Understory fire
A fire that burns beneath a canopy of trees. It can occur during the course of a wildfire or may be a tactic for a prescribed burn.

Prescribed burn A planned and supervised burn carried out under specified environmental conditions to remove fuel from a predetermined area of land and at the time, intensity and rate of spread required to meet land management objectives.

6.2 Recent fires in The Backlands

Fires since the early 1900s have included those listed below, likely amongst others.

2012: Approximately 15 ha on high barrens and associated forest/woodland on the south side of Williams Lake (see fire icons in Fig. 3.4) burned on May 21, 2012 before being doused by fire fighters. It was a stand-replacing fire in which aboveground portions of all trees and shrubs were killed. Our observations in 2013 indicate the hardwoods (birch, red maple, oak) promptly stump-sprouted, bushes such as Huckleberry and Rhodora grew up from underground rhizomes, while Jack Pines and Black Spruce and Broom Crowberry are regenerating from seed.

2009: The 2009 Spryfield fire burned an area reported to be approximately 800 ha in the Purcell's Cove Backlands. The northwestern extremity reached Jack Pine barrens just southeast of Colpitt Lake (Fig. 3.4), as revealed in a survey of that area on Nov. 6, 2013.

2006/2007: During a survey on Sept 12, 2013, we noted charcoaled debris on the ground and partially burnt white pines in an open area on top of the drumlin just to the east of Williams Lake. For the location, see Fig. 3.4. Inspection of historical imagery in Google Earth suggest the fire occurred between June of 2006 and July of 2000, most likely in the spring of 2007 which is a peak time for fires in Nova Scotia. The limited burn of the sparsely distributed trees suggest this was essentially a surface fire, and the Google imagery suggest it was limited to about 5 ha (Fig. 6.1).

1964: Residents in the Williams Lake area cite 1964 as the year of a fire in the backlands that extended into the forest on the eastern side of Williams Lake, sparing only the large red and white pines that today bear prominent fire scars at their bases.

Circa 1959: A local resident David P. met in 2009 while monitoring recovery of vegetation in the vicinity of Lower Mud Pond after the 2009 Spryfield fire told him that the last big fire in the Lower Mud Pond Area occurred 45 years prior to the 2009 fire, i.e. in 1959. (He recalled the fire from his childhood.)

1917: At a talk David P. gave to the Halifax Field Naturalists in 2010 about regeneration of forest and barrens after the Spryfield Fire of April 30, 2009, the late Jill Alexander, daughter of Captain Arnell, said the last big fire on the Captain Arnell property was in 1917. (The Capt Arnell property is one of two adjacent properties contributed to the Nova Scotia Nature Trust to form The Purcell's Cove Conservation Lands.)

Residents in the Williams Lake area commented that they report sightings of smoke in the backlands to fire department officials at least once a year. Often they are campfires that don't escape, sometimes they have required fire fighters to put them out.

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.

6.3 Modeling the fire risk

Ellen Whitman and colleagues applied a spatially oriented fire modeling approach to examine "Future Wildfire Risk in the HRM Wildland-Urban Interface Under Climate Change" and "Urban Forests And Hazard Management: Trade-Offs Between Wildfire Risk And Benefits From Trees In The HRM Wildland-Urban Interface" (Whitman et al., 2013). Spryfield and Beaver Bank were used as case study areas. They concluded:

> At present, WUI [Wildland-Urban Interface] wildfire risk is high, and modeling suggests that the severity of climate conditions for wildfire will increase in the future. This increase in fire weather will be offset by a shift from high-fire risk species in the AFR [Acadian Forest Region] to a deciduous, lower-fire risk community. This shift will be gradual, and may include intermediate periods of elevated wildfire risk in the mid-term. In the short-term the reduction of wildfire risk through fuel treatments should be the priority for management, but as wildfire hazard decreases with the changing forest community, priorities should shift towards the promotion of urban forests. To mitigate the removal of trees through fuel treatments, managers can plant low-wildfire risk tree species that are also adaptable to future climate change, under the recommendations of both *FireSmart* and the UFMP [Urban Forest Management Plan]. When given a spatial and temporal context the management trade-offs are easily navigated.

Whitman and colleagues did not discuss the possibility of zoning for no-build areas in the most fire-prone landscapes such as the WLB. The spatial modeling, detailed in a thesis by Ellen Whitman (Whitman, 2013), included the entire Williams Lake watershed, and utilized Fuel Codes of the Canadian Forest Fire Behaviour Prediction System, which is specific for different vegetation types including vegetation type similar to those in the WLB. We wrote Ellen Whitman to clarify some aspects of the modeling.

> David P. :
> I have been working with a colleague in the Williams Lake area to document possible conservation values. A highlight for us are the Jack Pine Barrens, which occur atop of ridges and scattered smaller outcroppings. They include a suite of fire dependent species including some rarities which can be described collectively as fire adapted and fire-dependent, and suggest a long history of fires probably dating well into pre-European times. We have some evidence for that from cores taken in a fen, but that needs follow up.
>
> There is rapid drainage of the Jack Pine Barrens and the lichens & litter and ground vegetation such as Broom Crowberry dry quickly providing good kindling. Thus we view the Jack Pine Barrens as "matchsticks" that increase the likelihood of fires over the larger area whether started by natural causes or humans. (A small fire occurred on the Jack Pine barrens by Williams Lake in spring 2012.)
>
> Would you concur with this view?
>
> Ellen W. :
> Your logic seems sound to me. The modeling I did assumed random ignitions all over the Spryfield study area, meaning that fires were dependent only on weather and fuels/landscape. Despite that randomness, large fires generally occurred much more often around the barrens, with some escaping downslope towards Purcell's Cove Rd., as has happened in the past two fires in that area. The Jack Pine and the dry brush are definitely a strong driver of fire in that area… I didn't try to focus on the Jack Pine barrens as a source of fires, the way you seem to be suggesting. I do, however think your 'matchsticks' idea is valid.

6.4 Vegetation-fire dynamics

The Williams Lake Backland landscape resembles a series of waves of windblown rock ridges that stretch in a northwest to southeast direction. The ridge tops are colonized by low bushy vegetation and some widely spaced, open canopy trees, while between the ridges, closed canopy forests develop on glacial till that is rich in cobble to boulder-sized material (Fig. 6.2) The plant communities that are adapted to such infertile, droughty conditions are highly flammable. The history of fire has led to a predominance of fire-adapted plant communities in the Backlands that differentiate it from plant communities bordering north side of Williams Lake. The upland plant communities in the WLB are dominated either by fire-dependent (notably Jack Pine and Broom Crowberry) or fire-adapted species (e.g.,White and Wire Birches, Big-toothed Aspen, Huckleberry). Non-adapted species (Hemlocks, Hobblebush, Yellow Birch, Sugar Maples and wildflowers such as Common Lady Slipper, Trillium, Cucumber Root) have long ago been selected against by fire, except by the wet corridor along the outflow stream from at the eastern end of Williams Lake and closer to houses where there is a higher degree of fire protection.

The most flammable vegetation is found on hard rock outcrops where glaciation has removed the till from the outcrops and left only occasional erratics. Between ridges, there is an accumulation of infertile till made less fertile by the predominance of cobble and boulders; these create fast surface drainage conditions selecting again for drought-tolerant vegetation. The infertility, acid conditions and droughtiness in the uplands, selects a stress-tolerant vegetation comprised for the most part of slow-growing woody plants. Extreme droughtiness leads to evergreen plants with inrolled leaves (the Broom Crowberry, Golden Heather and Jack Pine) as well as flammable reindeer lichens, and volatile oils and resins (in Huckleberry and Jack Pine) (Fig. 6.2). There is a smaller fuel load on the most exposed ridges but these areas dry out within hours in the sun and their fine tinder makes them the matchsticks that can spread fire through Jack Pine to paper birch stands and down to large White and Red pines closer to the lake.

Viewed in this context, the upland plant communities can be grouped in three classes going from those with species that are fire dependent, to a mix of fire-dependent and fire adapted species, and finally to the lakeside forest that lacks species that are highly sensitive to fires, with the more sensitive species found along stream corridors and in better protected areas near houses and roads.

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.

1. The Fire Dependent Outcrop Community

The Broom Crowberry-Blueberry/Lichen Barrens VT on the exposed outcrops is a fire-dependent community. It includes a guild of fire-dependent species, the signature species being the **Broom-Crowberry** (*Broom Crowberry conradii*), a dwarf evergreen, needled shrub. This is a globally uncommon (G4) species restricted to disjunct patches of fire-shaped landscape from the New Jersey Pine Barrens to Nova Scotia. It regenerates best after fire* and its occurrence in a landscape belies a history of fire (Martine et al., 2005). **Golden Heather** (*Hudsonia ericoides*) and **Pinweed** (*Lechea intermedia*) occur with the Broom-Crowberry and are members of the fire-adapted Rockrose Family (Cistaceae). This family is well-known for having seeds with a physical dormancy overcome by exposure to fire (Baskin and Baskin, 1998) and although there is no information on such a dependency in our Cistaceae in the Barrens, their seedlings were first to germinate after the Spryfield fires of 2009 (Beazley and Patriquin, 2010). Lastly, **Carex brûlé** (or Crowded Sedge, *Carex adusta*), the vernacular name accepted by Flora North America, is also known as the Burnt Sedge (Arsenault et al., 2013). This sedge requires disturbance such as fire that exposes mineral soil for it to establish and persist (Arsenault et al., 2013, Voss and Reznicek, 2012).

A guild of seed-banking annuals (Matlack and Good, 1990) to short-lived perennials take advantage of the fire disturbances. These species are not, in contrast with the above, necessarily fire-dependent though their recruitment at Williams Lake Backlands is restricted to these fire bald areas. These include the rare **Mountain Sandwort** (*Minuartia groenlandica*—S2), two Panic grasses (*Panicum depauperatum* & *Panicum acuminatum*), and a sedge (*Carex umbellata*).

Fire adapted Huckleberry occurs towards the edges of the Broom Crowberry-Blueberry/Lichen Barrens VT where there is more soil and moisture retention (the Huckleberry Heath VT) and continues as a carpet into the adjacent treed communities. Huckleberry *Gaylusaccia baccata*) with its with resinous leaves is not strictly dependent on fire, has been shown to become increasingly dominant after multiple fire in southwest Nova Scotia (Strang, 1972) because its rhizomes allow it to survive the most intense fires. It was one of the first shrubs to re-green the burned backlands landscape after the 2009 fire (Beazley and Patriquin, 2010).

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*Broom Crowberry vegetation is completely destroyed by most fires, but the plant survives by accumulating seeds in a below-ground seedbank. Seedlings are rare except after fires which stimulate germination by an as yet unknown mechanism but which may involve smoke rather than heat (Martine et al., 2005). Another oddity of this species involves seed dispersal. Broom Crowberry makes use of ants to move its seeds away from the parent bush. It equips each of its seeds with a fat-rich packet called an elaisome. The ants carry the seeds into their underground nests where they feed the fatty tissue to their larvae. The seeds are discarded but remain in storage around the nests until they germinate after a fire. Recent research has shown that without the ants, the population growth and survival of Broom Crowberry would be limited by lack of dispersal (Hilley and Thiet, 2013).

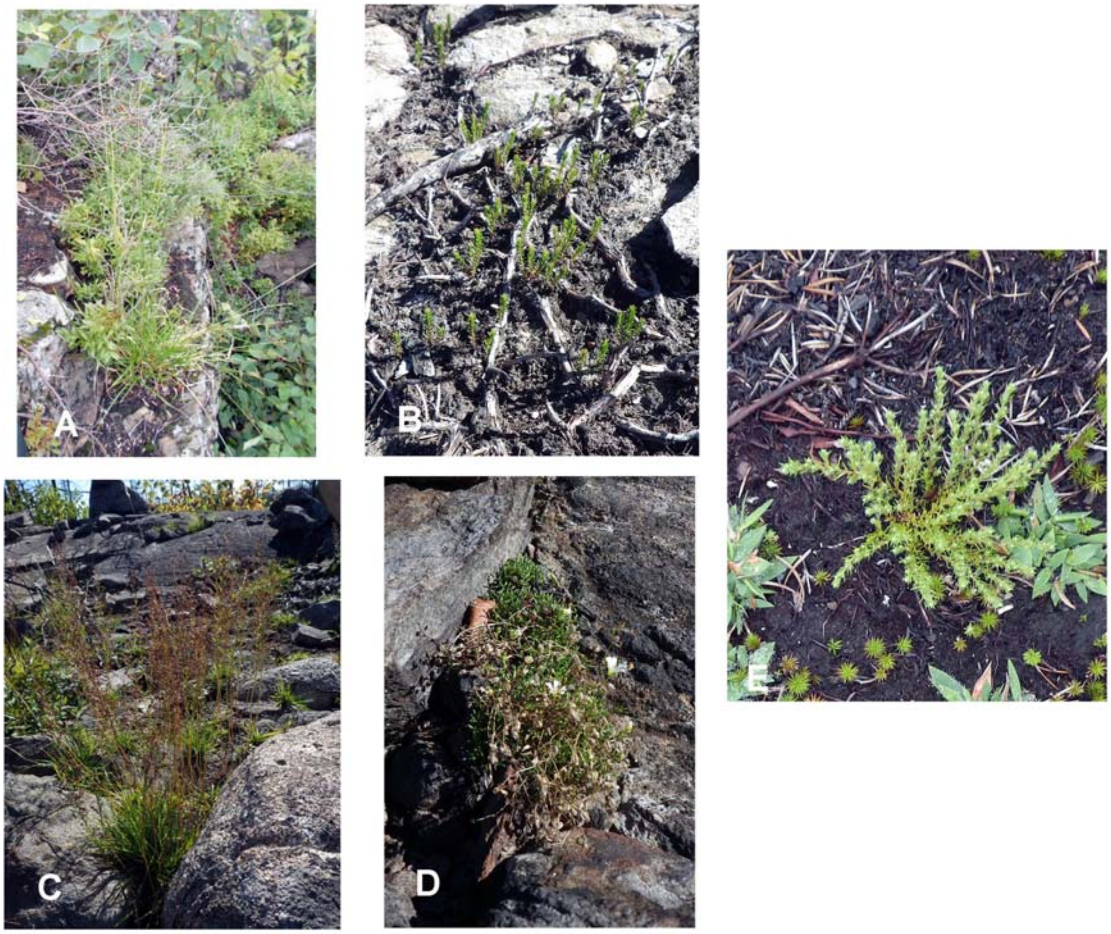

Fig. 6.3 Seedbankers establishing in fire-bared peat in an area burnt in 2012.
A Crowded Sedge, B Broom Crowberry, C Pinweed, D Mountain Sandwort,
E Golden Heather.

2. **Fire-Dependent to Fire-Adapted Transition Communities**
Immediately adjacent to the bare outcrop community are slopes that have developed a layer of dry peat humus on top of the same rocky outcrops and support the treed areas of VTs 3,4 and 5 (Jack Pine/Broom Crowberry Barrens, Red Pine-Jack Pine/Broom Crowberry Coniferous Forest, Birch-Maple-Aspen Early Successional Forest). Most prominent in the backlands is the fire-dependent, **Jack Pine** (*Pinus banksiana*) which is a short-lived, shade-intolerant pine growing in Nova Scotia on fire dominated, exposed rock along the Atlantic Coast and on sandy gravels in northwest Nova Scotia. This pine can withstand low-intensity fire but with time after a previous fire, flammability of Jack Pine stands increases and generates stand-replacing canopy fires which it survives through production of serotinous cones (Flannagan and Wotton, 1994; Carey, 1993). Temperatures of 50ºC degrees and higher, generated by crown fires are required to melt the resin and allow cones to open and release seed. This is a genetic condition; the proportion of trees whose cones must have fire to release seed reflects the fire history of the landscape. Serotiny levels in Jack Pine populations reflect the time since stand-replacing fires (Gautier et al., 1996). The New Jersey Pitch Pine Barrens populations are high proportion serotinous populations whereas populations in fire-suppressed regions (Givnish, 1981) or in barrens habitats in which stressors other than fire limit competition in the absence of fire (Conkey et. al., 1995) have low proportion of serotiny. In this regard, it is notable that counts made at five sites in the WLB indicate that the majority of Jack Pines were serotinous (>70% of cones completely sealed - Radeloff et al. 2004). Seedlings of Jack Pine begin to appear within a year after a fire, spurred on by the removal of competitors and release of nutrients following the fire.

Underneath these scrubby pines is a well-adapted deep rhizomed, heath community dominated by Black Huckleberry. Other deep rhizomed, fire adapted members of this community include Bracken (*Pteridium aquilinum*), Sheep Laurel (*Kalmia angustifolia*) and Lowbush Blueberry (*Vaccinium angustifolium*).

The Red Pine-Jack Pine/Broom Crowberry Coniferous Forest VT, dominated by Red Pine occurs in a very restricted area just to the southwest of Williams Lake. Red Pine is a species of the "Great Lakes - St. Lawrence Forest Region and in the southern sections of the Boreal Forest Region extending from southern Manitoba, eastward to Newfoundland, and as far south as West Virginia" (Flannagan and Woodward, 1994). It is adapted to surface fires of moderate intensity which suppress competitors, but regrowth after intense top-killing fires is dependent on reinvasion by seedlings from trees that escape fires (Bergeron and Brisson, 1990). Thus the limited presence of the Red Pine-Jack Pine/Broom Crowberry Coniferous Forest VT in the WLB is likely due to a relatively high frequency of stand-replacing fires.

Fire-Adapted stump-sprouting hardwoods of the Birch-Maple-Aspen Early Successional Forest VT grade into Jack Pine and Red Pine VTs. At high fire intensity, Jack Pine seeds survive in serotinous cones to repopulate the open charred landscape. At lower intensities and lower frequencies of fire, Jack Pine establishment is prevented by ground shading from vigorous stump sprouting hardwood trees and tall shrubs—primarily from the Paper Birch, Red Maple and Witherod (Wild Raisin) and, on some sites, Wire Birch and Big-toothed Aspen which regenerate quickly from buds on the root crown or roots. The short-lived

Paper Birch is a keystone plant of Boreal Forest regions that are prone to fire. Its extremely peeling bark— akin to the Eucalyptus spp.—is highly flammable and good tinder for putting succession back to regeneration (Fralish and Franklin, 2002). The Paper Birch trunk succumbs to the fire it brings on but fire produces a seedbed for the next generation of birch and the parent birch trunk base resprouts multiple times to resume its place.

The Red Oak–Red Maple/Witch-hazel Hardwood Forest VT is a bit of a special case, occurring around the top of the drumlin in deeper soil/ till than elsewhere in the WLB, but well drained and droughty as in VTs 1,2,3,4, 5. It's a typical situation for this VT which corresponds closely to the NSFVT IH2 of the same name (Neily et al., 2011). Red Oak withstands and benefits from surface (understory) fires which suppress competitors of Red Oak seedlings, especially on higher fertility sites, but it is killed by most canopy fires (Basquill et al., 2001, Dey and Fan, 2009). On the Drumlin, the Red Oak dominated stands merge into Birch-Maple-Aspen Early Successional Forest VT and thence open Huckleberry Heath which burned in 2006 or 2007 and are likely subject to intermittent surface fires.

In all of these burned VTs, there are few of the typical woodland wildflowers. In these hardwood "shrub savannahs", the most frequent herbs grew from tough (*Aralia nudicaulis, Gaultheria procumens*) underground stems. Long rhizome herbs were uncommon in upland (e.g. Wild Lily of the Valley and Starflower—*Maianthemum canadense*, and *Trientalis borealis*). Herbs with fleshy, short-rhizomed underground storage (Painted Trilliums, Lady Slipper Orchid, Cucumber Root, Twisted Stalk = *Trillium undulatum, Cypripedium acaule, Medeola virginiana, Streptopus roseus*) that are common in typical acidic woodlands in the HRM are absent.

An unbroken cycle of fire-regeneration-fire has wholly shaped every facet of these ecosystems.

3. The Lakeshore Pine-Oak Woods

As fire moves to the more sheltered areas, closer to Williams Lake, it passes through large individuals of White and Red Pine. Repeated fire appears to have reduced the surface fuel load to low levels in comparison with most Nova Scotian mixed forests. Fires that sweep down from the barrens and shrub savannah reinforce the fire-adapted membership of even these lakeside communities. Key signs are the near absence of the guild of fleshy forest herbs (see above) and the prevalence of Huckleberry and Wild Raisin in the understory shrub community. The large White and Red Pines have not escaped fire, rather they have been able, for the most part, to recover from fire injury. The predominance of flat-faced trunks with bark suture healing shows that these pines recovered after fire blistered their trunk in the direction facing the fire. The surviving cork cambium tissue on either side of the burned trunk face, grew laterally, and slowly covered the fire exposed wood. Photos show a gallery of both White and Red Pines in a sequence from full recovery to permanently scarred to succumbed to fire (Fig. 6.6). Wildflowers such as Common Lady Slipper, Trillium and Cucumber Root have long ago been selected against by fire. The more fire-sensitive trees such as Hemlock and Yellow Birch, and Hobble Bush are generally absent except by wet corridors and closer to houses where there is a high degree of fire protection.

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

6. 5 Fire record in the Jack Pine Fen

The prominence of Jack Pine and Broom Crowberry in the WLB, the perspective of foresters that such areas as naturally fire prone, and the modeling of Whitman and colleagues all suggest that while the frequency of fires increased with European settlement of the area, this is a naturally fire prone area and there is likely a longer history of recurrent fires in the area.

We looked to the fens for a possible record of pre-European fires. On our May 30th survey we found Jack Pine growing amongst sphagnum in a section of a fen near Colpitt Lake. Jack Pine–Broom Crowberry communities border the fen, thus we suspected that fires had swept right up to if not across the fen and that there could be record of such fires in the peat. Auger samples taken though the peat showed several layers of charcoal.

We went back to that fen on Aug. 3rd to more precisely document the occurrence of charcoal and to obtain samples for carbon dating. After removing the surficial, loose sphagnum, blocks of peaty substrate approximately 15 x 15 cm square were cut with a saw and laid out in pieces as they were removed from successively deeper layers. Any smeared surfaces were removed and then we looked for layers with darkened debris resembling charcoal. Such layers were cut out and placed in plastic bags. Later they were washed onto a sieve and darkened debris removed with forceps and stored in plastic bags in a freezer. Subsequently, we examined a subset of the samples submicroscopically under the guidance of Quaternary geologist, Dr. Ian Spooner (Acadia University), to distinguish charcoal from woody debris darkened by sulfides by their iridescence – this is more discerning for larger fragments, than smaller. Putative charcoal fragments, some together with what were clearly non-charcoal, darkened woody debris, were found in all of the 5 samples we examined, including some large fragments in the deepest sample. We sent 3 large fragments taken from the deepest sample (75 to 78 cm at site 1) to Beta Analytic in Miami for carbon dating. In their procedure, they confirmed the presence of charcoal and dated it at 1250 years BP +/- 50 years (Appendix D).

Table 6.1

Site:	**Site 1**	**Site 2**
Horizons with darkened debris (extruded)	13-22 38-44 38-43 46-50 66-70 75-78*	0-15 30-40 50-60
Total length of extruded chunks	90	85
Depth to rock base	83	75

*Charcoal fragments carbon dated

Since this sample came from close to the bedrock, it might be said that fires in the area go back to *at least* 1250 years. It is interesting that there were more zones of darkened debris at site 1 than at site 2. Site 1 was in a more restricted area with more tree cover both in the fen and nearby than at site 2 which was at the edge of the open, non-treed area of the fen; thus it could be expected that fires would more frequently impact site 1 than site 2.

With a saw at hand for the peat cores, we also sawed a slice from the base of a Jack Pine at site 1 (Fig. 6.8) to obtain a disc for aging: dating showed the tree to be 44+/-1 years old (1959+/-1), quite similar to the reported time for a large fire in this vicinity cited above (circa 1959).

6.6 Fire intervals required to maintain Jack Pine and Broom Crowberry

Jack Pine and Broom Crowberry are quintessential "fire-dependent" species. Thus the occurrence of either species in abundance, and more so the two in combination, suggests a history of repeated fires at fairly short intervals.

To be sustained in abundance and as even-aged stands, Jack Pine stands require fire intervals that are not too long (roughly, in excess of 100-150 years) or too short (5-10 years):

> The minimum seed-bearing age of open-grown jack pine is 5 to 10 years. Some seed is produced every year and serotinous cones accumulate in the crown… Jack pine begins to show signs of decadence by age 75 [17], decreases in frequency by 150 years, and may disappear completely after 200 years [13], although some relic jack pine survive nearly 250 years [40]. In the absence of fire, jack pine is succeeded by longer lived species such as red pine (P. resinosa) or white pine, or by more shade-tolerant species such as balsam fir and black spruce (Picea mariana). Black spruce, which often seeds in at the same time as jack pine, grows slower but lives longer, becoming codominant after 90 years and eventually succeeding jack pine [16,40,42]. On the driest, harshest sites, jack pine may persist and form an edaphic climax [67]…
>
> Fire regime: Estimates of fire intervals in jack pine forests are generally less than 50 years [40]. Based on jack pine fire scars, the shortest and longest times between major fires in jack pine forests of northern Ontario were 5 and 30 years, respectively [50]. The mean fire return interval for jack pine forests in the Athabasca Plains in northern Saskatchewan and northeastern Alberta is 38 years [16]. Large upland ridges and ridge complexes, far from natural fire breaks, burn most frequently. Jack pine forests that burn more frequently than every 5 to 10 years become pine barrens [31]. Major stand-replacing fires in the Boundary Waters Canoe Area occurred in years with summer droughts [40].
>
> The accumulation of litter and debris on the forest floor over time increase the likelihood of moderate- or high-severity fire [40]. A lichen mat, a highly flammable and continuous fuel source at ground level, develops within 40 years and is important in supporting fires in jack pine forests [16]. [See Fig. 6.9]
>
> Source: Carey (1993)

> Fire intervals, the time between fires on the same area (26), have been calculated for jack pine in various locations. In the Boundary Waters Canoe Area of Minnesota, fires burned over the same area an average of every 6.1 years between 1727 and 1972 (21). Before settlement (1727-1868), the average fire interval in this area was 4.3 years with 21 to 28 years between major fire years (21). Eighty-four percent of the 532,000-acre land area burned during these major fire

> Years. Heinselman (19) believes that jack pine barrens on sandy plains experienced light, surface fires as often as once every 15 to 30 years throughout jack pine's range. In lower Michigan, Simard and Blank (32) found a 28-year average fire interval between 1830 and 1980. Before settlement (1830-1849) the average interval was 27 years and dropped to 10 years during settlement (1850-1909).
>
> With initial suppression efforts, the period lengthened to 18 years and is now about 30 years. Major fires now occur an average of once every 28 years.
>
> Source: Rouse 1986

Whether local extinction of Jack Pine Crowberry occurs under longer fire intervals (e.g., 100+ years) depends on spatial factors as well as fire intervals (Le Goff and Sirois, 2004).

Like Jack Pine, Broom Crowberry is largely restricted to habitats historically subject to repeated fire and declines in abundance have been related to fire suppression (Martine et al., 2005; NatureServe, 2013). Martine et al. (2005) reviewed literature and conducted observations related to regeneration of Broom Crowberry after fire. Typically plants are completely killed by hot fires, but such kill-off is followed by high seedling recruitment from the buried seedbank the following year.

> To summarize, populations of Corema conradii that experience an intense fire show a number of common responses. One immediate response is the death of the adult plants. This culling can be so effective that local populations may appear to have been extirpated. A longer-term response is the emergence of many new seedlings in the years immediately following an intense fire. The stimulus that fire provides to cue or condition the seeds to germinate is not known. One consequence of mass mortality in adult plants and the subsequent emergence of a new cohort of juvenile plants is the production of uniformly aged subpopulations.

High seedling recruitment of Broom Crowberry was likewise noted in local barrens after the Spryfield fire of 2009 (Beazley and Patriquin, 2010), and in the fall of 2013, we noted high seedling densities in barrens by Williams Lake that burned in May of 2012 (Fig. 6.9).

Martine et al. (2005) discuss the dynamics of Broom Crowberry populations in relation to life history characteristics, in particularly the species' dioecious habit (separate male and female plants), its spreading growth habit, a juvenile growth stage (without reproduction) of 5-10 years, growth and reproduction over 10 to 25+ years, senescence after 25+ years and die-off after 40-50 years. They suggest that longer delayed (e.g. 30+ years), very intense fires may completely wipe a population. Shorter interval fires, being less intense, may be less damaging, but a moderately intense fire that stimulates recruitment followed by a second fire in less than 10 years (i.e. before they begin to set seed) could again wipe out a local population. Thus, broadly, the "desirable fire interval" for Broom Crowberry, circa 10-50 years, corresponds to intervals cited as favouring Jack Pine.

The frequency of recent fires noted under Section 6.2 suggests frequencies in that range, and likely explains the relatively healthy nature of the Jack Pine and Broom Crowberry populations in the WLB.

Our observations of charcoal in the fen suggest a history repeated fires going back at least 1250 years. Based on the occurrence of six distinct charcoal horizons at Site 1 above with the oldest dated 1250 years, we might estimate the historical frequency as considerably longer than 10-50 years but it is likely that the less intense or extensive fires are not reflected in that record. As well, our separations of charcoal layers, conducted visually in the field, were rather crude and more precise studies could reveal a greater frequency of charcoal in the fen record. On the other hand, it's possible that Broom Crowberry, whose recruitment can be stimulated by disturbances other than fire (Martine et al., 2005), would survive intervals longer than 50 years regardless of fire on the most exposed barrens areas (Burley and Lundholm, 2010; Porter, 2013; Strang, 1972). Likewise, while the serotony ratio was high for Jack Pines in the WLB, it was not 100%, and there could be some recruitment of Jack Pine over longer intervals into barrens habitats in which other stressors limit competition in the absence of fire (Conkey et. al., 1995). So while the current abundance of Broom Crowberry and Jack Pine likely reflect fairly short intervals (10-50 years) between fires, they may also have persisted over longer intervals (but probably less than 200 years) in the rock barren habitats in pre-European times.

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.

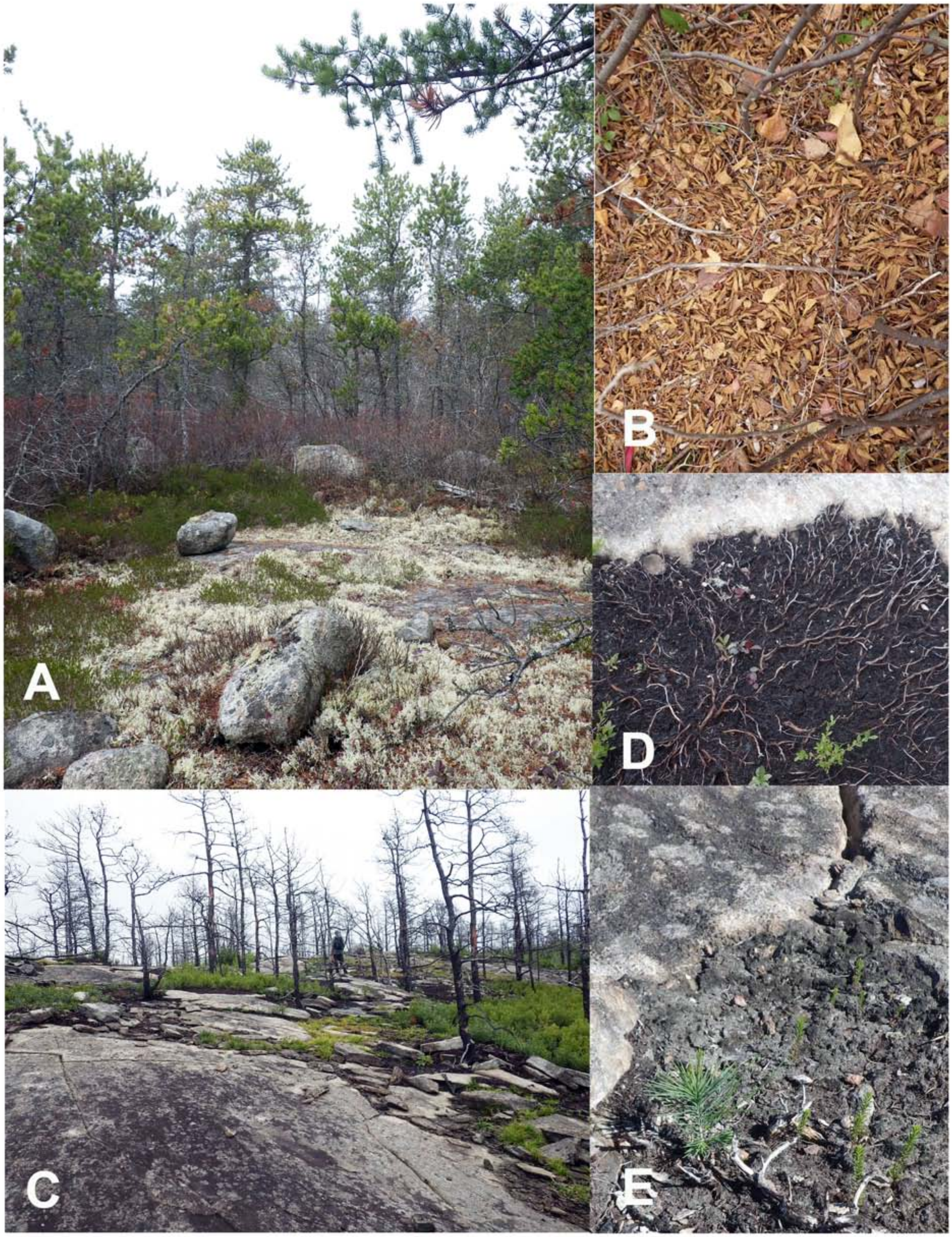

Fig. 6.9. Pre and Post-Fire scenes in Jack Pine/Broom Crowberry Barrens.

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.

7. Water Channels to Wetlands

The parent materials at Williams Lake include massive rock outcrops (Fig. 7.1), erratics and boulder fields and a very limited supply of any finer glacial till. The urban analogy to this natural landscape is a hardscaping of the impervious surfaces of paved surfaces and buildings. Unlike the urban analog, the WLB ecosystems regulate and filter run-off and deliver purified water to Williams Lake.

7.1 The landscape components of water regulation & filtration

The following is a description of three major components of the regulation and filtration system that has developed from weathering and the adaptations of biological communities in the WLB.

I. Run-off from ridge tops

Run-off from ridge tops and outcrops is immediate. Light rains are absorbed by a cryptobiotic community of crustose of fructicose lichens (Fig. 7.2) that had been in a desiccated state of life (anhydrobiosis).

II. Run-off channels: boulder fields and washes

During intense rainfall, water sheets off ridges and outcrops and takes one of two routes.

(i) Run-off in higher slope areas: **Boulder Fields** in ridge coves

(ii) Run-off in moderate to gentle slope areas: **Washes**

Neither of these are traditionally recognized WETLAND types, however, both are critical areas to maintain effective flood control in this natural hardscape.

Boulder Fields

Boulder Fields (Fig. 7.3, 7.4) are not wetlands but harbour an underground stream network. Water can be heard gurgling below surface after rainfall and in fall and winter, they may partially fill with water.

Our reference to "boulder fields" is primarily to the visually striking, rather stark appearing boulder fields with large, very angular (not rounded) boulders, mostly free of any vegetation except for a few mosses and lichens (Fig. 7.4). They are prominent features in the areas of black slates of the Halifax Series. Marcos Zentilli remarked that the scarcity of biotic cover on the boulders could be due to chemical acidity of these commonly sulphide-rich, rocks.

These types of boulder fields might better be referred to as "block fields" which the U.S. Natural Resources Conservation Service defines as:

> A thin accumulation of stone blocks, typically angular, with only rock fragments in the upper part, over solid or weathered bedrock, colluvium, or alluvium, without a cliff or ledge above as an apparent source. Block fields occur on high mountain slopes above tree-line, or in polar or paleo-periglacial regions; they are most extensive along slopes parallel to the contour; and they generally occur on slopes of less than 5%. Synonym – felsenmeer. Compare – block stream, talus slope, scree slope. (NRCS, n.d.)

Elsewhere, in the areas of granitic rock, boulders in somewhat similar accumulations are more rounded, and there is more cover by mosses and bushes in exposed areas than you see in the areas of Halifax Series bedrock, but otherwise the accumulations are similar to those described above. Most stream courses are lined by boulders, and much of the terrain with tree cover is bouldery underneath as well as on top. The WLB are a bouldery landscape (Fig. 7.5). Some of these latter accumulations may be more of the nature of talus slopes.

The role of boulder fields in relation to wetlands and watercourses is only now being addressed. A recent publication by Lichvar et al. (2012) of the U.S. Army Corps of Engineers, "Testing Wetland Delineation Indicators in New England Boulder Fields" examines properties and functions of boulder landscapes similar to those found in the WLB.

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.

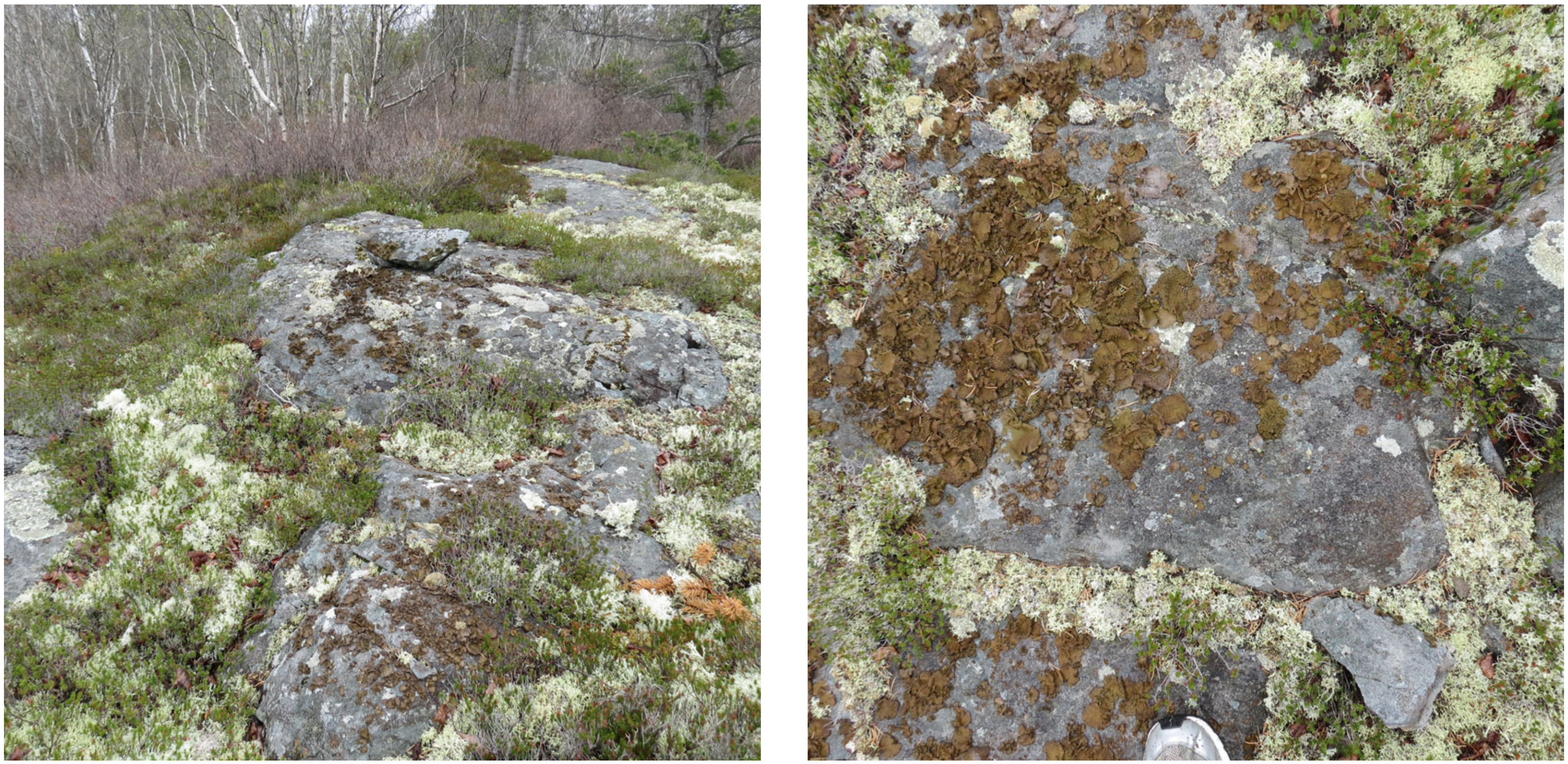

Fig. 7.2 Lichens on rock outcrop.

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

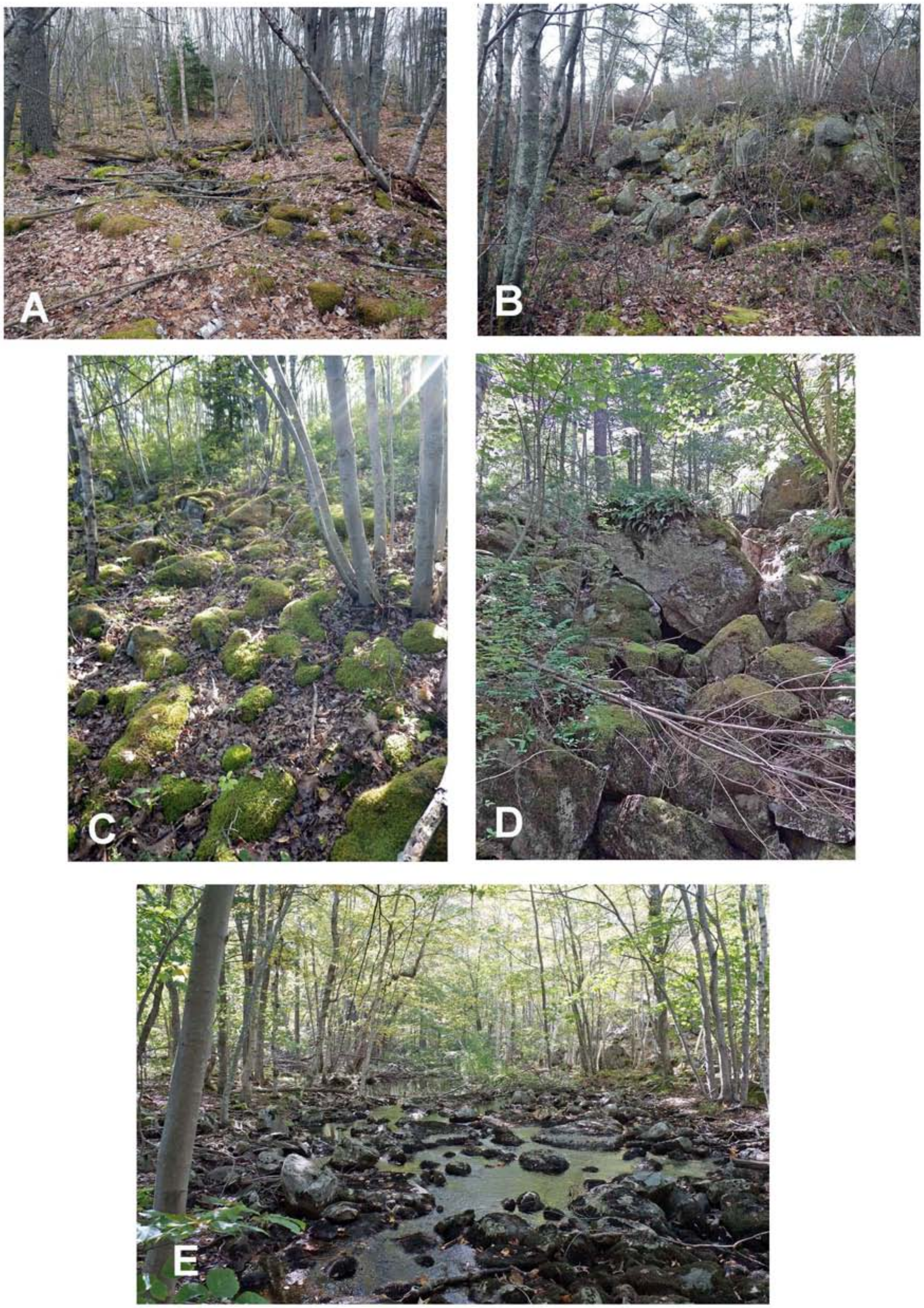

Fig. 7.5 Other types of boulder accumulations.
A, B, and C are in areas of granite bedrock, D and E in areas of Halifax Series bedrock.

Mountain Holly intermittent streams or "Washes"
In the WLB, there is a network of Mountain Holly Washes, or infiltration channels, that are trough depressions down slopes between the exposed ridge and rocks, and the swamps at lower elevation.

Mountain Holly (*Nemopanthus mucronata)* is the signature species and marker of these washes. Mountain Holly has been listed as a Facultative Wetland (FAC) species by Nova Scotia (Blaney, 2011) however, it is recognized as an Obligate (OBL) wetland plant in listings (Lichvar, 2013). It is a tall shrub with slow twisting growth and red barked roots that go deep to wet sediments in these washes; the plant takes two years to germinate and its seedlings occur in washes where leaf litter has been removed by runoff (Fig 7.6).

Mountain Holly marks these wash channels and often co-occurs with Red Maple. The inside wash typically has a shallow peat layer and a mix of sand and fines (silt & clay), the wash channel is lined by a small boulder transition zone outside of which is a HUCKLEBERRY (FAC in NS, FACU = Facultative Upland in US) shrub savannah with birch (Paper or Wire) or Jack Pine.

Washes can be described as infiltration channels or intermittent streams. In dryland regions, larger intermittent streams are called arroyos or gullies and in some US states they are afforded the protection of perennial stream courses, e.g., see New Mexico Wetland Regulations (n.d.) because they account for the majority (e.g. 80%) of the water flow channels in these regions (Levink et al., 2008). Headwater, first order streams can also account for 60% of the total volume of flow of watersheds in the northeast (Alexander et al., 2007) and it has been estimated that such streams have been underestimated in 80% of cases (Brooks and Colburn, 2011).

Flows from ephemeral and intermittent streams drive hydrological regimes in small watersheds such as the Williams Lake Backlands. Mountain Holly and Red Maple canopies of the washes shade and cool the water that flows through them; a part of this overland flow infiltrates in these Washes but a larger portion flows through the channels and infiltrates at Vernal Pool nodes that occur throughout this network of washes wherever slope levels off. Altogether, this system delays and slows water flow, it also shades and cools water, infiltrating a portion and delivering the remainder to vernal pool nodes at intermediate rainfall intensities or the overflow to swamps. Run-off in the Backlands is driven by topography and glacial history—by the ridges and rocky slopes that have little fine glacial till—and the hydrology of the small watersheds functions in the same manner as a dryland area although the climate is quite different. At the Backlands, run-off initially speeds into Mountain Holly Washes, it temporarily fills vernal pool nodes, and then overflows into lower elevation washes, their vernal pools, and finally and into the swamps just above Williams Lake.

Despite the essential role of these ephemeral and intermittent streams in the WLB in channeling and infiltrating water and delivering it to Vernal Pools nodes that form where the slope of Washes levels off, these stream courses have no official protection. To promote infiltration to avoid flooding and stormwater backup, such courses are designed into urban designs and are termed "Swales".

Swales and Washes alike may or may not conform to the requirements for designating wetland:

Table 7.1 Mountain Holly Washes: Evidence for Wetland Status.

Criterion	**Comment**
Hydrophytic Vegetation	The dominant species are FAC, which passes the "50:20" test*
Hydric Soils	Not present
Wetland Hydrology	Yes, because of two secondary Indicators: 1 Geomorphic position (they are troughs) 2 Presence of bare areas & exposed roots (Fig 7.4)

*FAC= Facultative wetland species. "50:20" test: the majority of the plants with largest cover that together account for 50% cover (and any with >20% cover) are at least facultative wetland species, i.e. dominant plants are all wetland plants or at least have facultative wetland status

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.

III. Wetlands

The following is a dichotomous key to the types of wetlands in the WLB:

A. Small wetlands, flooded over winter or after intense rainfall, not saturated in summer

Vernal Pools

A. Larger wetlands, permanently saturated with or without seasonally flooded margins

B. Hydric soils with low accumulation of peat, or treed or shrub dominated communities on peaty soils with large seasonal waterlevel fluctuation and influenced by mineral rich groundwater

C. Wetlands where surrounding topography creates vernal pooling in the marginal zone

Swamp/Vernal Pool complexes

C. Wetlands where topography does not result in such pronounced seasonal differences in flooding, or in soil saturation, at the margin

D. Plant communities dominated by shrubs
Shrub Swamps

D. Plant communities dominated by trees
Treed Swamps: Black Spruce, Tamarack, Red Maple

B. Peatlands that remain permanently saturated and may be flooded over winter and where tree growth is usually stunted or of low (< 30%) cover.

E. Peatlands with substantial groundwater or surface flows

F. Flows from surrounding landscape and upstream wetlands
Fens (Topogenous and Soligenous)

F. Flows associated with lakeshores
Lakeshore Fens

E. Peatlands whose surface layers are largely independent of such flows
Bogs

A **wetland** is defined as: *land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation and various kinds of biological activity which are adapted to a wet environment*. Organic wetlands are more simply referred to as **peatlands**. Peatlands contain more than 40 cm of peat accumulation on which organic soils (excluding Folisols) develop (National Wetlands Working Group. 1997).
Hydric soils are defined as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part of the soil (USDA, NRCS. 2003).

7.2 Wetland organization in the backlands landscape

The Pathway of Water

In natural systems, wetlands are important for filtering water and slowing it down. At Williams Lake, the headwater pathways of flow are not along conventional wetlands or streams yet they function as filters and regulators. Understanding the pathway of water is critical because development typically reduces the number of water pathways and straightens the pathways so run-off is shunted from hardscape to waterbody (Marsh, 2005). This has the effect of reducing the time of run-off and increasing its speed, resulting in greater erosion and less filtration. The loss of ground infiltration, has the secondary effect of increasing water temperature of runoff in summer as water remains on the surface. This may have impacts on the ability of water to hold oxygen for salmonids in Williams and Colpitt Lakes.

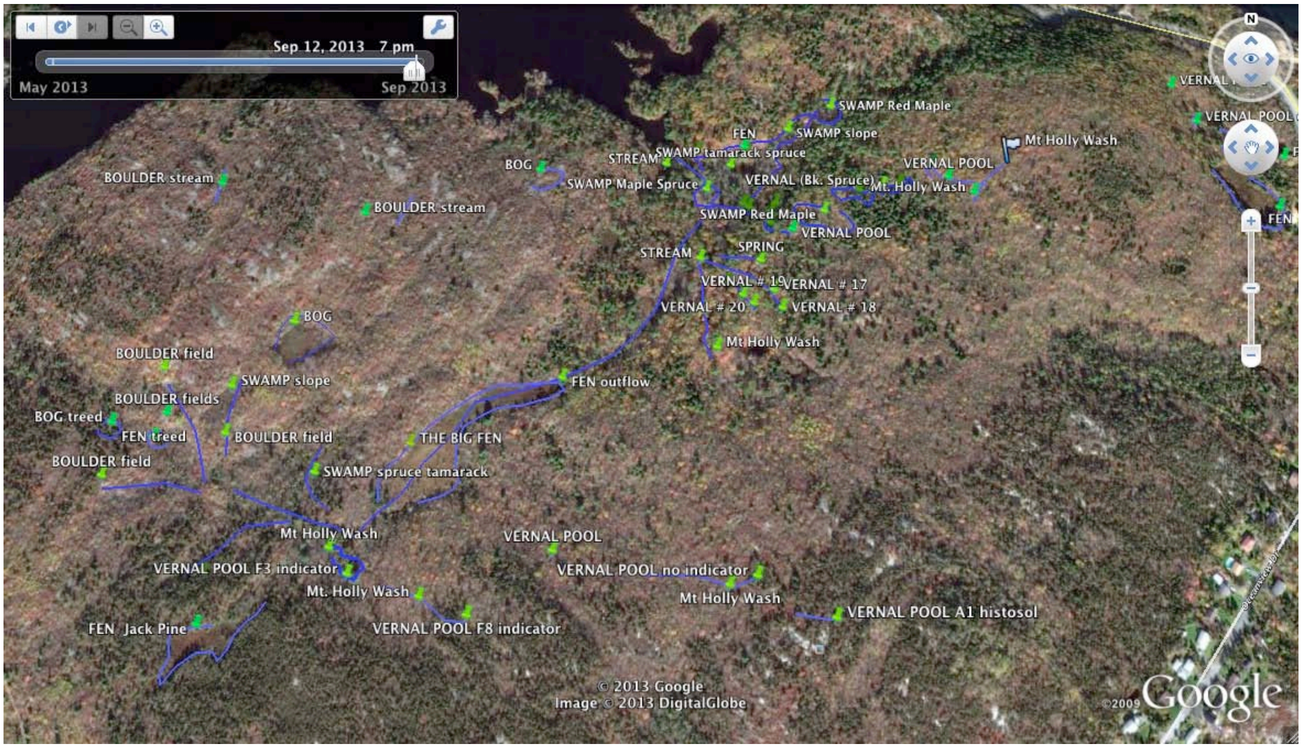

Fig. 7.7 Partial representation of water flows from the barrens into the water course that flows northeast along the contact zone between rocks of the South Mountain Batholith and the Halifax Formation and finally into Williams Lake. See next page for a larger version of this figure.

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**.

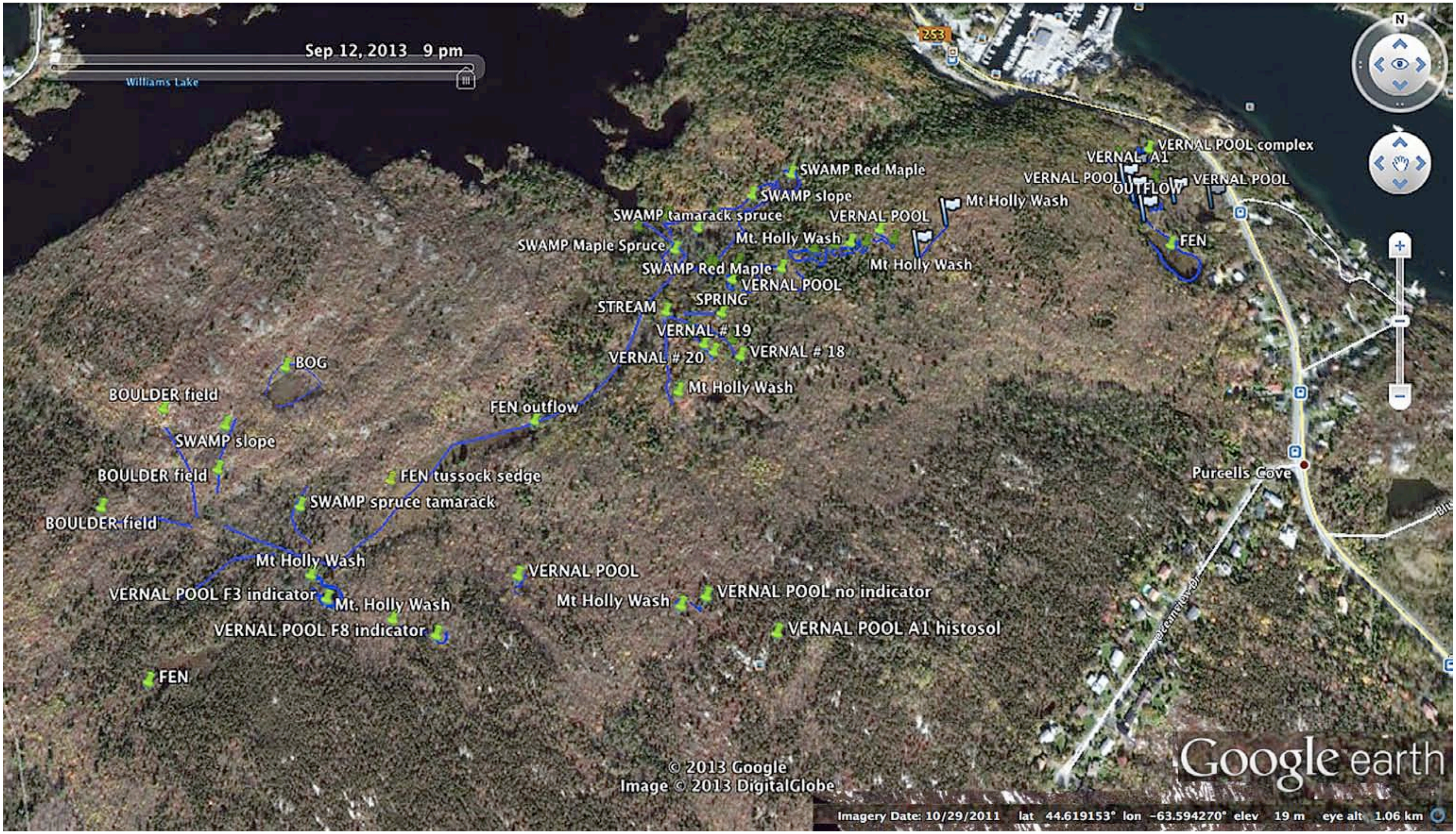

Fig. 7.7 Partial representation of water flows from the barrens into the water course that flows northeast along the contact zone between rocks of the South Mountain Batholith and the Halifax Formation and finally into Williams Lake.

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.

Below, the nature and roles of vernal pools, bogs, fens and swamps in water movement and storage in the WLB are described and discussed.

Vernal Pools

Vernal pools occur wherever there are depressions in the landscape and there are impermeable soil or rock layers. Vernal pools ranged in size from less than $5m^2$, a pool that might be the pit formed after a tree fall, to several hundreds of square meters.

For a project supervised by Patricia Manuel at the School of Planning, Dalhousie University, Huan Liu (2012) investigated various remote sensing techniques (aerial photography, satellite photography, and LiDAR - Light Detection and Ranging) and Digital Elevation Modeling for mapping of vernal pool mapping using the undeveloped land in the Williams Lake Watershed as a test case. Her synthesis map of all PVPs (Potential Vernal Pools) is in Appendix A Map 3 of this document. Liu conducted ground-truthing to help in developing criteria for designating a PVP but a formal survey would be required to test the predictions. We documented locations of every vernal pool encountered on six of our surveys (Fig. 2.2). These data, with photographs and descriptions, are being compiled separately from this report and should allow calibration of Liu's PVPs.

Water beetles and Culicid (mosquitoe) larvae were common in the vernal pools. Amphibians (Green Frogs) &/or their egg masses were noted in a few pools in May, but there was no evidence of amphibians for most of the pools. The sparsity of amphibians is quite possibly due to low pH in these poorly buffered systems still highly affected by acid rain (Clair et al., 2011).

The ecological significance of vernal pools is often related to diversity (e.g. amphibians or rare plants) in other areas (Colburn, 2004), but in the WLB their major value relates to hydrological function.

Vernal pools were of most regular occurrence along the network of Mountain Holly Washes and occurred wherever there was a leveling out in these slopes and where there was a rock barrier to flow.

A majority of the vernal pools in the Mountain Holly Washes have Wetland status although none of these appear to have been delineated in the Backlands property while the traditional wetlands (e.g. fens and swamps) were. They are sparsely vegetated in the herb layer (shrub growth is largely large clonal Mountain Holly) and they are bowl-shaped depressions (=Geomorphic Position). The vegetation is dominated (40% cover each, n=4 pools) by Red Maple (on hummocks in the bowl and overhang from pool sides) and by Mountain Holly which suckers up clonally from the lowest pool positions. There are minor amounts of Sheep Laurel and Paper Birch and trace amounts of Bracken and Huckleberry (dominants of the surrounding upland).

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.

Bogs
Unlike all the preceding systems—the boulder fields, Mountain Holly Washes, vernal pools in networks or interconnected as above via an underground spring—the bogs at Williams Lake Backlands alone, fit Tiner's (2005) description of a terrene system without definite inflow zone or an outflow. Bogs, by definition, are self-contained systems and may be plentiful in flatter landscapes where drainage is poor (e.g. the coastal bogs between Peggy's Cove and West Dover). Their main source of mineral nutrient supply comes from precipitation and hence they are appropriately termed: **ombrotrophic** (Greek words, ombros + trophikos translate to rain + nourishment).

The Barrens landscape is a flow-through landscape and the Bog terrene was an exception to this rule. The drainage map reveals that boulder fields, Mountain Holly Washes, their vernal pools and other isolated vernal pools are higher in the landscape than swamps and fens.

Fens and Swamps
The Barrens landscape is a flow-through landscape with the few bogs as an exceptions to this rule. The drainage map reveals that boulder fields, Mountain Holly Washes, their vernal pools and other isolated vernal pools are higher in the landscape than fens and swamps (Fig. 7.7)

Fens and swamps are flowing systems and both of these ecosystems may be highly organic. There is a greater influence from minerals and sediments in swamps. In contrast, fens are strictly peatlands and as a rule are consistently wetter than swamps, drying out less in summer. Fens can support a tree community (a treed fen) but these trees are usually more impoverished, less robust and contribute less cover than is the case in swamps. Swamps may have a large influence from dead wood incorporation into its organic profile. (National Wetlands Working Group,1997).

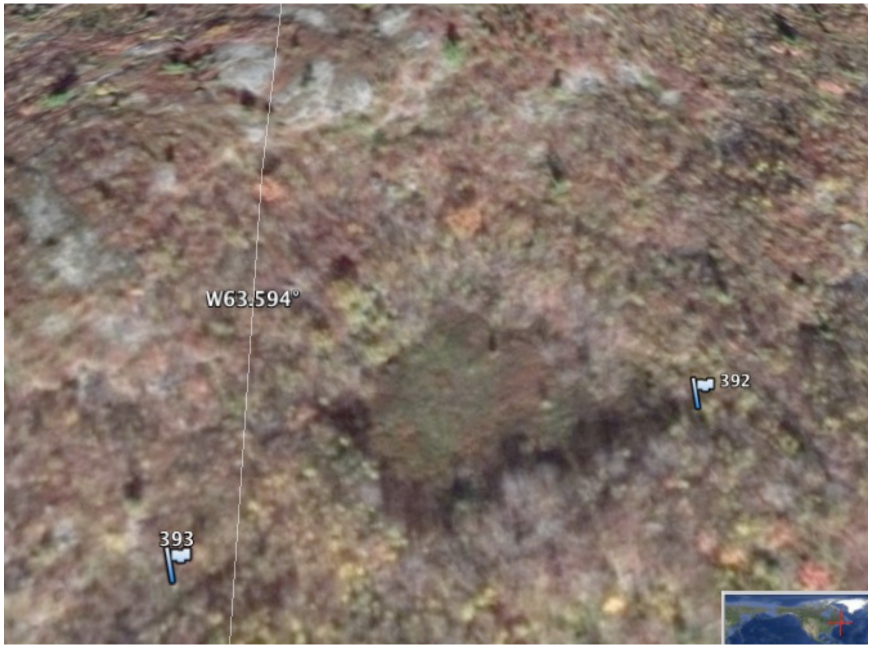

Fig. 7.11 Google image of a bog in the WLB (left) and some of its heath family plants.

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.

8. The Case for Conservation

The WLB and the Purcell's Cove Backlands more broadly present a Thomsoneseque Wilderness close to peninsular Halifax and minutes away from moderately dense residential and commercial settings along Herring Cove Road from smaller neighbourhoods along Purcell's Cove Road. There is pressure to develop more of the area. From an ecological perspective, there are substantive reasons to protect the area, one of which is that it hosts rare, fire-dependent plant communities and species. In turn, recognition that the area is one of the most fire-susceptible landscapes in Nova Scotia and management to reduce fire risk to adjacent communities has benefits for both conservation and fire control.

8.1 Prime ecological values

We suggest three aspects of the WLB make them prime candidates for conservation from an ecological perspective.

(i) The Jack Pine/Broom Crowberry Barrens

The combination of Jack Pine, an iconic boreal species, and broom crowberry, an Atlantic Coastal Plain dwarf shrub of the heather family, is found within Canada only on scattered rocky outcrops near the Atlantic coast of Nova Scotia. It occurs only sparingly in similar habitats in Maine, where it overlaps with the globally rare Pitch Pine/Broom Crowberry association. Nova Scotia's Jack Pine/Broom Crowberry Barrens are likewise globally rare (Appendix C).

Coastal ecosystems at large are the most modified of all Nova Scotian and North American systems because 80% of roads and development are focused here. The **Jack Pine/Broom Crowberry Barrens** are particularly vulnerable, and so especially rare, because they are slow-growing, stress-tolerant, evergreen communities. These are most susceptible to all of the suburban modifications: nutrient enrichment, increased pH (from pavement, concrete and imported gravel beds and soils) and increased disturbance.

This stress-tolerant barrens ecosystem hosts, in addition to the Jack Pine and Broom Crowberry, three slow-growing, rare plants: the Mountain Sandwort (S2), Golden Heather (S2) and Lesser Brown Sedge (S2/S3). Broom crowberry has S4 status in Nova Scotia, but is precarious outside of Nova Scotia. The WLB Jack Pine/Broom Crowberry Barrens is a rare ecosystem with stress-tolerant plants that have survived only because the area escaped development.

A variety of open canopy, fire structured pine barren and pine savannah communities involving a dozen plus species of pine occur across North America (Anderson et al., 1999). Historically these ecosystems have been reduced to a few percent of their original extent through settlement and agriculture and, in the last 50-100 years, through conversion to other vegetation types as a result of fire suppression. Today, conservation of as much as possible of the remaining intact areas is a priority of many agencies and communities.

> "Northeastern U.S. pine barrens are globally rare, pyrogenic, early-successional habitats that support rich and unique assemblages of rare and declining biodiversity" (Gifford et al., 2010)

In Nova Scotia, the sandy pine barrens of the Annapolis Valley, in which broom crowberry is a signature component, have been reduced to less than 3% of their original cover through settlement and agriculture (Carbyn, S. et al. 2006.). Our rocky Jack Pine/Broom Crowberry Barrens are being whittled away by development, a prime example being the loss of jack pine barrens to the development at the edge of the Williams Lake Backlands (see Landscape in Transition at http://versicolor.ca/transition). Also, barrens close to settled areas tend to be favourite sites for Mountain Biking and ATVs, both of which, if not focused on specific trails, are very destructive of barrens habitats.

The Jack Pine/Huckleberry/Broom Crowberry Barrens of the WLB and the larger Purcell's Cove Backlands are amongst the most healthy and locally abundant of this community type in Nova Scotia (Appendix C.) Clearly, the Jack Pine/Huckleberry/Broom Crowberry Barrens of the WLB and as much as possible of the larger Purcell's Cove backlands deserve protection. Nature Trust's Purcell's Cove Conservation Lands, an 35 ha strip of land just to the south of the WLB represent a significant first step. Protecting all or most of the WLB (approx 200 ha) would be a substantive second step.

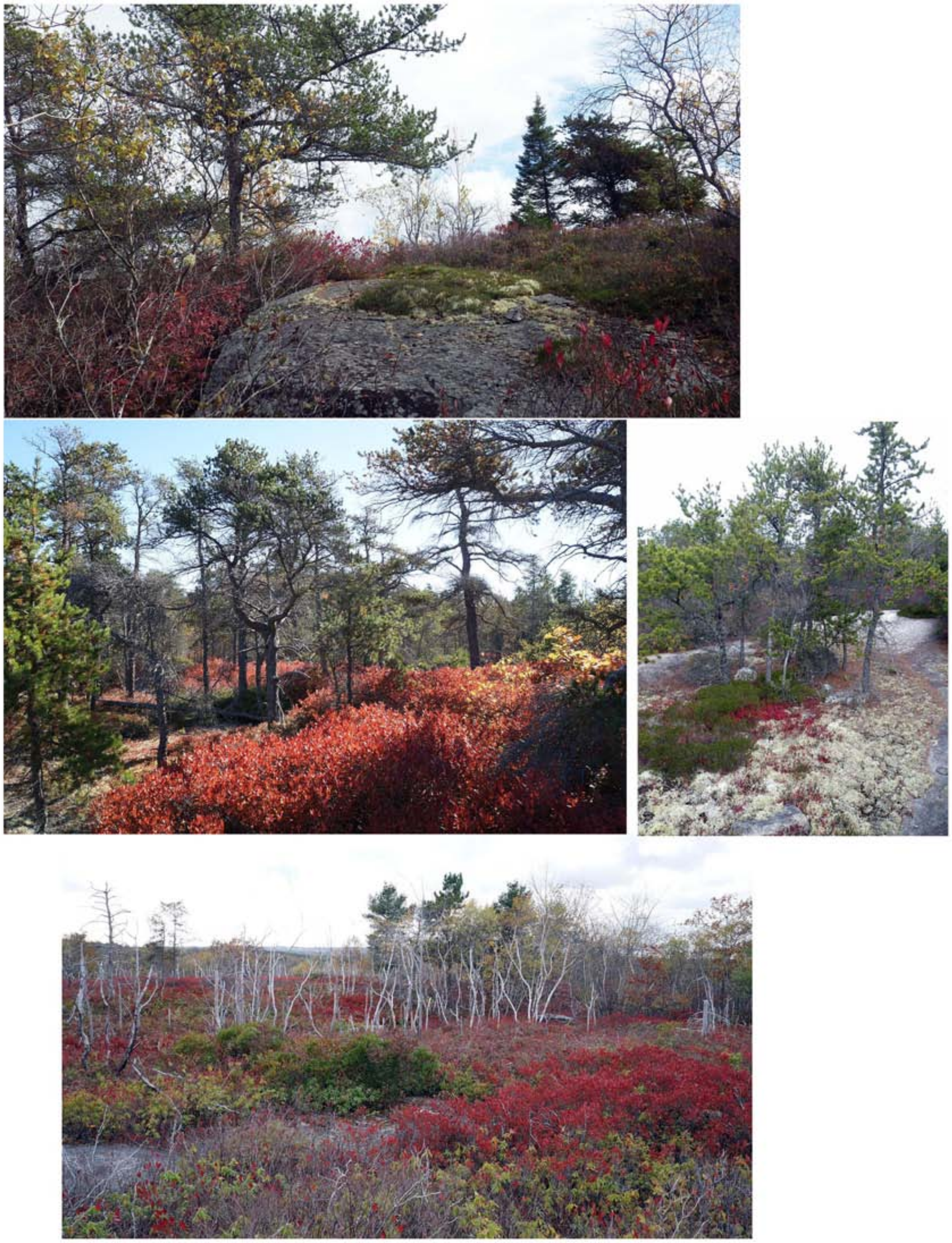

Fig.8.1 Fall in the Jack Pine/Broom Crowberry barrens (top 3 pics) and heathland on top of the drumlin that burned in 2007.

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.

(ii) The Wetland/Watercourse Complex
The WLB host a complex set of small and larger wetlands and stream courses that purify water finally entering Williams Lake and presumably, water reservoirs tapped for well water along Purcell's Cove Road.

Many of the smaller but collectively vital elements of this system are not legally protected in Nova Scotia as they are either smaller than minimum area of $100m^2$ required for wetland protection (e.g., many of the vernal pools and Mountain Holly Washes) and/or they would not qualify as wetlands under wetland Protection regulations (e.g., some Mountain Holly Washes, the boulder fields) or are not routinely identified as stream courses to protected under the Wildlife Habitat and Watercourses Protection Regulations (e.g. many of the boulder fields and Mountain Holly Washes), or the protection is very limited (e.g. a 5 m buffer for stream course less than 50 cm width.). In addition to a lack of legal mechanisms to ensure protection, many areas that qualify as wetland (such as slope swamp corridors between flat swamp, vernal pools greater than the legal minimum area or the vernally flooded zone at the margin of swamps having the requisite hydric soil indicators—e.g. F8 or A11) may escape notice by "efficient" delineation which concentrates on closing the wetland being delineated rather than on following up connections between wetlands.

The WLB are mostly scrubby, rocky savannah that would appear to have little ability to moderate flows shed from these impervious rock surfaces, yet, it is well known that unlike many lakes in HRM that have seen development, water quality in the partially settled Williams Lake is exceptional. Water quality is exceptional because within this seemingly hostile landscape is an organization that slows, cools and filters water, maintaining a cool base flow in streams regulating the lake. Williams Lake water quality is maintained through a network of natural swales or "washes" which are intermittent streams that increase the distance of water flow and infiltrate some of it in shaded passageways through fine sediments along wash troughs. The swale-wash network delivers water via surface and ground flow to vernal pools that are unidirectional wetlands which often have an inflow but little outflow. Their flows occur underground and they maintain base flow to fen and swamp along stream systems. The combination of natural swales and infiltrating vernal pools removes both sediment and nutrients of water going into Colpitt and Williams Lake.

Williams Lake is surprisingly transparent for this area of more typically brown water lakes. The brown water comes largely from humic acids produced in the organic soils in swampy forests and fens on much more nearly level landscapes around or feeding the lakes. In the WLB, water washes more quickly off the precipitous landscape and through the relatively small (but still critically important) swamps and fens, so does not bear the load of humic acids so common in most Nova Scotian watersheds. What the wetlands do remove, however, is sediment and nutrients, both detrimental to our oligotrophic lakes.

Currently, the waters of the WLB are thoroughly scrubbed by these networks of washes and vernal pools or in other parts of the barrens, by boulder fields and fens. Development of the Barrens, as we have seen at Dartmouth Crossing or Bayers Lake, would transform this vertically-integrated system of swale and vernal pool into a limited series of impervious plateaus connected by a limited number of surface water run-offs. Run-off hydrographs would not only be flashy but their waters would be warmer in summer because of surface heating from open pavement. The removal of overburden necessary to create the required area of flatscape-hardscape for development of Dartmouth Crossing was piled to form an artificial hillside of rubble and organic debris (soil, peat, trees). The water in the swamp at the base of this artificial hill supported luxuriant growth of filamentous green algae. Williams Lake area has good groundwater water quality for drinking and good lake water quality and temperature for bathing and salmonids (Brook Trout). For the reasons just elaborated using the Dartmouth Crossing model, these ecological services will be lost if this area becomes suburbanized.

(iii) Bird Habitat
This undisturbed wilderness area with its mosaic of habitats is near the coast in the most urbanized area of the province; as such it is important habitat for both breeding and migratory birds as documented for the Williams Lake Conservation Company by Fulton Lavender (2012). This boreal habitat supports a guild of boreal birds that are becoming increasingly rare.

8.2 Fire Management

Formal protection of the WLB would require a management strategy that recognizes the fire-dependent and fire conducive nature of the Jack Pine/Broom Crowberry Barrens, and reduces fire risk to neighbouring communities.

The WLB and the larger Purcell's Cove Backlands must rank amongst the most fire-susceptible landscapes in Nova Scotia and even with a high level of vigilance, fires *will* occur there as attested by recent fires. Thus we surmise that the current level of fire protection in HRM would still allow our settled areas to co-exist with the fire dependent communities of the WLB. A fire starts within the backlands and we put it out, but over time the frequency and spatial distribution of burning is sufficient to maintain the fire dependent communities of the backlands.

It could well be that some use of prescribed fires in the Purcell's Cove Backlands would enhance conservation of the fire-dependent ecosystems and, by reducing excessively high fuel loads, increase fire protection for the adjacent communities. Following the infamous Yellowstone Fire, we have come to recognize that a high level of fire suppression can lead to unnaturally catastrophic fires due to increased fuel loads. The modeling approach of Ellen Whitman and colleagues (Whitman et al., 2013; Whitman, 2013), combined with appropriate monitoring*, could provide a way to assess various options and risks of prescribed fires.

> Wildland fire is not going away. It is time we learn to live with it. Fire is not a war, and an absolute victory is impossible. But to accept reality is not to accept defeat. For perhaps the first time in this nation's history, we know the basics of how to live with fire. We know a great deal about how fire works, and we know how to mitigate its effects in a way that can improve our

*E.g., it might be appropriate to document the age structure/patch distribution of both Jack Pine and Broom Crowberry in the backlands, perhaps combined with measures of fuel load and Jack Pine serotiny. Such information might be used to infer the history of fire in the area and its patch dynamics, in turn contributing to prediction of fire risk and assessment of different fire management options.

lives in a myriad of ways. We can use fire to maintain and increase biodiversity, to protect our water supply and other natural resources, and to meet the many stewardship goals that we set as a society and as landowners. At the same time, we know how to make out homes as safe as possible from fire and to prepare for fire where it is inevitable.
SOURCE: *Living with Fire* (Jenson and McPherson, 2008)

Intrusions into the backlands complicate our co-existence with the fire-dependent plant communities by disrupting the water flows that maintain the larger wetlands and lakes, which in turn act as barriers to fire movement. An example of the protection afforded by wetlands: the movement of the 2009 fire towards Purcell's Cove Road in the vicinity of the Purcell's Cove Conservation Lands stopped at some large wetlands roughly two kilometers inland. Also, as shown by the 2009 Spryfield Fire, developments which retain a significant portion of the natural landscape within their boundaries for aesthetic value, increase the fire risk to residents. Inevitably, the actual experience of fire leads to destruction of more of the natural landscape both within and surrounding such developments.

Other developments in which the natural landscape is pulverized and replaced with watered lawns reduce the fire risk to normal levels for an urbanized landscape, but completely destroy the native ecosystem. Thus neither model of development can lead to coexistence with the backlands. What is needed is essentially to retain the status quo, i.e., what remains today as natural landscape in the backlands should remain natural landscape. This both retains the backlands as natural systems and reduces fire risk to adjacent communities compared to allowing more intrusions into the backlands short of completely obliterating them. The risk to the community can and should be further reduced by implementing programs similar to those being developed in the U.S. northeast to enhance protection of communities in the area of the fire-dependent pitch pine communities. These include prescribed (controlled) burns and mechanical methods to reduce fuel loads, limiting development in the most fire prone landscapes, and specific building and landscaping codes. A recent presentation to 2013 Backyards & Beyond Wildland Fire Education Conference in the U.S. provides some good models.

The Pine Barren Connection: Living Compatibly with a Common Fire-Adapted Ecosystem (PDF, 13 MB*)
Presenter(s): Heidi Wagner, NFPA Firewise Advisor
Description: Extensive undeveloped tracts of pitch pines are located in New York, Massachusetts, Long Island and New Jersey. These fire-prone environments are adapted to and require periodic fire to maintain forest health. As development into these areas continues, firefighters have been forced to quickly contain any fires that ignite to protect surrounding communities. Due to the lack of fire, high fuel loads exist in these natural areas. Dry conditions have the potential to produce fires that burn with greater intensity than fires would have historically. This presentation will review Firewise® strategies being implemented by residents and communities to mitigate this common threat.
(*http://www.nfpa.org/~/media/files/training/backyards-and-beyond/2013%20proceedings/sa09.pdf)

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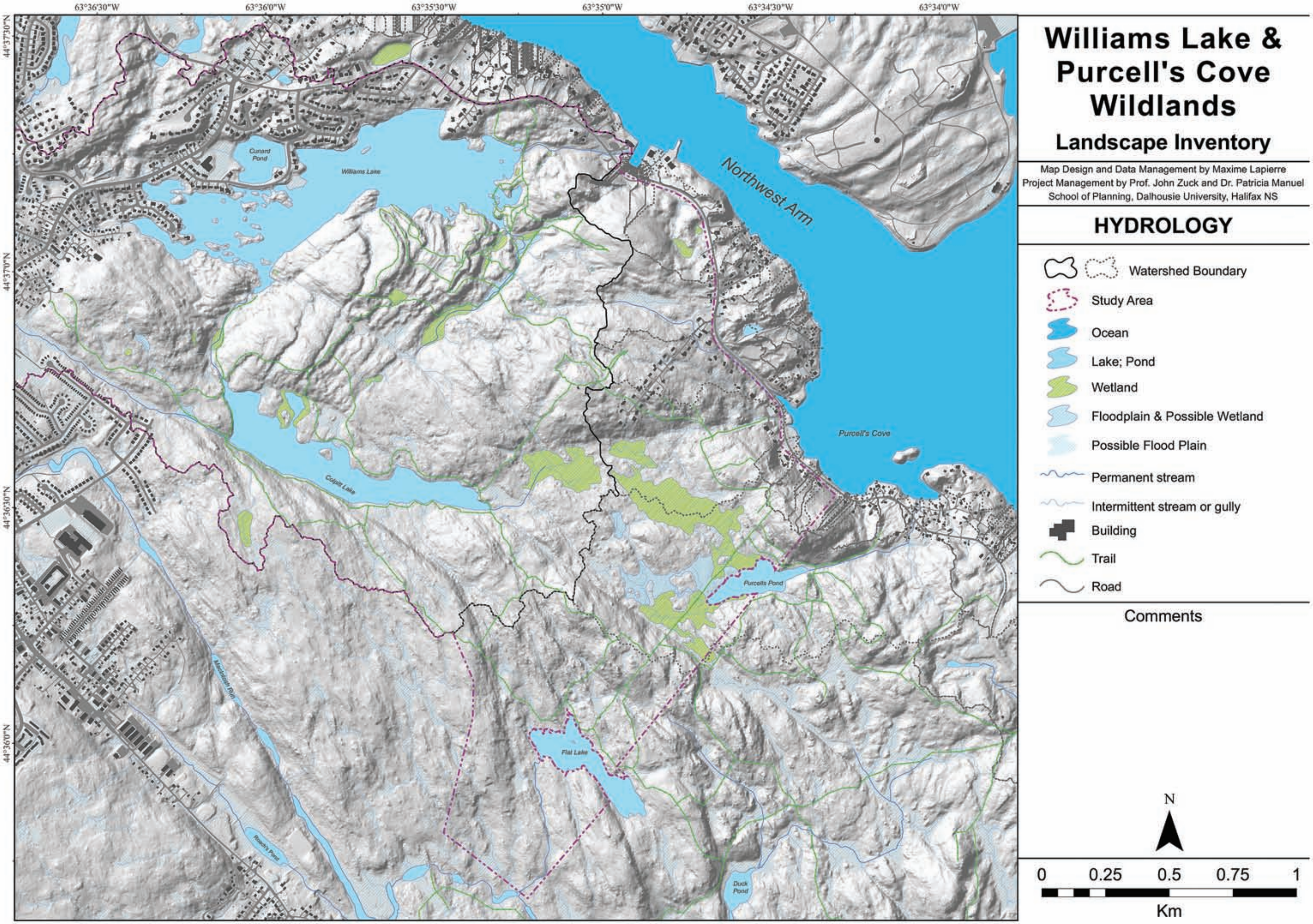
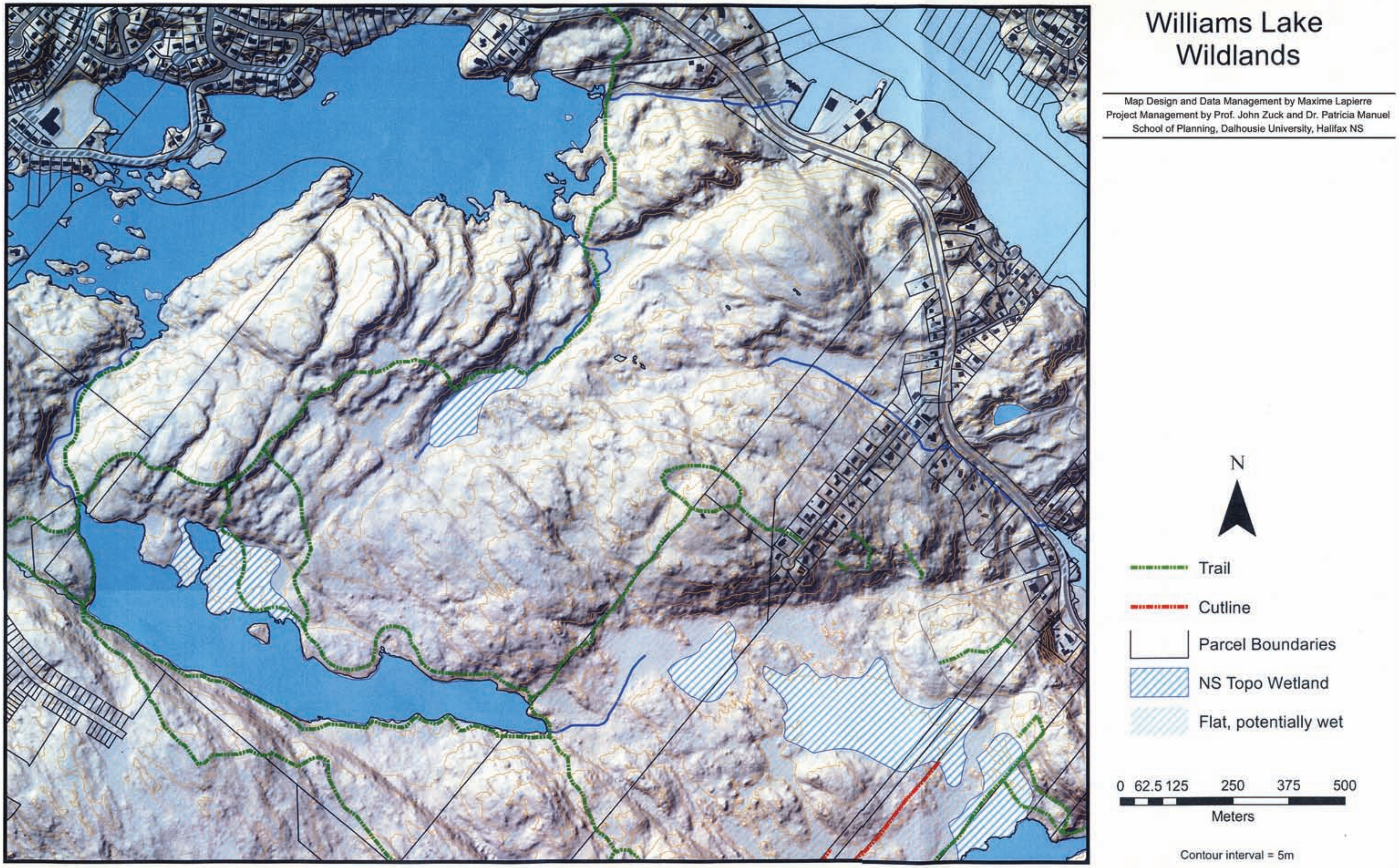
APPENDICES

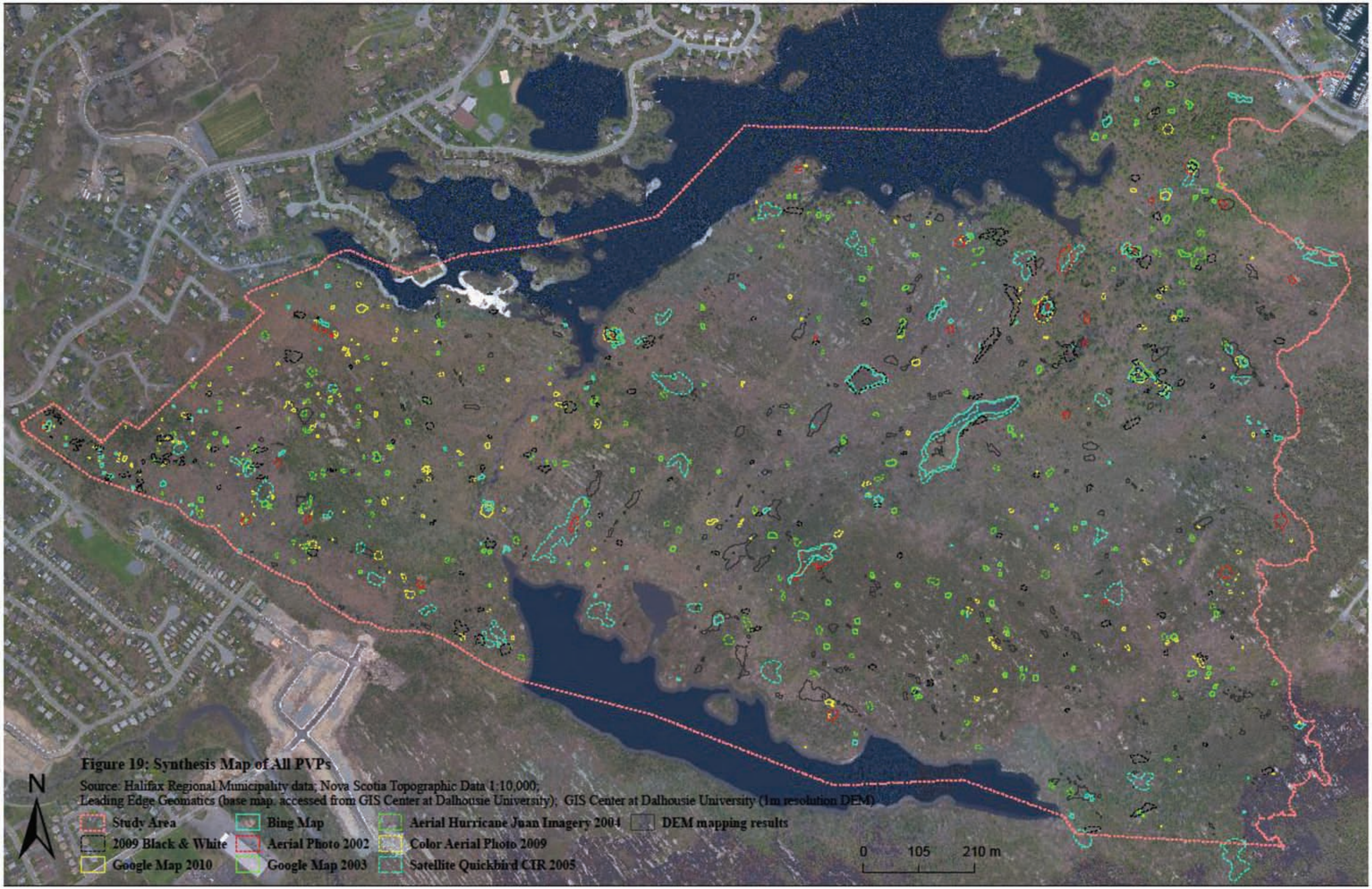
Photos posted online: http://versicolor.ca/wlbphotos



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.

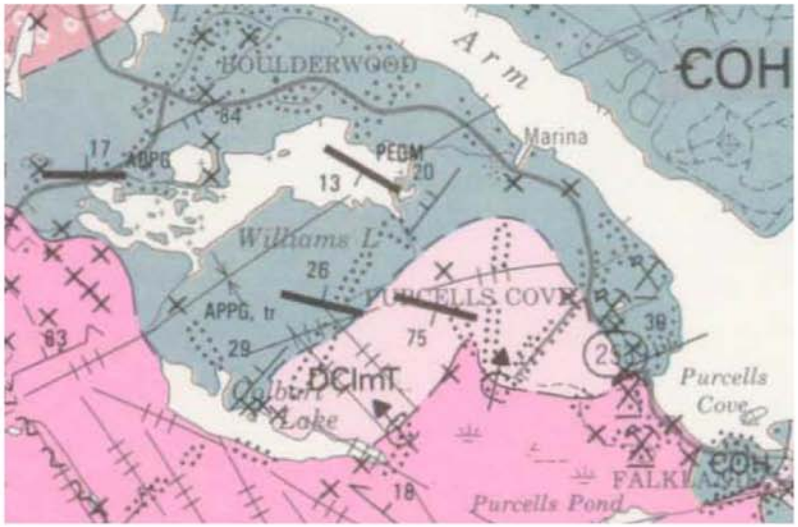


Appendix A Map 2 in *Ecological Assessment of the Plant Communities of the Williams Lake Backlands* REPORT to Williams Lake Conservation Co., Dec. 2013. Courtesy of Prof. Patricia Manuel, School of Planning, Dalhousie Univerity.

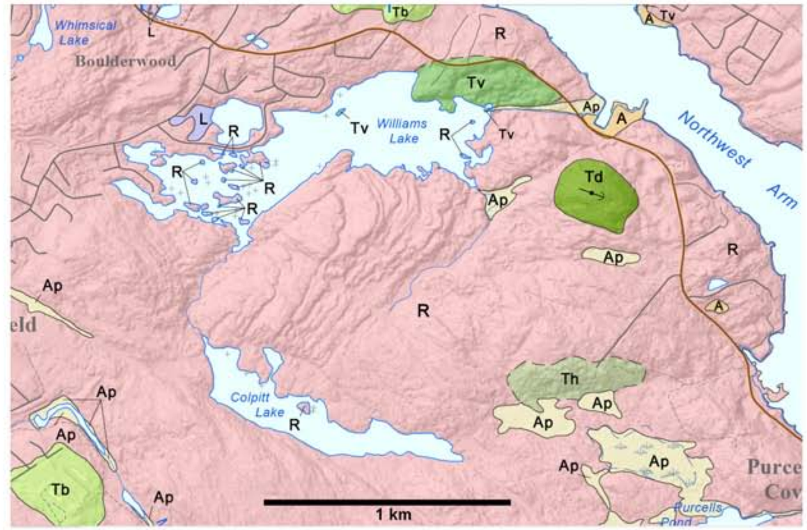


Appendix A Map 3: H. Liu's Synthesis Map of All Potential Vernal Ponds. In *Ecological Assessment of the Plant Communities of the Williams Lake Backlands:* REPORT to Williams Lake Conservation Co., Dec. 2013. Courtesy of Prof. Patricia Manuel, School of Planning, Dalhousie Univerity.

BEDROCK GEOLOGY



SURFICIAL GEOLOGY



DEVONO-CARBONIFEROUS

DCImHX 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%)

DCImT 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

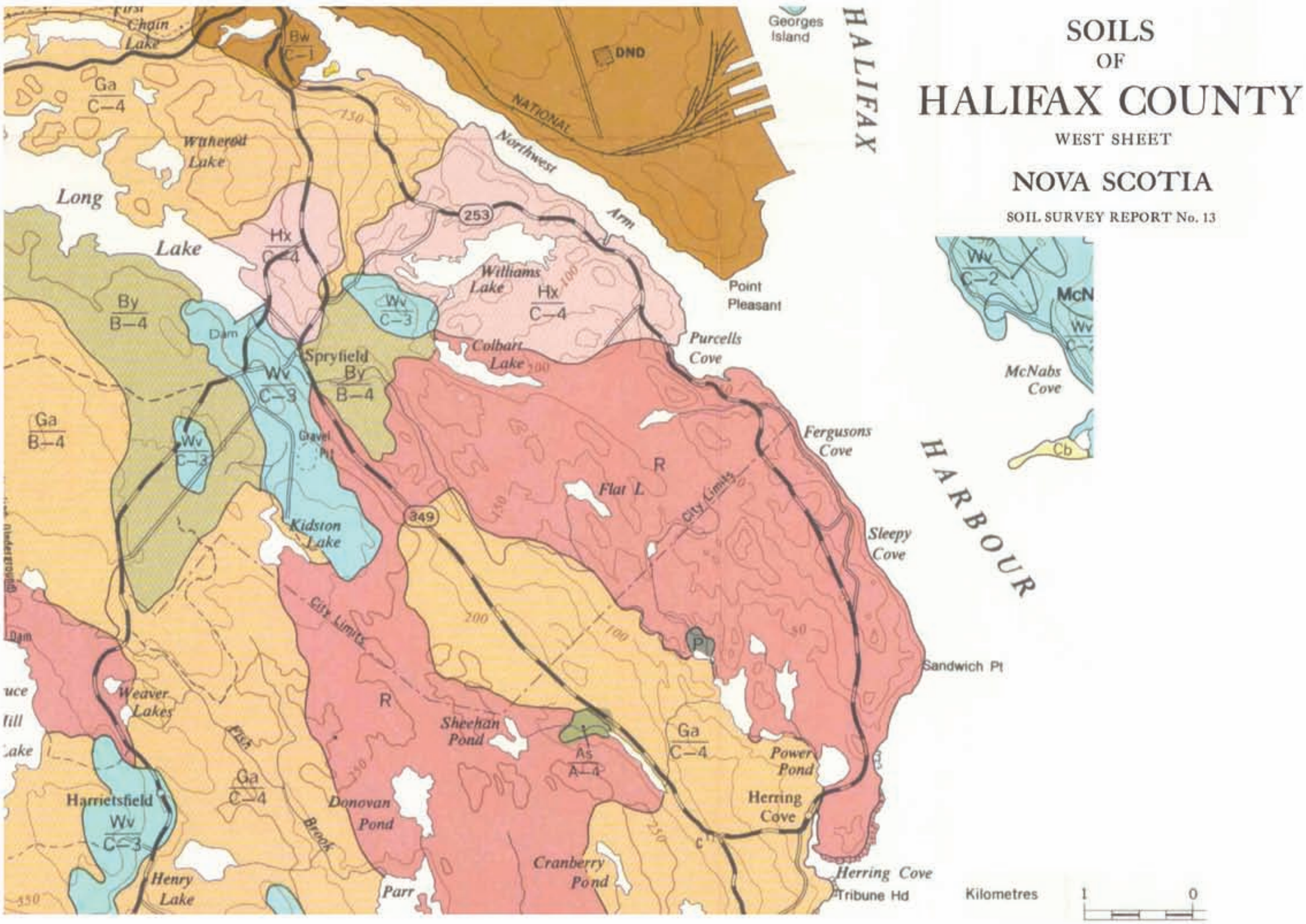
R *Bedrock*
Bedrock exposed at surface or beneath shallow soil. It may include minor fluvial, lacustrine and till deposits. Exposed surface is glacially scoured with ice movement features, such as striae, which are indicated by symbols where identified. Obvious 'strike ridges' seen on the LiDAR hillshade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

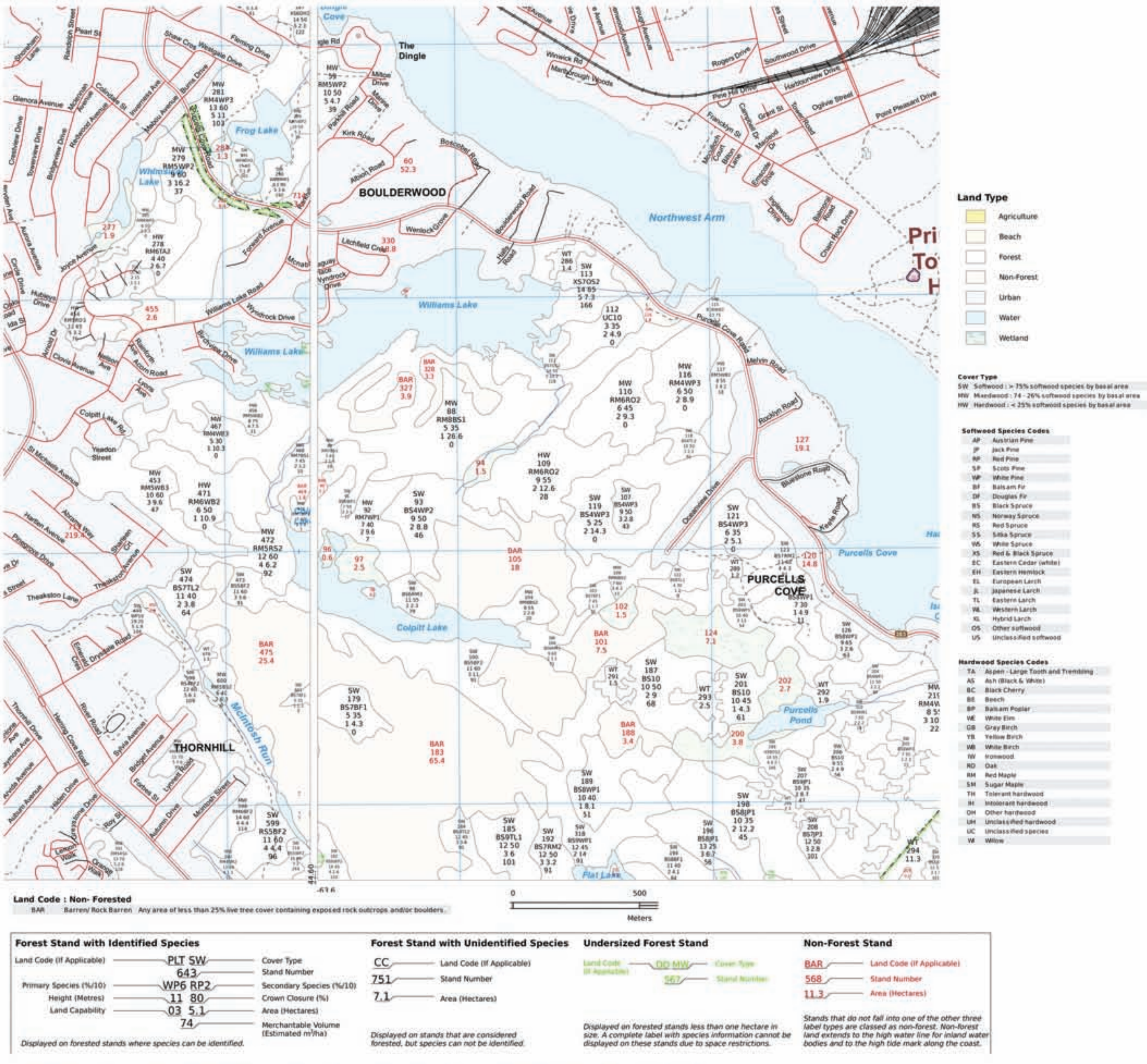
MAP COLOUR AND SYMBOL	SOIL SERIES OR LAND TYPE	DESCRIPTION OF SURFACE AND SUBSOIL	PARENT MATERIAL	TOPOGRAPHY	DRAINAGE
By	**BAYSWATER**	Grayish-brown sandy loam over dark yellowish brown sandy loam; mottled	Yellowish-brown coarse sandy loam till	Gently undulating to gently rolling	Imperfect drainage
Ga	**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).

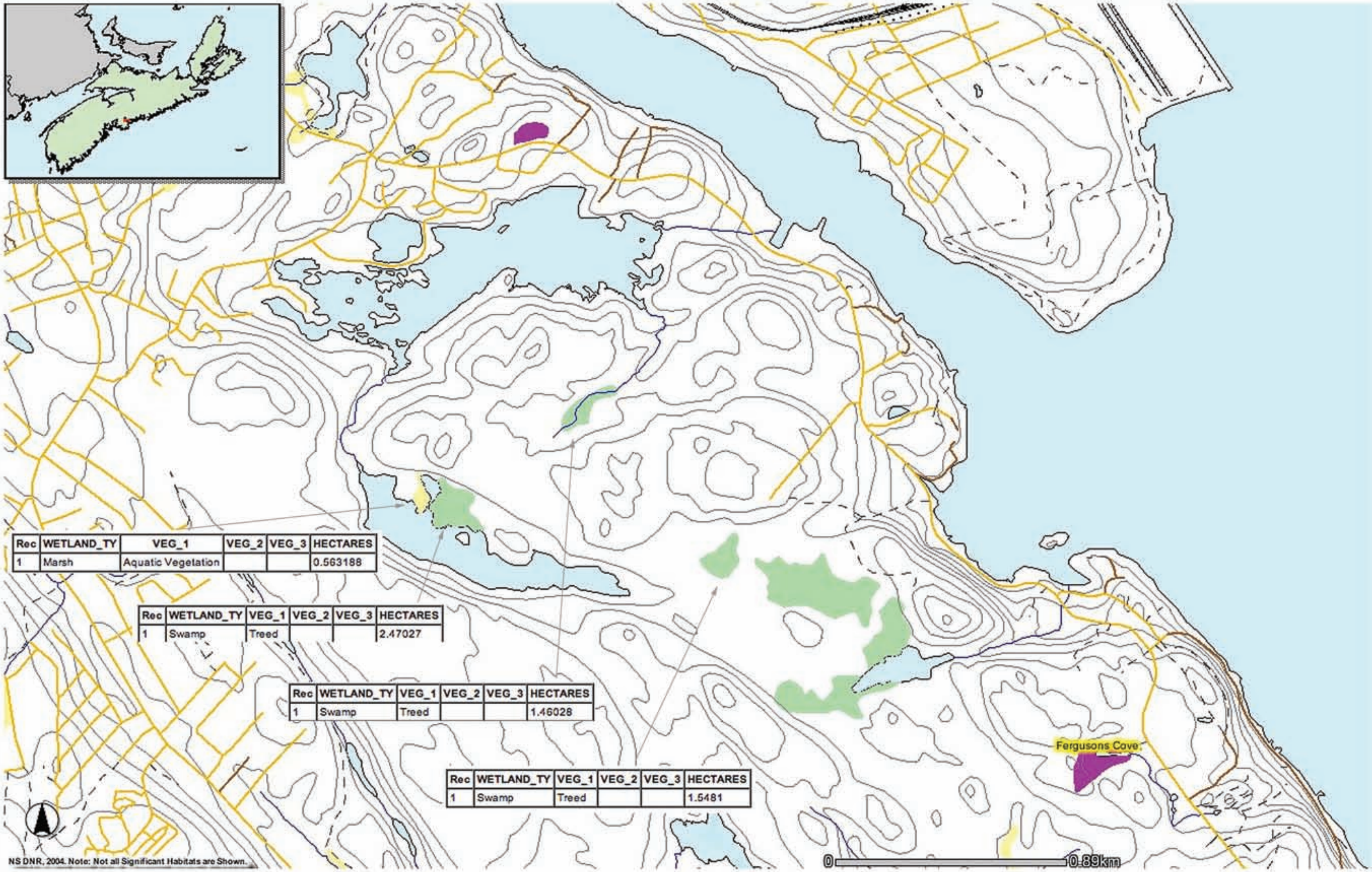
Nova Scotia DNR Forest Cover Type Map

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



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

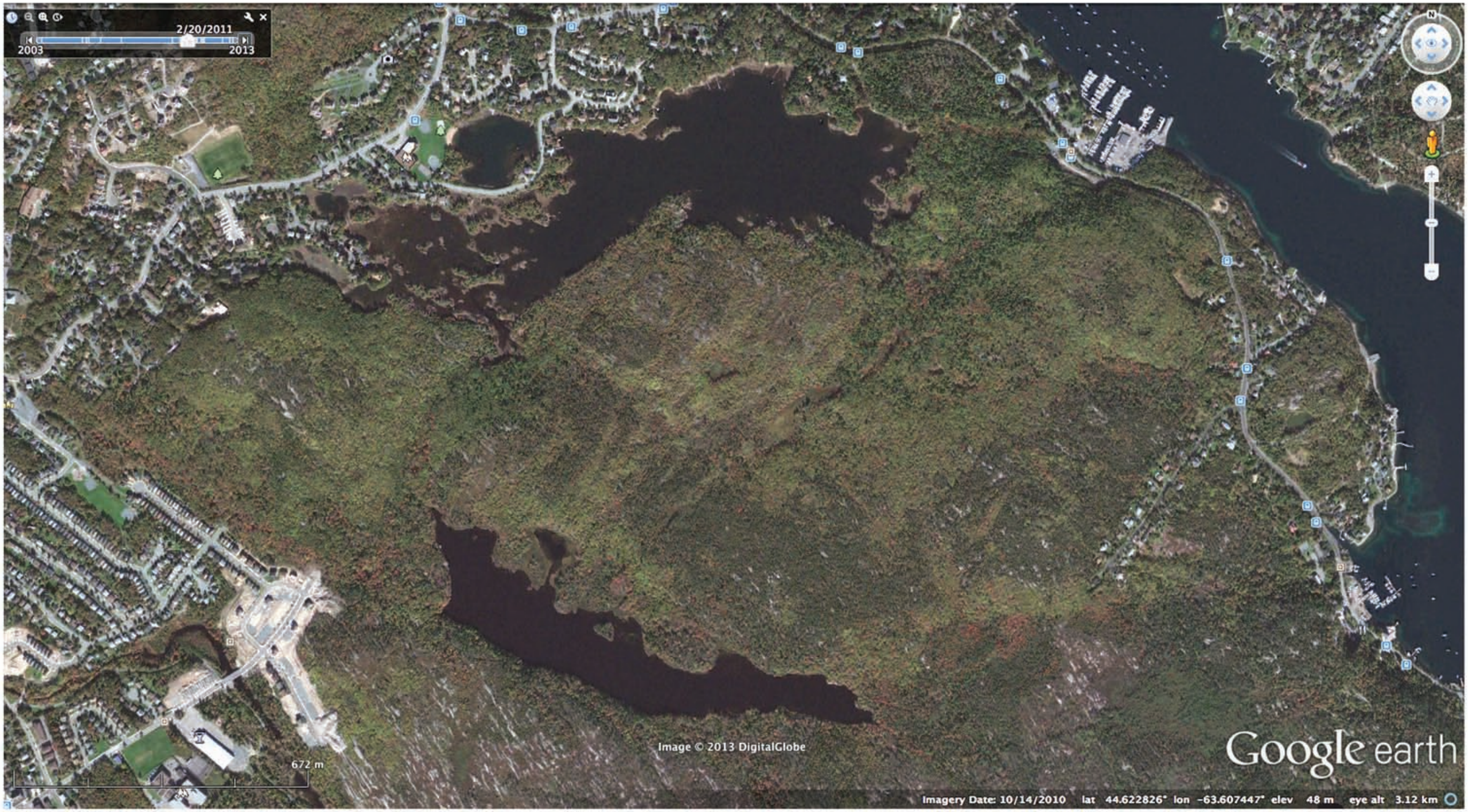
Appendix A Map 6 N.S. Forest Cover Map; in *Ecological Assessment of the Plant Communities of the Williams Lake Backlands:* REPORT to Williams Lake Conservation Co., Dec. 2013.



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

Appendix B. Common and Scientific Names for Vascular Plants
See Table 4.1 for these species listed alphabetically by scientific name.

Common Name	**Scientific Name**
American beech	*Fagus grandifolia*
American fly honeysuckle	*Lonicera canadensis*
American Mountain Ash	*Sorbus americana*
Atlantic Manna Grass	*Glyceria obtusa*
Balsam-Fir	*Abies balsamea*
Bayberry	*Myrica pensylvanica*
Bearded Shorthusk	*Brachyelytrum erectum*
Bebb's Willow	*Salix bebbiana*
Black chokeberry	*Photinia melanocarpa*
Black Huckleberry, Huckleberry	*Gaylusaccia baccata*
Black Spruce	*Picea mariana*
Bluejoint Reed Grass	*Calamagrostis canadensis*
Bobblebush	*Viburnum lantanoides*
Bog Aster	*Oclemena nemoralis*
Bog Fern	*Thelypteris simulata*
Bog Laurel	*Kalmia polifolia*
Boreal Bog Sedge	*Carex magellanica*
Bracken fern	*Pteridium aquilinum*
Bristly Sarsaparilla	*Aralia hispida*
Broom Sedge	*Carex scoparia*
Broom-crowberry	*Corema conradii*
Brown-Fruited Rush	*Juncus pelocarpus*
Bunchberry	*Cornus canadensis*
Canada Goldenrod	*Solidago canadensis*
Canada Holly	*Ilex verticillata*
Canada Manna Grass	*Glyceria canadensis*
Canada Rush	*Juncus canadensis*
Cinnamon Fern	*Osmunda cinnamomea*
common bladderwort	*Utricularia vulgaris*
Common Juniper	*Juniperus communis*
Common Woolly Bulrush	*Scirpus cyperinus*
Cow-wheat	*Melampyrum lineare*
Creeping Snowberry	*Gaultheria hispidula*
Dewberry	*Rubus hispidus*
Downy Goldenrod	*Solidago puberula*
Early Low Blueberry	*Vaccinium angustifolium*
Eastern Larch, Tamarack	*Larix laricina*

Evergreen Wood Fern	*Dryopteris intermedia*
Fibrous-Root Sedge	*Carex communis*
Flattened oatgrass	*Danthonia compressa*
Forest Woodrush	*Luzula luzuloides*
Gold-thread	*Coptis trifolia*
Golden Heather	*Hudsonia ericoides*
green alder	*Alnus viridis*
Harlequin Blue Flag	*Iris versicolor*
Hemlock	*Tsuga canadensis*
Horsetail	*Equisetum arvense*
Indian Pipe	*Monotropa uniflora*
Inkberry	*Ilex glabra*
Jack Pine	*Pinus banksiana*
Japanese barberry	*Berberis thunbergii*
Japanese knotweed	*Polygonum cuspidatum*
Labrador Tea	*Rhododendron groenlandicum*
Large Cranberry	*Vaccinium macrocarpon*
Large-pod Pinweed	*Lechea intermedia*
Large-toothed Aspen	*Populus grandidentata*
Leatherleaf	*Chamaedaphne calyculata*
Lesser Brown Sedge, Carex brûlé	*Carex adusta*
Low Rough Aster	*Eurybia radula*
Mayflower	*Epigaea repens*
Mountain Cranberry	*Vaccinium vitis-idaea*
Mountain Holly	*Nemopanthus mucronata*
Mountain Sandwort	*Minuartia groenlandica*
Northern Long Sedge	*Carex folliculata*
Northern Wild Raisin	*Viburnum nudum*
Partridgeberry / Twinberry	*Michella repens*
Pickering's Reed Grass	*Calamagrostis pickeringii*
Pin Cherry	*Prunus pensylvanica*
Pitcher plant	*Sarracenia purpurea*
Poison ivy	*Toxicodendron radicans*
Red Maple	*Acer rubrum*
Red Oak	*Quercus rubra*
Red Pine	*Pinus resinosa*
Red Spruce	*Picea rubens*
Rhodora	*Rhodora canadense*
Rhynchospora alba	*Rhyncospora alba*
Rock Polypody	*Polypodium virginianum*
Rough-stemmed Goldenrod	*Solidago rugosa*
Round-leaved Sundew	*Drosera rotundifolia*

Royal Fern	*Osmunda regalis*
Shadbush / Indian Pear	*Amelanchier laevis*
Sheep Laurel, Lambkill	*Kalmia angustifolia*
Shining Rose	*Rosa nitida*
Small Cranberry	*Vaccinium oxycoccus*
Speckled Alder	*Alnus incana*
Star Sedge	*Carex echinata*
Starflower	*Trientalis borealis*
starved panicgrass	*Dicanthelium depauperatum*
Striped Maple	*Acer pensylvanicum*
Sweet Gale	*Myrica gale*
Tawny Cottongrass	*Eriophorum virginicum*
Three-leaved Rattlesnakeroot	*Prenanthes trifoliolata*
Three-seeded Sedge	*Carex trisperma*
threeway sedge	*Dulichium arundinaceum*
Tree Clubmoss	*Lycopodium obscurum*
Trembling Aspen	*Populus tremuloides*
Tussock Sedge	*Carex stricta*
Umbellate Sedge	*Carex umbellata*
Velvet-leaf Blueberry	*Vaccinium myrtilloides*
Virginia Rose	*Rosa virginiana*
White Birch	*Betula papyrifera*
White Birch	*Betula populifolia*
White Pine	*Pinus strobus*
White-edged Sedge	*Carex debilis*
Whorled Wood Aster	*Oclemena acuminata*
Wild Lily of the Valley	*Maianthemum canadense*
Wild Sarsaparilla	*Aralia nudicaulis*
Wintergreen, Teaberry	*Gaultheria procumbens*
Witch-hazel	*Hamamelis virginiana*
Woolly Panic Grass	*Dichanthelium acuminatum*
Yellow Birch	*Betula alleghaniensis*

Appendix C. Jack Pine/Broom Crowberry Barrens: their occurrence and status as a recognized plant association

The Jack Pine/Broom Crowberry Barrens represent a type of pine barrens and a plant association that is nationally unique (occurring only in Nova Scotia) and found elsewhere only sparingly in northeastern Maine. (Jack Pine, but not Broom Crowberry, occurs in New Brunswick.) In both Maine and Nova Scotia, The Jack Pine/Broom Crowberry/Barrens are restricted to rocky outcrops near the Atlantic coast, and are associated with fires historically.

Jack Pine/Broom Crowberry Associations in Nova Scotia
Under the NSFVT classification (Neily et al., 2011), the Jack Pine/Broom Crowberry Barrens fall within VT (Vegetation Type) OW1 (Jack Pine/Huckleberry/Black crowberry/Reindeer lichen) and are well described as such, except for the occurrence in the WLB associations of Broom Crowberry (without black crowberry), and the absence of the more fire-sensitive species listed under OW1 such as Hemlock and Bazzania (a liverwort). Of the 1500+ plots sampled for the whole province to develop the NSFVT classification, 8 were classified as OW1. Broom Crowberry is mentioned under OW1 as follows:

> …dwarf heaths like black crowberry and less often boom crowberry are characteristic, especially in coastal areas

Broom Crowberry is not listed under the characteristic plants for OW1, meaning that it was not present in any of those 8 plots but the authors were aware of its occurrence elsewhere.

Sean Basquill (Nova Scotia Dept. Natural Resources) commented in an e-mail:

> Jack pine / Corema is recognized as a subassociation in the CNVC*. It is limited to Nova Scotia. These plots were not included in the provincial forest ecosystem classification (the primary author preferred to only include government and AC CDC plots) otherwise we would have recognized it as a variant in that framework… All coastal jack pine woodland is rare to uncommon in NS (with or without Corema).

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*The CNVC is the Canadian National Vegetation Classification. The website is at http://cnvc-cnvc.ca/ Specifically, he is referring to Subassociation A301b Corema conradii. It is one of three subassociations in the Association A301 *Pinus banksiana/Gaylussacia baccata-Empetrum nigrum/Sibbaldiosis tridentate/Cladina spp. Woodland* (Jack Pine/Black Huckleberry – Black Crowberry/Three-toothed cinquefoil/reindeer Lichen Woodland). Source: S. Basquill, personal communication.

OWI in the larger context is described as "relatively uncommon… rare in New Brunswick… [and] not known from anywhere else in Canada.

In regard to Jack Pine/Broom Crowberry associations, Sean Basquill remarked

> I have seen Jack pine and Broom Crowberry together but not very often. Most occurrences are coastal and I found one inland in Cumberland County. I have four coastal plots where jack pine and Broom Crowberry co-occur…I would speculate that the Broom Crowberry expression of OW1 may be found as far west as the Aspotogan peninsula and east to Canso.

Jack Pine/Broom Crowberry Associations in Maine

Formal reports on the occurrence of Jack Pine/Broom Crowberry associations in Maine appear to be limited to that by Redfield (1889) on "Pinus Banksiana with Broom Crowberry Conradii" in which he comments:

> When Mr Rand a year or two ago mentioned to me the existence of *Pinus banksiana* upon Schoodic Peninsula, I was very desirous to visit the locality, and on the 24th of August last I was enabled to do so in company with Mr. Theodore B. White, a member of the Agassiz Club of New York. At that time I had not the benefit of Mr. Rand's notes as given above, and ignorant of the topography, we were obliged to make our search very much at random. From Winter Harbor, we drove by the road which crosses to the *eastern* side of the peninsula and then turns southerly till it terminates in a farm. Long before reaching this terminus we passed through a forest composed almost exclusively of *Pinus banksiana ,* the trees reaching to the height of at least twenty or thirty feet. Occasionally a spruce or arbor vitae appeared but for the most part this pine seemed to have displaced the usual coniferous growth of the Maine coast.... We continued to see more or less of this pine…We may therefore safely conclude that this peculiar species abounds over the whole peninsula.
>
> While gazing at the trees of *Pinus Banksiana* we were surprised at finding ourselves in the midst of a remarkable station of *Broom Crowberry Conradii*. This plant was growing most abundantly in the open, rocky glades among the pines, and seemed to cover every spot where there was sufficient earth to support it. One of these glades was about 250 feet in length by125 feet in width, and another of nearly equal extent was also covered more or less with patches of *Broom Crowberry*, and probably we did not see its utmost limits. Wherever the glades were closed by a more compact growth of pines the *Broom Crowberry* disappeared, and was replaced mostly by *Vaccinium pennsylvanicum*. In the localities of *Broom Crowberry* farther west and south which I have seen, the accompanying tree growth has usually been of *Pinus rigida*, but evidently this little shrub is equally at home with *Pinus banksiana*.

The Schoodic Peninsula lies within Acadia National Park in Maine. Current descriptions of the area (e.g. in Beginning with Habitat, n.d) refer to Pitch Pine/Broom Crowberry Associations, and do not mention Jack Pine. In e-mail correspondence we received the following comments:

> We have one documented occurrence of the pitch-pine broom crowberry woodland in Acadia, but not on Schoodic Peninsula (on Mount Desert Island). In our vegetation map report, there is a brief mention of a northern variant of this community being dominated by jack pine instead of pitch pine. Here's a link to our vegetation map report (http://www.usgs.gov/core_science_systems/csas/vip/parks/acad.html), and the passage I mentioned is in Appendix I, page 39 under the Globally section.
>
> Unfortunately the Acadia vegetation map and report were completed under the old U.S. National Vegetation Classification System, which is now obsolete. The latest USNVC doesn't mention anything about jack pine in the description of the pitch pine/ broom crowberry woodland (now called that Coastal Pitch Pine Rocky Woodland, with unique identifier CEGL006154). I searched the NatureServe Explorer (http://www.natureserve.org/explorer/servlet/NatureServe?init=Ecol) for jack pine woodland communities in Nova Scotia, and only turned up Jack Pine Heath Barrens (CEGL006641), and broom crowberry isn't mentioned in this community description.
>
> Jack pine and broom crowberry probably do co-occur on Schoodic Peninsula, but it's not common (I haven't seen it). I unfortunately don't have any data to back this claim up, and it's

not mapped by the USNVC that way (just as jack pine woodland or mixed conifer woodland). Jack pine and black crowberry do occassionally occur together on Schoodic Peninsula where the jack pine woodlands meet the exposed headlands. But again, they're not classified as a special community and I have no data to support that claim.

- Kathryn Miller, (Plant Ecologist, Northeast Temperate Network Acadia National Park)

Here are some photos of this community in Maine. I know of at least two locations of this community type (Pitch Pine/Jack Pine/Broom Crowberry) on Vinal Haven island.

- **Jeremy Lundholm** (Saint Mary's University, Halifax)

Interesting discussion. As you know, we have all the species referenced in the dialogue below in Maine, but very seldom are they in the same place. Things generally break out here with Pitch Pine and Broom Crowberry falling into our Pitch Pine Woodland type (http://www.maine.gov/dacf/mnap/features/communities/pitchpinewoodland.htm). This type generally occurs west of Penobscot Bay (i.e., southwest coast of Maine).

Meanwhile, Jack pine and Empetrum mixes fall into our Jack Pine Woodland type (http://www.maine.gov/dacf/mnap/features/communities/jackpinewoodland.htm), which is generally east of Penobscot Bay.

There are, as Jeremy mentions, a handful of sites around Penobscot Bay where both of these types intergrade, including Vinalhaven, Isle au Haut (part of Acadia National Park), and perhaps a few other places in Acadia NP. I think of these mixes as transitions rather than distinct types, but our state classification tends to be more coarse than that used in the Maritimes.

- Andrew Cutko (Maine Department of Agriculture, Conservation, and Forestry)

Thus whatever was the case in 1889 when Redfield reported his observations, it is clear that today Jack Pine/Broom Crowberry associations are very rare in Maine.

<u>Significance of Jack Pine/Broom Crowberry Barrens in the WLB and larger Purcell's Cove Backlands.</u>

The restriction of Jack Pine/Broom Crowberry Barrens to the Atlantic Coast of Nova Scotia, and coastal NE Maine can be attributed to the unique coincidence of several factors in those areas:

- Jack Pine, a boreal species, is close to the southern extent of its range while Nova Scotia is at the northern extremity of the range for broom crowberry, an Atlantic Coastal Plain species.
- Both species require or do best in rapidly draining, acidic, nutrient-poor environments and are shade intolerant.
- Both species have specific adaptations to drought and fire and are stimulated by recurrent fire and tend to be eliminated if fire intervals are very short (perhaps less than 10-20 years) or very long (100+ years), although they may persist in the most exposed barrens habitats in which other stressors limit competition in the absence of fire.
- Broom Crowberry is restricted to areas not experiencing a high level trampling, ATVs & deer grazing.

Between us (N. Hill & David P.), we have observed coastal or near coastal Jack Pine/Broom Crowberry barrens at Blandford Nature Reserve (on the Aspotogan Peninsula), on crown land in the Peggy's Cove area and in the Five Bridge Lakes Wilderness Area (Chebucto Peninsula), in Blue Mountain-Birch Cove Lakes Protected Wilderness Area, on the Crowbar Trail (Salmon River Wilderness Area) and in the Canso Barrens. The Jack Pine/Broom Crowberry barrens in the WLB and the larger Purcell's Cove backlands are the most locally concentrated and overall most healthy of any of these sites. The complex of patch sizes and ages since burns of Jack Pine/Broom Crowberry barrens in the WLB and larger Purcell's Cove backlands are likely factors in the overall health of these stands. The largest single patch of Jack Pine/Broom Crowberry Barrens in the Purcell's Cove Backlands appears to be the approximately 22 ha patch just north of the eastern half of Colpitt Lake (Fig. 3.3).

Clearly, the WLB and the larger Purcells Cove Backlands are key to the conservation of the nationally unique and globally rare Jack Pine/Broom Crowberry Barrens community for which Nova Scotia would seem to have the primary global responsibility for conservation.

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REPORT OF RADIOCARBON DATING ANALYSES

Dr. David Patriquin — Report Date: 11/27/2013

Dalhousie University — Material Received: 11/20/2013

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 365325	1270 +/- 30 BP	-26.1 o/oo	1250 +/- 30 BP

SAMPLE : JP75cmSite1C
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 680 to 830 (Cal BP 1270 to 1120) AND Cal AD 840 to 870 (Cal BP 1110 to 1080)

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.1:lab. mult=1)

Laboratory number: **Beta-365325**

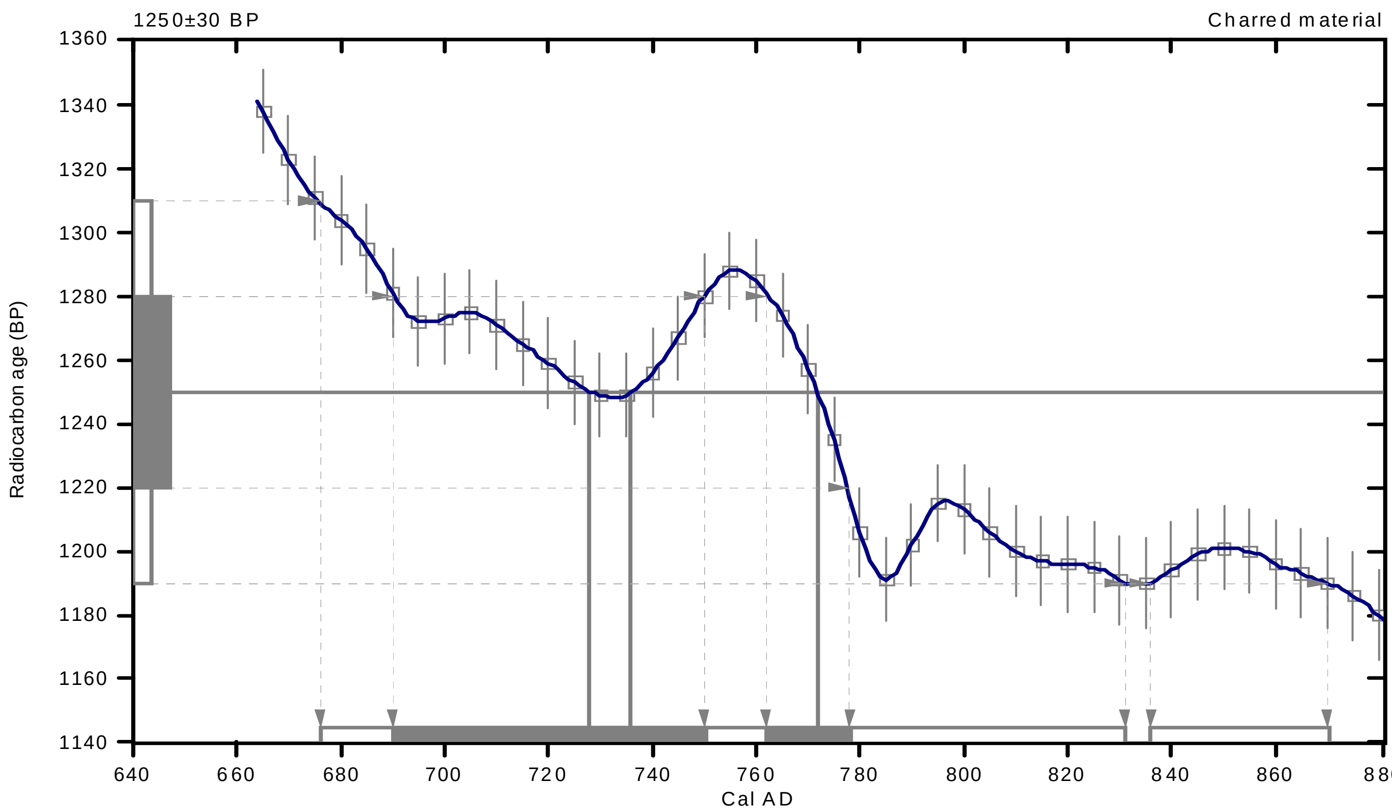
Conventional radiocarbon age: **1250±30 BP**

2 Sigma calibrated results: **Cal AD 680 to 830 (Cal BP 1270 to 1120) and**
(95% probability) **Cal AD 840 to 870 (Cal BP 1110 to 1080)**

Intercept data

Intercepts of radiocarbon age
with calibration curve: Cal AD 730 (Cal BP 1220) and
Cal AD 740 (Cal BP 1210) and
Cal AD 770 (Cal BP 1180)

1 Sigma calibrated results: Cal AD 690 to 750 (Cal BP 1260 to 1200) and
(68% probability) Cal AD 760 to 780 (Cal BP 1190 to 1170)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):1-244, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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