Community Stewardship and Biodiversity Enhancement of Public Greenspaces

Daniel Buckles[1,2], Catherine Shearer[1], Kris Phillips[1], Adrian Bradley[1], Chieu-Anh Ta[3], Braydon Hall[3] and John Thor Arnason[1,3]*

1. Champlain Park Environment Committee, Kitchissippi, Ottawa ON
2. Sociology and Anthropology Department, Carleton University, Ottawa ON
3. Biology Department, University of Ottawa, Ottawa ON
* Corresponding authors: dbuckles@sas2.net, john.arnason@uottawa.ca

Abstract: Plant biodiversity in urban woodlands near the Ottawa River was assessed and found to have low native biodiversity. Community volunteers responded by planting native trees using various techniques (Hügelkultur mounds, Miyawaki or "Tiny Forest" plantations, terracing) and establishing several native pollinator gardens. Biodiversity enhancement included both native Great Lakes and St. Lawrence forest species and Carolinian species, with attention to ethnobotanical and forest food species as well as herbaceous plants supporting native pollinators. The experience suggests that community stewardship of public greenspaces offers an efficient and effective means to achieve meaningful conservation and public education outcomes.

Keywords: Native plants, Carolinian species, biodiversity enhancement, Hügelkultur mounds, medicinal plants, food forest, pollinator garden.

Monarch Butterfly on White Turtlehead. Photo by C. Shearer.

1. Context and Rationale

The woodlands and meadows in the City of Ottawa along the Ottawa River no longer resemble the historic communities of plants and animals characteristic of the habitat. Many native species of plants are missing from the landscape, replaced by introduced and invasive species that provide poor habitat for native species of insects, birds and other animals. The overall effect is severe biodiversity loss and weakened ecosystem function.

The Champlain Park neighbourhood in Kitchissippi Ward, between Tunney's Pasture in the east and Island Park Drive in the west (Map 1), illustrates this transformation in ways consistent with the most important direct drivers of recent global anthropogenic biodiversity loss: land use change and direct exploitation of natural resources (Jaureguiberry et al. 2022).

The area was cleared and developed for cottage lots by the Cowley family over 100 years ago (Buckles and Huron, unpublished). In the 1950s, a narrow strip of land bordering the Ottawa River on the north was expropriated by the National Capital Commission (NCC) to make way for the Ottawa River Parkway running west to east into Ottawa's downtown. Cottage properties with gardens were demolished and greenspace left to regenerate unattended on "alvar-like" conditions (very shallow rendoll soil on limestone subject to frequent wet-dry cycles). Over time, a very dense thicket dominated by invasive buckthorn (a mix of *Rhamnus* spp.) emerged, along with a few native trees and a mix of introduced perennials such as lilacs (*Syringa vulgaris*) and periwinkle (*Vinca* spp.), and native understory plants such as Smooth Rose (*Rosa blanda*) and Poison Ivy (*Toxicodendron radicans*).

The 1998 ice storm affecting eastern Ontario and the arrival in the region of the Emerald Ash Borer, both drivers of biodiversity loss associated with climate change and invasive alien species, also took their toll, displacing native species and arresting the process of natural regeneration.

In 2016, residents in Champlain Park applied through the neighbourhood association to the NCC for a land access permit with a view to enhancing recreational uses of a section of the NCC woodlands known as the Champlain Woods and introducing native species of trees. An existing informal trail was improved and several hundred Bur Oak acorns planted using acorns collected from individual trees in the neighbourhood that predated residential development and were likely part of the original riverine ecosystem (Buckles and Huron, unpublished). An inventory of 344 trees in a three-block residential section of the neighbourhood guided the selection of additional native tree species introduced into the woods (Shearer and Buckles, unpublished).

In 2019, in cooperation with the office of the Councillor for Kitchissippi Ward, the City of Ottawa, the EnviroCentre and the Champlain Park Community Association, residents de-paved an underutilized section of Pontiac Street between the City Park and the NCC woodlands (Map 1: D; photo below). This 600-m^2 space connected the Ottawa River summer cycling/walking pathways and network of winter ski trails to a trailhead at the Champlain Park field house. The City covered the de-paved area with a thin layer of soil and seeded it with grass.

Map 1: Champlain Park and planting sites.

It immediately became evident to residents that other actions were needed to make the most of the public space and to improve its overall aesthetic appeal. Broken fences, dead trees and abandoned gravel parking areas along the roadway

Neighbours removing sections of Pontiac Street. Photo by D. Buckles.

that had gone unnoticed or were tolerated prior to closure of the street, marred the experience of the public space. This prompted the authors, under the auspices of the Environment Committee of the Champlain Park Community Association, to organize a series of actions to both beautify and rehabilitate the de-paved area and surrounding open space, including both NCC and City of Ottawa property. Different species were selected and different site preparation methods used, depending on the specific conditions at each sub-site, resources available and experimental interest. Results from four sub-sites within the public space are reported here (Map 1).

Site preparation. Photo by K. Phillips.

2. Results

2.1 Existing plant biodiversity in the Champlain Woods

Of three woodland transects in 2017, reported here is a representative 10 x 100 m quantitative E-W transect starting from 10 m north of a benchmark at the Carleton Ave. entrance. It was dubbed the broken canopy site because there are many gaps and an uneven canopy, with buckthorn *(Rhamnus cathartica* and *R. frangula*) reaching 5 m in height and emergent trees 10-20 m. The most important tree in the transect was invasive buckthorn (Table 1) with an importance value of 71 out of a total of 300. This indicates that it was the dominant species, occupying approximately 25% of the canopy ecosystem.

Buckthorn has a very low (5 m) and dense canopy with little light below and little undergrowth. Knight et al. (2007) reported that buckthorn's high fecundity, bird-dispersed fruit, high germination rates, seedling success in disturbed conditions, and secondary metabolite production (anthroquinones) contribute to its success. Seltzner and Eddy (2003) found fruit and leaf extracts to be allelopathic and research by Arnason and Cappucino (unpublished) showed that buckthorn anthroquinones administered orally induced mortality or reduced growth and development of herbivorous insects.

Ash was the second most important tree. It was experiencing high mortality at the time of sampling due to the invasive Emerald Ash Borer, contributing to the overall situation of open canopy and low density of large trees. The transect revealed the presence of only six healthy native species which appeared as emergent trees above the low buckthorn canopy (American Basswood, White Pine, American Elm, Balsam Poplar, Bur Oak, hawthorn) and some ornamental lilac. The density and diversity of healthy native trees was less than in a comparable undisturbed forest we observed in Britannia and Shirley's Bay.

Table 1. Trees in broken canopy forest.

Species	**Rank of importance***
Buckthorn *Rhamnus* spp.	1
Red Ash *Fraxinus pennsylvanica* Marshall	2
White Pine *Pinus strobus* L.	3
Bur Oak *Quercus macrocarpa* Michx.	4
American Elm *Ulmus americana* L.	5
Balsam Poplar *Populus balsamifera* L.	6
American Basswood *Tilia americana* L.	7
Lilac *Syringa vulgaris* L.	8
Black Walnut *Juglans nigra* L.	9
Hawthorn *Crataegus* sp.	10

Mapping methods described in Lambert and Arnason (1978).
*The sum of the relative frequency, density and dominance of a tree species determines its rank of importance in the surveyed area.

The transect showed that the sapling layer was dominated to a great extent by both Common and Glossy Buckthorn, which represented 319 out of 521 saplings counted. In comparison, native sapling tree species found included ash, Bur Oak, maple, and Balsam Fir. A few native shrubs/saplings were found such as Wild Rose, hawthorn and cherry, but the non-invasive introduced species such as lilac and honeysuckle had a much higher frequency.

The ground cover was sparse and dominated by weedy species such as grasses, dandelion, cinquefoil and Creeping Charlie, among others. We encountered the highly invasive Dog-strangling vine (*Vincetoxicum rossicum*) and Lesser Periwinkle (*Vinca minor*) within the transect. Garlic Mustard (*Alliaria petiolata*) and Japanese Knotweed (*Falopia japonica*) were also found in adjacent areas. In buckthorn-dominated areas, there was almost no ground cover except moss, due to the intense canopy cover and allelopathy. Native forest spring ephemeral species such as trillium, ginger, or bloodroot were not found in the transect. The only spring flowers were Purple Violet and Trout Lily, which were found in isolated adjacent patches but not in the transect.

Two other transects in other locations showed similar results, adding a few other tree species (Butternut, Silver Maple, Crack Willow) to the sample. Additional observations in the Champlain Woods by Owen Clarkin found Rock Elm, Slippery Elm and Common Hackberry (personal communication).

2.2 Species selection for introduction

The authors selected species considering specific conditions at each site and experimental interests. A literature search conducted to determine suitable native species for the Champlain Woods focussed on the nearby Britannia Conservation Area (BCA), reported to have a flora of 365 species (239 native) in the mature mixed forest of White Pine or hardwoods around Mud Lake and a diverse understory of native trees, shrubs and ground cover (iNaturalist). Although BCA has more varied habitats than the Champlain Woods, this checklist served as the basis for the selection of native species for introduction.

Trees of Canada provided a useful checklist for Carolinian species, as did a list of Carolinian species present at the Central Experimental Farm Arboretum. Mature specimens of Northern Catalpa, Black Walnut and Kentucky Coffee-tree (Carolinian species) were also found in the neighbourhood.

Ethnobotanical, medicinal and edible species information available in publications by the uOttawa team were also considered (Arnason et al. 1981, MacKinnon et al. 2009, Hamersley Chambers and Harris 2012), along with candidate species known to be in the Fletcher Wildlife Garden where one of the authors volunteers. In addition, surveys by Catling et al. (2014) provided lists of typical alvar species from the Burnt Lands near Almonte, which have similar conditions to the Champlain Woods (limestone on very thin soils and strong hyper-seasonal flooding in spring and dry in summer).

Species names presented here are consistent with the Database of Vascular Plants of Canada (VASCAN) on the Canadensis website at https://data.canadensys.net.

2.3 Tree Planting

2.3.1 Miyawaki plantation of native trees

A Miyawaki forest is a high-density, high-diversity forest in an urban environment (Lewis 2022). The high density and diversity balances cooperation and competition among plants that root at different depths and grow to different heights. Density also encourages vertical growth rather than spreading branches. Overall, a Miyawaki forest, also known as a "Tiny Forest," has been shown to grow faster than a normal native forest or plantation forest due to the positive competition of plants and rapid formation of organic matter on the soil surface.

A Miyawaki forest was planted on a linear strip (2 x 90 m) along Pontiac Street formerly used for parking (Map 1, A). The existing soil was mainly a mix of gravel with construction fill on an underlying layer of rock and native soil within 50 cm of the surface. The planting method was to dig holes by hand at 1 m separation and approximately 50 cm in diameter, and refill with a mix of the native soil and commercial black topsoil. The soil mix was intended to improve soil quality while also habituating root growth to the surrounding soil type.

A total of 134 trees and shrubs, including 27 native species typical of the Ottawa area, were planted in spring and fall 2020, mainly from small caliper bare root stock obtained at the Ferguson Tree Nursery (Table 2). This collection of species increased tree and shrub diversity several-fold over that found in the Champlain Woods transect. The trees were mulched and watered regularly during the growing season, mainly by students doing volunteer hours. In addition, most saplings were protected from herbivores with 1-cm mesh metal cages. After two years, 90% of the tree saplings planted have survived. Trees that didn't were replaced.

Table 2. Miyawaki plantation of native trees		
Eastern Tiny Forest Site (Map 1: A)		
Summary: 134 trees, 27 species		
Planting method: direct planting in holes dug to bedrock in native soil; with black and native soil mix; mulched with leaves		
Verification Period: Autumn 2022		
	Species	**Number of Specimens**
1	Alternate-leaved Dogwood *Cornus alternifolia* L.f. (Cornaceae)	7
2	American Basswood *Tilia Americana* L. (Tiliaceae)	1
3	Black Raspberry *Rubus occidentalis* L. (Rosaceae)	2
4	Red Raspberry *Rubus idaeus* var strigosus (Michx.) Focke (Rosaceae)	1
5	Bur Oak *Quercus macrocarpa* Michx. (Fagaceae)	15
6	Butternut *Juglans cinerea* L. (Juglandaceae)	3

7	Choke Cherry *Prunus virginiana* L. (Rosaceae)	15
8	White Snowberry *Symphoricarpos albus* (L.) S.F. Blake (Caprifoliaceae)	1
9	Eastern White Cedar *Thuja occidentalis* L. (Cupressaceae)	1
10	Eastern White Pine *Pinus strobus* L. (Pinaceae)	4
11	Fragrant Sumac *Rhus aromatica* Aiton (Anacardiaceae)	2
12	Highbush Cranberry *Viburnum opulus* var. *americanum* Aiton (Adoxaceae)	15
13	Ironwood *Ostrya virginiana* (Mill.) K. Koch	1
14	Nannyberry *Viburnum lentag*o L. (Adoxaceae)	15
15	Eastern Ninebark *Physocarpus opulifolius* (L.) Maxim (Rosaceae)	1
16	Pin Cherry *Prunus pensylvanica* L.f. (Rosaceae)	1
17	Red Maple *Acer rubrum* L. (Sapindaceae)	1
18	Red Oak *Quercus rubra* L. (Fagaceae)	5
19	Red-osier Dogwood *Cornus sericea* L. (Cornaceae)	15
20	Canada Serviceberry *Amelanchier canadensis* (L.) Medik. (Rosaceae)	1
21	Silver Maple *Acer saccharinum* L. (Sapindaceae)	15
22	Tamarack *Larix laricina* (Du Roi) K. Koch (Pinaceae)	2
23	White Birch *Betula papyrifera* Marshall (Betulaceae)	6
24	Common Winterberry *Ilex verticillata* (L.) A.Gray (Aquifoliaceae)	1
25	Yellow Birch *Betula alleghaniensis* Britton (Betulaceae)	2
26	Kentucky Coffee-tree *Gymnocladus dioicus* (L.) K. Koch (Sapindaceae)*	1
27	Tulip Tree *Liriodendron tulipifera* L. (Magnoliaceae)*	1
Total		**134**

*Carolinian or warmer climate species.

2.3.2 Interplanting trees in woodlands using Hügelkultur mounds

Hügelkultur is a German term meaning hillock or mound cultivation. It is a method of building planting beds using woody material, garden debris and soil arranged in mounds or trenches (Chalker-Scott 2017). It is ideal for thin soils where mounds can provide a slow release of nutrients for plants and contribute to soil building.

While normally used for growing vegetables and herbs, the Hügelkultur planting method was selected for two subsites in the Champlain Woods because of the very thin rocky soil. Previous efforts to plant in these areas involved considerable time and effort to dig holes for saplings, with mixed results. Ash removal at the sites by the NCC provided a ready supply of woody debris, which was mixed with commercial black soil and leaf litter to create mounds approximately 35 cm high and 70 cm in diameter.

Hügelkultur mound with Bur Oak sapling. Photo by D. Buckles.

A total of 87 trees, 19 species native to the Great Lakes/Saint Lawrence area plus some of Carolinian origin, were planted at two sites in the fall of 2020, spring of 2021 and spring of 2022, mainly using very small-caliper saplings in a greenhouse plug obtained from the Ferguson Nursery through a program of Ecology Ottawa. At one of the sites, Black Walnut Way (Map 1: B), species were chosen for their tolerance of juglone allelopathy due to the presence of mature Black Walnut trees. The other site, Trout Lily Lane (Map 1: C), is a similar habitat, with very thin soils and occasional flooding (Table 3).

Table 3. Species interplanted into Champlain Woods with Hügelkultur mounds		
Table 3.1. Black Walnut Way Site (Map 1: B)		
Summary: 47 Trees and shrubs, 16 species		
Planting method: Hügelkultur mounds; black and native soil mix; mulched with leaves		
Verification Period: Autumn 2022		
	Species	**Number of Specimens**
1	Alternate-leaved Dogwood *Cornus alternifolia* L.f. (Cornaceae)	3
2	Sycamore *Platanus occidentalis* L. (Platanaceae)*	1
3	Choke Cherry *Prunus virginiana* L. (Rosaceae)	2
4	Black Elderberry *Sambucus nigra* L. (Adoxaceae)	6
5	American Bladdernut *Staphylea trifolia* L. (Staphylaceae)*	1
6	Burr Oak *Quercus macrocarpa* Michx. (Fagaceae)	13
7	Eastern White Cedar *Thuja occidentalis* L. (Cupressaceae)	6
8	Eastern Redbud *Cercis canadensis* L. (Fabaceae)*	1
9	Eastern White Pine *Pinus strobus* L. (Pinaceae)	1
10	Northern Bush-honeysuckle *Diervilla lonicera* L. (Caprifoliaceae)	3
11	Fragrant Sumac *Rhus aromatica* Aiton (Anacardiaceae)	2
12	Silver Maple *Acer saccharinum* L. (Sapindaceae)	2
13	Tamarack *Larix laricina* (Du Roi) K. Koch (Pinaceae)	1
14	White Birch *Betula papyrifera* Marshall (Betulaceae)	2
15	White Spruce *Picea glauca* (Moench) Voss (Pinaceae)	1
16	Yellow Birch *Betula alleghaniensis* Britton (Betulaceae)	2
Total		**47**

*Carolinian or warmer climate species.

Heritage Champlain Bur Oak in the neighbourhood; Bur Oak seedlings in a backyard nursery. Photos by D. Buckles.

Table 3.2. Trout Lily Lane (east and west side of trail) (Map 1: C)		
Summary: 40 trees, 13 species		
Planting method: Hügelkultur mounds; black and native soil mix; mulch; 20% planted directly in native soil		
Verification Period: Autumn 2022		
	Species	**Number of Specimens**
1	Alternate-leaved Dogwood *Cornus alternifolia* L.f. (Cornaceae)	5
2	Black Chokeberry *Aronia melanocarpa* (Michx.) Elliott (Rosaceae)	2
3	Black Elderberry *Sambucus nigra* L. (Adoxaceae)	3
4	Bur Oak *Quercus macrocarpa* Michx. (Fagaceae)	7
5	Eastern Buttonbush *Cephalanthus occidentalis* L. (Rubiaceae)	1
6	Choke Cherry *Prunus virginiana* L. (Rosaceae)	1
7	Eastern White Cedar *Thuja occidentalis* L. (Cupressaceae)	2
8	Showy Mountain-ash (*Sorbus decora*) (Sargent) C.K. Schneider (Rosaceae)	1
9	Tamarack *Larix laricina* (Du Roi) K. Koch (Pinaceae)	2
10	White Birch *Betula papyrifera* Marshall (Betulaceae)	8
11	White Spruce *Picea glauca* (Moench) Voss (Pinaceae)	2
12	Smooth Rose (*Rosa blanda*) Aiton (Rosaceae)	2
13	Yellow Birch *Betula alleghaniensis* Britt. (Betulaceae)	4
Total		**40**

The very small caliper of the stock used was in keeping with the limited volume of soil in each mound, anticipating that the tree roots would enter the native soil within a few years. The mounds were subsequently mulched with large amounts of leaf litter brought in from trees in the residential area. All saplings were also protected from herbivores with 1-cm mesh metal cages or poultry wire. Some 80% of the tree saplings planted survived two years, a rate better than previous attempts to plant directly into the shallow soils. Trees that didn't survive were replaced.

2.3.3. Terrace gardens

De-paving of Pontiac Street exposed a roadbed of mixed gravel only lightly covered with soil (Map 1: D). The road shoulder, also a former parking area, was comprised of hard-packed gravel and fill similar to the section of roadway converted to a Miyawaki Forest. Starting in the fall of 2020 and continuing throughout the summer of 2021, the space was transformed into three terraced beds totaling 440 m^2.

The level of effort required was considerable and the outcome transformative. Using pick and shovel, the hard-packed gravel and construction fill was turned over and mixed with commercial black soil and large amounts of wood chips delivered to the site by Hydro

Ottawa following their tree trimming operations. Stones of various sizes unearthed in the process were used to establish the terrace edges, creating low walls to retain the garden beds. Three different plant communities were then introduced, adding significantly to the biodiversity of the space and providing novel demonstrations of plant diversity relevant to public education on climate change, wildlife and traditional food and medicinal uses of plants.

Overview of terraces. Photo by K. Phillips.

I. Native pollinator garden

Native pollinators and their host plants are generally in decline because of land use change, invasive plant species, pesticide use, climate change (especially drought) and loss of wild habitat (Mathiasson and Rehan 2020). The native pollinator garden, established in the spring of 2021, was a response to this pressure.

Native plants that flower at different times of the year and that show different flower shapes and colours were selected with a view to supporting pollinators throughout the growing season and to provide food for caterpillars. The authors obtained native seedlings from the Fletcher Wildlife Garden and started others indoors in the winter from wild seed obtained from Prairie Moon and Richter's nurseries. The collection includes local plant species, alvar species and western Ontario and eastern Manitoba flora (Table 4). By the end of the second summer (2022), many native pollinators could be observed at the garden (bumble bees, sweat bees, leaf cutter bees, wasps, hover flies, Monarchs and other butterflies, Ruby-throated Hummingbirds, etc.).

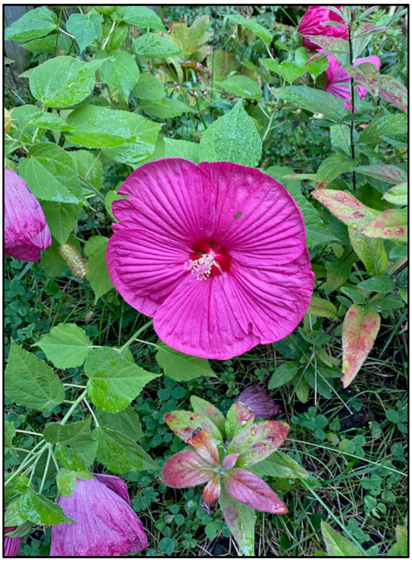
Watering, done mainly by student volunteers, was critical to plant survival during the first year. By the end of the second summer however, all plant types, including the alvar and western Ontario and eastern Manitoba flora, were thriving. The prominent location of the garden at the public entrance from the community to the Ottawa River Parkway system beautifies the de-paved space and demonstrates a much broader diversity of native plant species than most residential gardens.

Table 4. Species in Pollinator Garden (Map 1: D)
Spring
Red Columbine *Aquilegia canadensis* L. (Ranunculaceae)
Spotted Geranium *Geranium maculatum* L. (Geraniaceae)
Three-flowered Avens (Prairie Smoke) *Geum triflorum* Pursh. (Rosaceae)
Shrubby False Indigo *Amorpha fruticosa* L. (Fabaceae)
Large False Solomon's Seal *Maianthemum racemosum* (L.) Link (Asparagaceae)
Hairy Beardtongue *Penstemon hirsutus* (L.) Willd. (Plantaginaceae)
Canada Anemone *Anemone canadensis* L. (Ranunculaceae)
Summer
Cup Plant *Silphium perfoliatum* L. (Asteraceae)
Compass Plant *Silphium laciniatum* L. (Asteraceae)
Wild Bergamot *Monarda fistulosa* L. (Lamiaceae)
Queen-of-the-prairie *Filipendula rubra* (Hill) B.L. Rob (Rosaceae)
Common Goatsbeard *Aruncus dioicus* (Walter) Fernald (Rosaceae)
Cardinal Flower *Lobelia cardinalis* L. (Campanulaceae)
Purple Coneflower *Echinacea purpurea* (L.) Moench (Asteraceae)
Blue Giant Hyssop *Agastache foeniculum* (Pursh) Kuntze (Lamiaceae)
False Sunflower *Heliopsis helianthoides* (L.) Sweet (Asteraceae)
Black-eyed Susan *Rudbeckia hirta* L. (Asteraceae)
Hoary Mountain-mint *Pycnanthemum incanum* (L.) Michx. (Lamiaceae)
Common Yarrow *Achillea millefolium* L. (Asteraceae)
Mad-dog Skullcap *Scutellaria lateriflora* L. (Lamiaceae)
Common Evening-primrose *Oenothera biennis* L. (Onagraceae)
Spotted Joe Pye Weed *Eutrochium maculatum* (Linnaeus) E.E. Lamont (Asteraceae)
Butterfly Milkweed *Asclepias tuberosa* L. (Asclepiadaceae)
Fall
White Turtlehead *Chelone glabra* L. (Plantaginaceae)
New England Aster *Symphyotrichum novae-angliae* (L.) G.L. Nesom (Asteraceae)
Great Blue Lobelia *Lobelia siphilitica* L. (Campanulaceae)
Pearly Everlasting *Anaphalis margaritacea* L. (Asteraceae)
Spotted Beebalm *Monarda punctata* L. (Lamiaceae)
Common Sneezeweed *Helenium autumnale* (Asteraceae)

Overview of pollinator garden, 2021. Photo by J. Arnason.

II. Carolinian terrace, a "future forest"

Carolinian forests in Canada are warmer climate deciduous forests found in Ontario, south of a line running approximately from Grand Bend on Lake Huron to Toronto. They grow in plant hardiness zones 5b to 7, and include many interesting economic and endangered species of northeastern North America.



Swamp Rose-mallow in Carolinian terrace. Photo by J. Arnason.

Ottawa is in plant hardiness zone 5a, just above the historic Carolinian zone. With climate change, these "near native" species can be expected to naturally migrate into the Ottawa area while some cooler adapted species decline. These considerations prompted the authors to plant 37 Carolinian saplings purchased from Southern Ontario nurseries in the spring of 2021 (Table 5), as an experiment in "assisted migration." After two summers, survival is >95%, with most plants growing vigorously despite Ottawa's cooler climate. A southern exposure and highly favourable soil environment in a raised bed may account for this success, along with heavy mulching of the terrace with leaves and protection from herbivores with 1-cm mesh metal cages.

Table 5. Carolinian Forest Site (Map 1: D)		
Summary: 23 trees (13 species) and 11 shrubs (11 species)		
Planting method: Direct planting in a constructed terrace with black and native soil, wood chips and gravel mix; mulched with leaves		
Verification Period: Autumn 2022		
	Tree Species	**Number of Specimens**
1	Tulip Tree *Liriodendron tulipifera* L. (Magnoliaceae)	2
2	Kentucky Coffee-tree *Gymnocladus dioicus* (L.) K. Koch (Sapindaceae)	3
3	Sycamore *Platanus occidentalis* L. (Platanaceae)	1
4	Cherry Birch *Betula lenta* L. (Betulaceae)	1
5	Pawpaw *Asimina triloba* (L.) Dunal (Annonaceae)	3
6	Red Mulberry *Morus rubra* L. (Moraceae)	2
7	Cucumber Tree *Magnolia acuminata* L. (Magnoliaceae)	1
8	Common Hop-tree *Ptelea trifoliata* L. (Rutaceae)	2
9	Black Maple *Acer nigrum* F. Michx. (Sapindaceae)	2
10	Black Gum *Nyssa sylvatica* Marshall (Nyssaceae)	1
11	Eastern Flowering Dogwood *Cornus florida* L. (Cornaceae)	1
12	Shagbark Hickory *Carya ovata* var. *ovata* (Miller) K. Koch (Juglandaceae)	2
13	Northern Catalpa *Catalpa speciosa* Teas (Bignoniaceae)	2
Total trees		23
	Species of Shrubs and Herbs	**Number of Specimens**
1	Eastern Redbud *Cercis canadensis* L. (Fabaceae)	1
2	Eastern Buttonbush *Cephalanthus occidentalis* L. (Rubiaceae)	1
3	Fragrant Sumac *Rhus aromatica* Aiton (Anacardiaceae)	1
4	Kalm’s St John’s-wort *Hypericum kalmianum* L. (Clusiaceae)	1
5	Northern Spicebush *Lindera benzoin* L. (Lauraceae)	1
6	Silky Dogwood *Cornus obliqua* Raf. (Cornaceae)	1
7	Old Field Aster *Symphyotrichum pilosum* (Wild.) G.L. Nesom (Asteraceae)*	1
8	Rhodora *Rhododendron canadense* (L.) Torrey (Ericaceae)	1
9	Swamp Rose-mallow *Hibiscus moscheutos* L. (Malvaceae)	1
10	American Witch-hazel *Hamamelis virginiana* L. (Hamamelidaceae)*	1
11	Butterfly Milkweed *Asclepias tuberosa* L. (Ascleiadaceae)*	1
Total shrubs		11

*Local native species planted in Carolinian site.

Preparations for planting the Carolinian terrace. Photo by J. Arnason.

III. Ethnobotanical and food forest terrace

In Eastern Canada, over 400 species of native plants are known to Indigenous peoples as medicines and food (Arnason et al. 1981). The authors introduced some of the plants used for ceremony by local Algonquin, Mohawk and Cree elders, as well as some traditionally used plants that are licensed in Canada as Natural Health Products for self-medication. Native food forest species from Ontario and Quebec were also introduced, along with one mature tree, a MacIntosh apple representing a heritage cultivar originally developed in nearby Spencerville, Ontario.

The collection (Table 6) is a sample of plants that are either animal or human foods, or medicines. The materials were obtained from the Fletcher Wildlife Garden or grown indoors and transplanted by the authors from seed obtained from native plant nurseries.

Table 6. Ethnobotanical Garden and Food Forest (Map 1: D)

Ethnobotanical		Use
Sweetgrass	*Hierochloe odorata* (L.) P. Beauv. (Poaceae)	smudging ceremony
Aztec Tobacco	*Nicotiana rustica* L. (Solanaceae)	smudging ceremony
White Sage	*Salvia apiana* Jeps (Lamiaceae)	smudging ceremony
Kinnikinnick	*Arctostaphylos uva-ursi* (L.) Spreng. (Ericaceae)	smudging ceremony
Eastern Teaberry	*Gaultheria procumbens* L. (Ericaceae)	aromatic tea
Narrow-leaved Purple Coneflower	*Echinacea angustifolia* DC (Asteraceae)	sore throat and thrush

Highbush Blueberry	*Vaccinium corymbosum* L. (Ericaceae)	diabetes (root)
Showy Mountain-ash	*Sorbus decora* (Sargent) C. K. Schneider Rosaceae	diabetes (bark)
Yellow Birch	*Betula alleghaniensis* Britton (Betulaceae)	diuretic tea (twigs)
Common Winterberry	*Ilex verticillata* (L.) A. Gray, (Aquifoliaceae)	antidiarheal (bark)
Steeplebush	*Spiraea tomentosa* L. (Rosaceae)	astringent
Red-osier Dogwood	*Cornus sericea* L. (Cornaceae)	colds (bark)
Natural health products		
Black Cohosh	*Actaea racemosa* L. (Ranunculaceae)	menopause
Mad-dog Skullcap	*Scutellaria lateriflora* L. (Lamiaceae)	anxiety
Common Feverfew	*Tanacetum parthenium* (L.) Sch.Bip. (Asteraceae)	migraine
Horseheal (Elecampane)	*Inula helenium* L. (Asteraceae)	anti-inflammatory
American Witch-hazel	*Hamamelis virginiana* L. (Hamamelidaceae)	astringent
Forest foodplants		
Nannyberry	*Viburnum lentago* L. (Adoxaceae)	edible nuts
Common Elderberry	*Sambucus canadensis* L. (Adoxaceae)	fruit for wildlife
Blue Fly-honeysuckle (Haskap)	*Lonicera caerulea* L. (Caprifoliaceae)	fruit for wildlife
Canada Serviceberry	*Amelanchier canadensis* L. (Rosaceae)	edible fruit
Canada Plum	*Prunus canadensis* L. (Rosaceae)	edible fruit
Black Chokeberry	*Aronia melanocarpa* (Michx.) Elliott (Rosaceae)	fruit for wildlife
Northern Bush-honeysuckle	*Diervilla lonicera* Mill. (Caprifoliaceae)	fruit for wildlife
Beaked Hazelnut	*Corylus cornuta* Marshall (Betulaceae)	edible nuts
Shagbark Hickory	*Carya ovata* (Mill.) K.Koch (Juglandaceae)	edible nuts
Purple Giant Hyssop	*Agastache scrophulariifolia* (Willd.) Kuntzev (Lamiaceae)	edible leaves

3. Managing Invasive Plants, Rare Species, Seed Sources and Plant Biomass

Management of invasive buckthorn in the Champlain Woods has focussed on selective cutting of individual trees on the border of open areas where new plants are introduced, with particular attention to removal of seed bearing female buckthorn plants. This has allowed for the gradual expansion of native trees while also retaining the sound barrier and green surroundings afforded by buckthorn stands. Vegetation of any kind is appreciated by the general public, so removal is gradual and immediately replaced with new plants. Attention is also given to identifying and protecting individual species of native plants that have self-propagated inside stands of buckthorn, and therefore provide a positive seed source.

The authors characterize the strategy as a “firm push” and “seed dispersal” approach to the presence of invasive buckthorn, rather than a “clear cut” response. Other invasive exotics, including Japanese Knotweed and Dog-strangling Vine, have also been removed from areas bordering new plantations. The strategy is incremental and gentle, relying on time, the dispersal of native seed and active monitoring by volunteers to enhance biodiversity and ecosystem function.

Leaf litter collected by residents during the normal course of fall raking is diverted from the City’s green program to multiple uses in the garden areas, thereby making effective use of locally available plant biomass. In 2022, some 500 bags of leaf litter (mainly Sugar Maple) were collected from neighbouring streets and applied to bare and sparsely vegetated areas of the gardens and to new planting areas cleared of buckthorn.

Great Black Wasp on Spotted Beebalm. Photo by J. Arnason.

4. Discussion

Urban and suburban greenspaces are relatively young, pioneer habitats compared to mature forests and meadows, due to disturbance by human activity. Native plant biodiversity is key to restoring these spaces, or at least avoiding a situation of arrested development and the proliferation of exotic plant species. Native plants are better adapted to local conditions and serve as the foundation for other components of the native ecosystem. For example, research in urban landscapes has shown that the minimum percentage of native plant biomass required to support the density of insect populations that songbirds need to successfully rear their young is 70% (Narango 2018). For the already reduced songbird population to rebound, an even higher percentage of native plant species is necessary.

Public greenspaces offer an opportunity to restore habitat to ecological function over time by accelerating the emergence of biodiverse plant communities and associated wildlife. Experience in Champlain Park suggests that community stewardship of public greenspaces can be an efficient and effective means to achieve this meaningful conservation outcome.

Key features of the approach are: i) introduction of native and near native plant species extirpated from nearby or similar habitats; ii) decreasing the presence or seed dispersal of non-native species; iii) protection of individual specimens of native species that self-propagate; iv) monitoring tree survival rates and the spread of exotics.

Public education is both a means and strategic outcome of this approach to community stewardship and enhancement of biodiversity in public spaces. The terraces and pollinator garden in particular, located at a prominent entrance to the Ottawa River pathway, have attracted the attention, funding and active support of passersby from multiple neighbourhoods in Kitchissippi Ward. The spaces have also prompted numerous requests for information and tours, including from school groups, university teaching programs focussed on Indigenous plant knowledge, community associations and garden clubs. The details of the experience are shared here to support other groups wishing to replicate methods in parks, streetscapes, hydro corridors, woodland fragments, degraded public green spaces and underutilized streets in Ottawa.

Bee on a Cup Plant flower. Photo by C. Shearer.

Acknowledgements: The authors are grateful to Ariel Buchler and Jason Kwan from the University of Ottawa who assisted in the 2017 mapping exercise, and to students from the neighbourhood contributing volunteer hours to tree and garden maintenance, including watering, weeding and removal of Spongy Moths. Many other community members contributed at different times and to varying degrees to site preparation, planting, watering and mulching. Owen Clarkin and Shelly Lambert also provided useful guidance. All errors remain the responsibility of the authors. Funding for the purchase of soil, saplings and tree protection measures was provided by the Champlain Park Community Association, by the City of Ottawa through the Community Environmental Projects Grant Program and by private donation.

References

Arnason, T., R.J. Hebda, and T. Johns. 1981. Use of plants for food and medicine by Native Peoples of eastern Canada. Canadian Journal of Botany. 59(11): 2189-325.

Buckles, D., and D. Huron. Unpublished. Champlain Park Community and Tree History.

Catling, P.K., P.M. Catling, J. Cayouette, M. Oldham, B. Ford, C. Hamel, and C. Friesen. 2014. Canadian alvars and limestone barrens: areas of "Special Conservation Concern" for plants. Canadian Botanical Association Bulletin 47: 9-11.

Chalker-Scott, L. 2017. Hügelkultur: What is it, and should it be used in home gardens? Washington State University Extension service rex.libraries.wsu.edu

Hamersley Chambers, F.C., and Harris. 2012. Wild Berries of Ontario. Lone Pine, Edmonton, AB.

Hosie, R.C. 1969. Trees of Canada, Queens Printer, Ottawa.

Jaureguiberry, P., N, Titeau, M. Wiemers, D.E. Bowler, L. Coscieme, A.S. Golden, C.A. Guerra, U. Jacob, T. Takahasi, J. Settele, S. Díaz, Z. Moinár, and A. Purvis. 2022. The direct drivers of recent global anthropogenic biodiversity loss. Science Advances 8, eabm9982. 10.1126/sciadv.abm9982

Knight, K.S., J.S. Kurylo, A.G. Endress et al. 2007. Ecology and ecosystem impacts of common buckthorn (*Rhamnus cathartica*): a review. Biological Invasions 9:925-937. https://doi.org/10.1007/s10530-007-9091-3

Lambert, J.D.H., and T. Arnason. 1978. Distribution of Vegetation on Maya Ruins and its Relationship to Ancient Land-use at Lamanai, Belize. Turrialba 28(1): 33-41.

Lewis, H. 2022. Mini-Forest Revolution: Using the Miyawaki Method to Rapidly Rewild the World. Chelsea Green Publishing.

MacKinnon, A., L. Kershaw, J.T. Arnason, P. Owen, A. Karst, and F.H. Chambers. 2009. Edible & Medicinal Plants of Canada. Lone Pine, Edmonton, AB.

Mathiasson, M.E., and S.M. Rehan. 2020. Wild bee declines linked to plant-pollinator network changes and plant species introductions. Insect Conservation and Diversity 12(6): 595-605. https://doi.org/10.1111/icad.12429

Narango, D.L., D.W. Tallamy, and P.P. Marra. 2018. Non-native plants reduce population growth of an insectivorous bird. Proceedings of the National Academy of Sciences, 115: 11549-11554.

Shearer, C., and D. Buckles. Unpublished. The Diversity and Financial Benefits of Trees in Champlain Park: Results of a Neighbourwoods Survey.

Seltzner, S., and T.L. Eddy. 2003. Allelopathy in *Rhamnus cathartica*, European buckthorn. The Michigan Botanist 42(2).

https://www.inaturalist.org/check_lists/766742-Britannia-Conservation-Area-Check-List?q=&view=photo&taxon=&iconic_taxon=47126&observed=t&threatened=any&establishment_means=any&occurrence_status=any&rank=species&taxonomic_status=active&commit=Filter. Last consulted December 12, 2022.