Restoring Tallgrass Oak Woodlands in Southern Ontario

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1.0 Introduction

"Oak trees once grew as lone sentinels out on the prairie. They also grew in open oak savannas, sun dappled oak woodlands and shady oak forests. These wooded communities changed with time and space and they blended into each other". Jerry Sullivan. Chicago Wilderness: An Atlas of Biodiversity

Prior to 1800 the southern Ontario landscape was a rich mosaic of natural habitats − meadows, alvars, tallgrass prairies, oak savannas, oak woodlands, open and closed forests, swamps, marshes, bogs and fens. The majesty of these ecosystems has been described and documented by early settlers and land surveyors. The fact that southern Ontario contained ecosystems other than forest and wetland is new to a lot of people.

European settlement resulted in profound changes to the southern Ontario landscape as the natural vegetation was cleared for agriculture and urban development. The loss of natural fire cycles and the introduction of non-native plants and animals have further jeopardized the remaining habitats. However, there is a growing awareness of the environmental damage and loss of species that has resulted from such extensive habitat conversion.

Recently, much effort has been paid to restoring natural habitats, especially tallgrass prairie, oak savanna, wetland and forest. However, little emphasis has been put on the restoration of less well-known habitats such as the fire-dependent oak woodland. This guide focuses attention on oak woodland or, more precisely, oak-pine-hickory woodland. This habitat type has become increasingly rare in southern Ontario because of the loss of fire, the introduction of non-native plants, inappropriate tree planting and other activities. Restoring it takes knowledge and time.

The following chapters describe oak woodlands, the natural disturbances that shape it, the threats to its survival, the reasons for restoring and creating it, the steps to recovering it. The information in this guide will be useful to people from a broad suite of interests and backgrounds including forestry, ecology, hunting, wildlife appreciation and environmental education.

Figure 1: Oak Woodland Prescribed Burn
Photo: Larry Lamb

2.0 The Prairie – Savanna – Woodland – Forest Continuum

Southern Ontario is situated between two very different biomes, prairie to the west (the Great Plains) and mixed deciduous-coniferous forest to the east. Because habitats "transition" from one to another, southern Ontario contains both of these habitat types and a wide range of habitats that are in between these extremes.

Across North America, the transition from short grasslands to tall forests is related largely to moisture; precipitation increases and the frequency of drought decreases as one travels from west to east. This west-east climate pattern also mirrors a fire regime gradient that was a significant force in the creation of specific habitats and associated plants and animals. In the west, fast fires frequently raced through the dry grasslands, preventing excessive fuel buildup and suppressing fire-intolerant trees and shrubs. Moving eastward, fires occurred less frequently but could be more catastrophic, simultaneously terminating and initiating long-lived species. Other factors that shaped the vegetation included topography, soil type and wildlife, especially grazers (e.g., bison).

Figure 2: Oak Woodlands and savanna (in background) often occurred in conjunction with tallgrass prairie (in foreground). Photo Larry Lamb

To understand oak woodlands, it is important to understand the habitat continuum into which it fits. The prairie – savanna – woodland – forest continuum is essentially a transition from sunny to shady, dry to moist, fire-dependent to fire-intolerant. Oak woodland often occurred in conjunction with oak savanna and tallgrass prairie. Table 1 summarizes the similarities and differences between these ecosystems.

Table 1. Similarities and differences between Tallgrass Prairie, Oak Savanna, Oak Woodland and Forest

	Tallgrass Prairie	Oak Savanna	Oak Woodland	Forest
Canopy Closure	0 - 24%	25 - 35%	36 - 60%	> 60%
Fire	Frequent high intensity	Frequent low intensity or infrequent high intensity	Frequent, low intensity	Usually infrequent (forest-type specific)
Layers	- Ground	- Tree canopy - Ground	- Tree canopy - Shrub (patchy) - Ground	- Tree canopy - Tree sub-canopy - Shrub - Ground
Dominant Species	- Tall grasses such as Big Bluestem - Numerous wildflowers, such as Butterfly-weed	- Oaks with hickory, poplar, pine - Prairie grasses and wildflowers, such as sunflowers	- Oaks with hickory, poplar, pine - Savanna and open forest grasses, sedges and wildflowers	- Sugar Maple - American Beech - Ash Spring wildflowers, such as Trilliums

Figure 3: Tallgrass prairie in bloom. Photo Larry Lamb

Tallgrass prairie is a fire-dependent grassland plant community with only 0 - 24% tree canopy closure. This open canopy is created by frequent (every 1 - 3 years) and intense fires that kill fire-intolerant trees and shrubs and cause fire-tolerant trees and shrubs to remain small. As the name suggests the community contains grasses that grow 0.5 – 3.0 meters tall including Big Bluestem, Little Bluestem, Indian Grass and Switch Grass. A rich assortment of wildflowers is found including Butterfly Milkweed, Showy Tick-trefoil, Round-headed Bush-clover and Flowering Spurge. Although a few species of grasses make up 50 - 75% of the plants, sometimes over 100 species of wildflowers can be found in single patch of tallgrass prairie. This rich assortment of plants sustains numerous types of invertebrates (e.g., leafhoppers, grasshopper, crickets, katydids, spiders, beetles, ants, bees, and wasps), birds (e.g., Henslow's Sparrow, Bobolink, and Eastern Meadowlark), reptiles and amphibians and mammals.

Prairies contain long-lived, fire-adapted plants, many of which have extensive root system that reach as deep as five meters into the soil. About 60% of the plant biomass is below ground and this, in turn, sustains a diverse ecosystem of soil invertebrates. In contrast, meadows, which look somewhat similar, are made up of short-lived, relatively shallow-rooted plants such as goldenrod and asters. Unlike prairie meadow is not a fire-dependent climax community; but is an early succession ecosystem following a catastrophic event, such as forest fire, agriculture or prolonged flooding (ex. Beaver meadow).

Oak savanna is a fire-dependent grassland ecosystem that lies at the transition between tallgrass prairie and oak woodland. The canopy closure is 25 - 35% and the trees consist primarily of species of oak with smaller numbers of other trees such as poplar, hickory and pine. The trees are widely-spaced, allowing sunlight to reach the ground and support a nearly continuous coverage of native grasses and wildflowers with some shrubs. These forbs (flowers) and graminoids (grasses, sedges, rushes) are made up of tallgrass prairie and oak woodland species, with a few oak savanna-obligate species (e.g., Purple Milkweed). There is no sub canopy layer of trees and the shrub layer is typically reduced or absent. The canopy openings are maintained by frequent, low-intensity fires or infrequent high-intensity fires that reduce the number of trees and shrubs. Also, oak savannas tend to be situated on dry soils or flooded soils that dry out by summer, because of limits to tree and shrub growth.

Figure 4: Oak Savanna. Photo: Graham Buck

Figure 5: Oak Woodland has an open canopy, which creates dappled shade. Photo: Graham Buck

Oak woodland is a fire-dependent plant community that occurs at the interface between oak savanna and forest and typically contains elements of both. The canopy closure is 36 - 60%. Typically, in oak woodland the dominant trees are species of oak but other trees, namely hickory, poplar, chestnut and pine are important components too. There is not a sub-canopy of trees and the shrub layer can be absent or include scattered thickets of American Hazel, Gray Dogwood and Chokecherry. The dappled sun and shade supports a rich undergrowth of sedges, ferns and wildflowers that bloom from spring to fall. The oaks have many side branches to reach

sunlight on all sides. A list of oak woodland plants is found in Table 2 in the next chapter. Oak woodlands support an abundance of insects that, in turn, support many insect-eating birds such as the Great Crested Flycatcher, Wild Turkey, Eastern Bluebird, Red-headed Woodpecker and Northern Bobwhite.

Forest is defined as a plant community with more than 60% canopy closure and typically one or more sub-canopy layers of shade-tolerant hardwood trees. Most southern Ontario deciduous forests are made up of fire-intolerant species (e.g., Sugar Maple, Ash, American Beech). However, some forest types such as oak-hickory-pine are fire-dependent, although the fires are infrequent and low intensity. Forest trees tend to have tall, straight trunks with little side branching as they reach upward, not outward, towards the sun. Figure 1illustrates the differences in form and tree density of oak savanna, oak woodland and forest.

Oak Savanna, Oak Woodland and Oak Forest Sketches (Source: Island Press, Washington, DC)

Figure 6: Oak Savanna. Sunny grassland with scattered trees, mostly oaks. Trees have many side branches.

Figure 7: Oak Woodland. Intermediate between oak savanna and forest. Characteristic thick turf of sedges, grasses and flowers throughout the growing season. Lack of sub-canopy and many trees have spreading lower limbs.

Oak Woodland. Intermediate between oak savanna and forest. Characteristic thick turf of sedges (many Pennsylvania Sedge) grasses and flowers throughout the growing season. Lack of sub-canopy and many trees have spreading lower limbs.

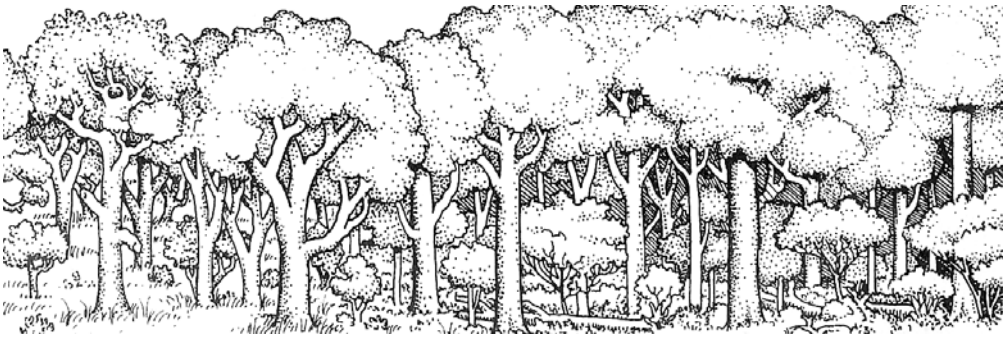

Figure 8: Forest. Distinct sub-canopy and canopy trees, tall trunks and without lower limbs Shade tolerant species in understory.

3.0 Plants and Animals of Oak Woodlands

3.1 Plants

In southern Ontario oak woodland provides important habitat for about 142 species of plants. Table 2 lists 84 "obligate" or "conservative" oak woodland species, meaning plants that are usually only found in oak woodlands and no other habitat type. Table 3 lists 58 "non-obligate" or "non-conservative" oak woodland plants, meaning plants that are usually found in oak woodlands but can also be found in open forests. Together, these tables show the diversity and type of plants that rely on oak woodland habitats for their survival.

Some of the colourful flowers that can be found in oak woodlands include Wood Anemone, Tall Bellflower, Woodland Sunflower, Wood Lily, Mayapple and Early Buttercup. Grasses and sedges make up an important component of the ground layer as well and include species such as Hairy Wood Brome Grass and Nebraska Sedge. The shrub and vine layer can contain aromatic and appealing species such as Summer Grape, American Plum, Sassafras and Fragrant Sumac. Figure 2 illustrates examples of several oak woodland plants.

While there are no conservative oak woodland trees, the most common trees found in this habitat are Hickories (Pignut, Shagbark or Shellbark), Aspens, American Chestnut, White Pine, Oaks (usually Red, Black, Hills, White and Bur and occasionally Swamp White, Chinquapin and Pin). Trees are not usually as site-specific as flowers and grasses.

Of the conservative and non-conservative plants, approximately 30% are considered rare in Ontario or Canada. Downy False-foxglove, Yellow Star Grass, American Columbo, Birdsfoot Violet and Rue Anemone are examples of flowering plants that are at-risk in Ontario because of the rarity of good quality oak woodland habitat. Recovery of these species depends on the restoration of oak savanna and woodland habitats.

Pictures clockwise from top left: Smooth False Foxglove, Yellow Stargrass, Birdsfoot Violet, Poke Milkweed, Hairy Bushclover, Seneca Snakeroot, Wood Lily, Woodland Sunflower New Jersey Tea (white flowers) with leaves of Summer Grape, Yellow Pimpernel. Photos: Graham Buck, accept Birdsfoot Violet- Larry Lamb

Figure 9: Conservative oak woodland plants

Table 2. Conservative Oak Woodland Plants of Southern Ontario (rare species in bold)

Common Name	Scientific Name	Common Name	Scientific Name
FLOWERING PLANTS			
Yellow Giant Hyssop	*Agastache nepetoides*	**Wild Blue Lupine**	***Lupinus perennis***
Wood Anemone	*Anemone quinquefolia*	Four-flowered Loosestrife	*Lysimachia quadriflora*
Rue Anemone	*Anemonella thalictroides*	Whorled Loosestrife	*Lysimachia quadrifolia*
Sicklepod	*Arabis canadensis*	Early Wood Lousewort	*Pedicularis canadensis*
Poke Milkweed	*Asclepias exaltata*	Racemed Milkwort	*Polygala polygama*
Four-leaved Milkweed	***Asclepias quadrifolia***	Seneca Milkwort	*Polygala senega*
Yellow False-foxglove	***Aureolaria flava***	Whorled Milkwort	*Polygala verticillata*
Fern-leaf Yellow False-foxglove	***Aureolaria pedicularia***	Giant Solomon's Seal	*Polygonatum biflorum*
Downy False-foxglove	***Aureolaria virginica***	Hoary Mountain Mint	*Pycnanthemum incanum*
Yellow False Indigo	***Baptisia tinctoria***	Early Buttercup	*Ranunculus fascicularis*
Bearded Shorthusk	*Brachyelytrum erectum*	**Hispid Buttercup**	***Ranunculus hispidus***
Wild Hyacinth	***Camassia scilloides***	White Goldenrod	*Solidago bicolor*
Tall Bellflower	*Campanula americana*	Hairy Goldenrod	*Solidago hispida*
Standley Goosefoot	***Chenopodium standleyanum***	**Elm-leaf Goldenrod**	***Solidago ulmifolia***
Spotted Wintergreen	***Chimaphila maculata***	Short-styled Sanicle	*Sanicula canadensis*
Hairy Small-leaved Tick-trefoil	***Desmodium ciliare***	Yellow Pimpernell	*Taenidia integerrima*
Toothed Tick-trefoil	***Desmodium cuspidatum***	**Yellowleaf Tinker's-weed**	***Triosteum angustifolium***
Maryland Tick-trefoil	***Desmodium marilandicum***	**Perfoliate Tinker's-weed**	***Triosteum perfoliatum***
Bare-stemmed Tick-trefoil	*Desmodium nudiflorum*	**Culver's-root**	***Veronicastrum virginicum***
Narrow-leaf Tick-trefoil	*Desmodium paniculatum var. paniculatum*	**Wood-vetch**	***Vicia caroliniana***
Prostrate Tick-trefoil	***Desmodium rotundifolium***	**Palmate-leaved Violet**	***Viola palmata***
American Columbo	***Frasera caroliniensis***	**Bird's-foot Violet**	***Viola pedata***
Northern Bedstraw	*Galium boreale*	**SHRUBS AND VINES**	
Wild Licorice	*Galium circaezans*	Summer Grape	*Vitis aestivalis*
Shining Bedstraw	***Galium concinnum***	New Jersey Tea	*Ceanothus americanus*
Hairy Bedstraw	***Galium pilosum***	Downy Arrowwood	*Viburnum rafinesquianum*
Thin-leaved Sunflower	*Helianthus decapetalus*	Fragrant Sumac	*Rhus aromatica*
Woodland Sunflower	*Helianthus divaricatus*	**GRASSES, SEDGES, RUSHES**	
Pale-leaf Sunflower	*Helianthus strumosus*	Broad-glumed Brome	*Bromus latiglumis*
Rock-geranium	***Heuchera americana***	Hairy Wood Brome Grass	*Bromus pubescens*
Rattlesnake Hawkweed	*Hieracium scabrum*	**Hirsute Sedge**	***Carex hirsutella***
Rattlesnake Hawkweed	***Hieracium venosum***	Nebraska Sedge	*Carex jamesii*
Eastern Yellow Star-grass	***Hypoxis hirsuta***	Muhlenberg Sedge	*Carex muhlenbergii*
Two-flowered Cynthia	***Krigia biflora***	**Cliff Muhly**	***Muhlenbergia sobolifera***
Violet Bush-Clover	***Lespedeza frutescens***	**Muhly**	***Muhlenbergia sylvatica***
Hairy Bush-clover	*Lespedeza hirta*	**Slender Muhly**	***Muhlenbergia tenuiflora***
Wand Bush-clover	*Lespedeza intermedia*	**Black Oat-grass**	***Piptochaetium avenaceum***
Trailing Bush-clover	***Lespedeza procumbens***	**Woodland Bluegrass**	***Poa sylvestris***
Slender Bush-clover	***Lespedeza virginica***	**Prairie Wedgegrass**	***Sphenopholis obtusata***
Pale Vetchling Peavine	*Lathyrus ochroleucus*	**Few-flowered Club-rush**	***Trichophorum planifolium***
Smooth Veiny Peavine	*Lathyrus venosus*		
Wood Lily	*Lilium philadelphicum*		

Table 3. Non-conservative Oak Woodland Plants of Southern Ontario (rare species in bold)

Common Name	Scientific Name	Common Name	Scientific Name
FLOWERING PLANTS		**TREES, SHRUBS, VINES**	
Soft Groovebur	*Agrimonia pubescens*	Spreading Dogbane	*Apocynum androsaemifolium*
American Hog-peanut	*Amphicarpaea bracteata*	Stiff Dogwood	*Cornus foemina* ssp. *racemosa*
Roundlobed Hepatica	*Anemone americana*	American Hazelnut	*Corylus americana*
Virginia Anemone	*Anemone virginiana*	American Plum	*Prunus americana*
Pussy-toes	*Antennaria parlenii*	Smooth Rose	*Rosa blanda*
Wild Columbine	*Aquilegia canadensis*	Carolina Rose	*Rosa carolina*
Tower-mustard	*Arabis glabra*	**Climbing Prairie Rose**	***Rosa setigera***
Smooth Rock-cress	*Arabis laevigata*	Sassafras	*Sassafras albidum*
Heart-leaf Aster	*Aster cordifolius*	Maple-leaf Viburnum	*Viburnum acerifolium*
Arrow-leaved Aster	*Aster urophyllus*		
Canada Honewort	*Cryptotaenia canadensis*	**GRASSES, SEDGES**	
Large Tick-trefoil	*Desmodium glutinosum*	Pubescent Sedge	*Carex hirtifolia*
Narrow-leaf Tick-trefoil	*Desmodium paniculatum* var. *dillenii*	Hitchcock's Sedge	*Carex hitchcockiana*
Nodding Fescue	*Festuca subverticillata*	Pennsylvania Sedge	*Carex pensylvanica*
Sweet-scent Bedstraw	*Galium triflorum*	Rosy Sedge	*Carex rosea*
Wild Crane's-bill	*Geranium maculatum*	Longbeak Sedge	*Carex sprengelii*
Common St. John's-wort	*Hypericum punctatum*	Bottlebrush Grass	*Elymus hystrix*
Tall Blue Lettuce	*Lactuca biennis*	Virginia Wild Rye	*Elymus virginicus*
Canada Lettuce	*Lactuca canadensis*		
Woodland Lettuce	***Lactuca floridana***		
Purple Twayblade	***Liparis liliifolia***	**FERNS, ETC.**	
Wild-lily-of-the-Valley	*Maianthemum racemosum*	Bulbostylis	*Bulbostylis capillaris*
Starflower False Solomon's Seal	*Maianthemum stellatum*	Cutleaf Grape-fern	*Botrychium dissectum*
Lopseed	*Phryma leptostachya*	Rattlesnake Fern	*Botrychium virginianum*
May Apple	*Podophyllum peltatum*	Braken Fern	*Pteridium aquilinum*
Old-field Cinquefoil	*Potentilla simplex*		
Bloodroot	*Sanguinaria canadensis*		
Virginia Saxifrage	*Saxifraga virginiensis*		
Upright Greenbriar	***Smilax ecirrhata***		
Illinois Greenbriar	***Smilax illinoensis***		
Bluestem Goldenrod	*Solidago caesia*		
Smooth Goldenrod	*Solidago gigantea*		
Early Goldenrod	*Solidago juncea*		
Trailing Wild Bean	*Strophostyles helvula*		
Early Meadowrue	*Thalictrum dioicum*		
Downy Yellow Violet	*Viola pubescens*		
Woolly Blue Violet	*Viola sororia*		
Barren Strawberry	*Waldsteinia fragarioides*		

3.2 Animals

The large diversity of plants in oak woodlands supports a large diversity of animal species. Table 4 lists 62 animal species that rely to some degree on oak woodlands including 22 species of insects, 8 species of reptiles and amphibians, 17 species of birds and 15 species of mammals. Some of the more common species include Silver Spotted Skipper, Brown Snake, Rose-breasted Grosbeak, and Red Fox.

Figure 10: Wild Turkey Photo Karen Lee

The availability of seeds and insects draws a diversity of bird life. Game birds such as Northern Bobwhite, Wild Turkey and Ruffed Grouse thrive in oak woodland habitats because of the availability of their choice food. The moderately dense understory vegetation (grasses and trees), provides cover and nesting sites. For ground-nesting birds, the tall grasses conceal the nest but at the same time are not so dense as to prevent the birds from surveying their surroundings. The spreading limbs of the large open-grown oaks are well suited as roosting sites for Wild Turkey.

Some 21 of the 62 animal species are designated 'at risk' primarily due to the loss of their preferred habitat – oak woodlands. Some oak woodland wildlife species can use similar habitats such as logged forests and forest edges where extra sunlight filters through.

Some oak woodland songbirds have declined due to a) loss of habitat and nesting sites, b) decline of flying insects, their principal food source, and c) increased competition and predation by starlings, feral cats and raccoons. Examples of songbirds that have suffered population declines include Cerulean Warbler, Hooded Warbler, Whip-poor-will and Red-headed Woodpecker.

Four species of reptiles found in oak woodlands ecosystems are considered rare: Gray (Black) Rat Snake, Eastern Hog-nosed Snake, Blue Racer and Five-lined Skink. Because reptiles are cold-blooded, many prefer oak savannas, oak woodlands and open forests because the mixture of sun and shade allows them to regulate their body temperature. Woodland Vole is another example of a rare animal that uses oak woodlands.

Figure 11: Gray Ratsnake. Photo Ministry of Natural Resources

Almost certainly, invertebrates made up the largest component of biodiversity in oak woodlands, yet little is known about their habitats, natural assemblages, or current status. Many invertebrates feed exclusively on a few selected plant species, so as their host plants

dwindle, so do they. It is likely that many invertebrate species of oak ecosystems were lost or are now very rare, such as the Mottled Duskywing which feeds on New Jersey Tea. Ontario has recently lost three oak woodland-dependent butterfly species: the Karner Blue, Frosted Elfin and Regal Fritillary. The Karner Blue and Frosted Elfin are dependent on Wild Lupines. Restoration of oak savanna and woodland habitats with Wild Blue Lupine populations are underway currently to recover these butterflies. Although butterflies are very visible and attractive, the insects that live in dead wood comprise the largest proportion of insect diversity of oak woodlands. Close to 150 species of ants, flies, beetles, and wasps live in dead oak logs.

Figure 12: Mottled Duskywing. Photo Jessica Linton

Table 4. Animals of Oak Woodland in Southern Ontario (rare species in bold)

Common Name	Scientific Name
INSECTS / BUTTERFLIES	
Tiger Beetle	***Cicindela patruela***
Silver Spotted Skipper	*Epargyreus clarus*
Frosted Elfin	***Callophrys irus***
Spring Azure	*Celastrina argiolus*
Dreamy Dusky Wing	*Erynnis icelus*
Juvenal's Dusky Wing	*Erynnis juvenalis*
Columbine Dusky Wing	*Erynnis lucilius*
Mottled Duskywing	***Erynnis martialis***
Wild Indigo Duskywing	***Erynnis baptisiae***
Horace's Duskywing	*Erynnis horatius*
Sleepy Duskywing	***Erynnis brizo brizo***
Persius Duskywing	***Erynnis persius***
Coral Hairstreak	*Harkenclenus titus*
Eastern Pine Elfin	*Incisalia niphon*
Karner Blue	***Lycaeides melissa samuelis***
Little Wood Satyr	*Megisto cymela*
Pearl Crescent	*Phycoides tharos*
Banded Hairstreak	*Satyrium calanus*
Hickory Hairstreak	***Satyrium caryaevorus***
Edwards Hairstreak	*Satyrium edwardsii*
Striped Hairstreak	*Satyrium liparops*
Regal Fritillary	***Speyeria idalia***
REPTILES & AMPHIBIANS	
American Toad	*Bufo americanus*
Five-lined Skink	***Eumeces fasciatus***
Blue Racer	***Coluber constrictor flaviventris***
Eastern Garter Snake	*Thamnophis sirtalis*
Brown Snake	*Storeria dekayi*
Eastern Hognose Snake	***Heterodon platirhinos***
Gray Ratsnake	***Pantherophis spiloides***
Eastern Fox Snake	***Pantherophis gloydi***

Common Name	Scientific Name
BIRDS	
Ruffed Grouse	*Bonasa umbellus*
Wild Turkey	*Meleagris gallopava*
Northern Bobwhite	***Colinus virginianus***
Whip-poor-will	***Caprimulgus vociferus***
Red-headed Woodpecker	***Melanerpes erythrocephalus***
Great Crested Flycatcher	*Myiarchus crinitus*
Blue Jay	*Cyanocitta cristata*
Tufted Titmouse	***Parus bicolor***
White-breasted Nuthatch	*Sitta carolinensis*
Brown Thrasher	*Toxostoma rufum*
Cerulean Warbler	***Dendroica cerulea***
Kentucky Warbler	*Oporornis formosus*
Hooded Warbler	***Wilsonia citrina***
Scarlet Tanager	*Piranga olivacea*
Eastern Towhee	*Pipilo erythrophthalmus*
Summer Tanager	***Piranga rubra***
Rose-breasted Grosbeak	*Pheucticus ludovicianus*
MAMMALS	
Virginia Opposum	*Didelphis virginiana*
Eastern Cottontail	*Sylvilagus floridanus*
Eastern Chipmunk	*Tamias striatus*
Grey Squirrel	*Sciurus carolinensis*
Southern Flying Squirrel	*Glaucomys volans*
White-footed Mouse	*Peromyscus leucopus*
Deer Mouse	*Peromyscus maniculatus*
Meadow Vole	*Microtus pennsylvanicus*
Woodland Vole	***Microtus pinetorum***
Red Fox	*Vulpes vulpes*
Long-tailed Weasel	*Mustela frenata*
Striped Skunk	*Mephitis mephitis*
White-tailed Deer	*Odocoileus virginianus*
American Badger	***Taxidea taxus jacksoni***

4.0 Natural Disturbance and Stress

Oak woodland ecosystems have probably existed in North America for about 20 - 25 million years (south of the extent of the glaciers). Oak woodlands, tallgrass prairies and oak savannas are disturbance-maintained systems. Disturbance is defined as any action that quickly removes some living biomass. A disturbance seldom affects all components of a community equally. Some components may be very stressed, some merely stressed, while others are unaffected or enhanced. Historically, the three major causes of disturbance within oak ecosystems were fire, drought, and herbivory (e.g., grazing herds). These disturbances are, in turn, affected by each other. Other, less important disturbances included disease (e.g., oak wilt), floods, tornadoes and high winds, and ice storms.

4.1 Fire

The open canopy of large trees with fire-resistant bark, scattered thickets of shrubs, and the solid ground cover of wildflowers, grasses, sedges and low growing shrubs, the signs of healthy oak woodland, are maintained by frequent, low-intensity fires. The result is an open, traversable landscape housing a diverse array of plants that flower from early spring to late fall. The large canopy trees survive the flames as they have fire-resistant bark. The young trees, although susceptible to fire, survive by persistent suckering following fire die-back.

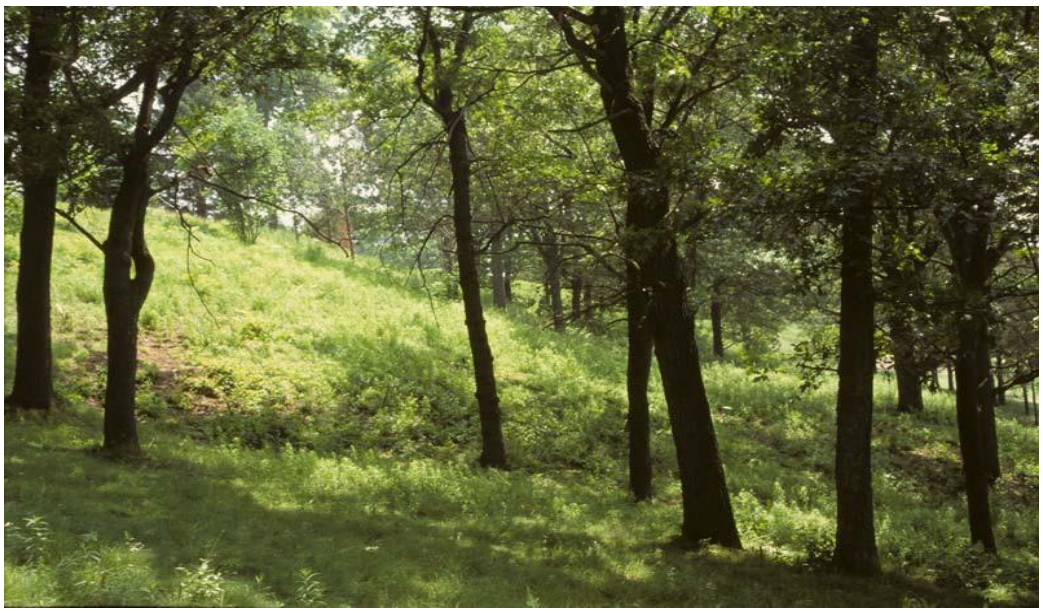

Figure 13: Oak woodland often occurs at the transition zone between oak savanna and forest. Photo Larry Lamb

The shade gradient from tallgrass prairie to oak savanna to oak woodland to forest is also a fire gradient; prairies experience fire most frequently and the other habitats less frequently (see Table 1). A tallgrass prairie is maintained by frequent (every 1 - 5 years), high intensity fires whereas an oak savanna typically burned as frequently (every 1 - 5 years) but with reduced intensity or much less frequently (5 - 20 years) with more intensity. Often, more fuel (e.g., dried grasses) would build up after a prolonged period of no burns, leading to more intense flames.

Oak woodlands typically burned at the same frequency as savannas (1 -5 or 5- 20 yrs) but with

less intensity due to the reduced fuel load of grasses and a topographic position that lessened the rate of flame spread. Mesic hardwood forests (sugar maple-beech)did not burn regularly.

Figure 14: Oak woodland after a spring fire. Photo Larry Lamb

Historically, tallgrass prairies, oak savannas, oak woodlands and forests grew next to each other in a mosaic pattern. Often, tallgrass prairies were ringed by oak savannas, oak woodlands and forests. One habitat type would start and another stop because of subtle differences in slope, soil, water, and fire frequency and intensity.

Nature does not draw firebreaks between the savanna, woodland and forests. Firebreaks were drawn by rivers, wetlands, geological features such as patches of bedrock, slopes, wind, wildlife activity, and other unknown factors. The frequency and intensity of fire was linked to several factors including plant community structure and vegetation type, topography and landscape context, soil texture, climate and activities of Aboriginal people.

Fires were started in two ways − lightning strikes and Aboriginal people. Lightning probably accounted for fire only in summer during drought years when the vegetation was dry enough to burn. Aboriginal or First Nations people routinely burned tracts of land for a variety of reasons. Fire was used to clear undesirable woody growth for agricultural use and to replace old growth with new growth which attracted more wildlife that they hunted for food. Reducing the subcanopy also made travel easier. Fire was also a means of herding animals during the hunt and was used to aid escape during battle. There are accounts that fire was set for entertainment. So, fires were set frequently and throughout the year.

Figure 15: Curled, dried oak leaves (Photo Graham Buck)

The structure and vegetation of healthy oak woodland encourages fire in many ways. The leaves of oaks, pines, hickories and chestnut are conducive to burning for a few reasons. Firstly, they are slow to break down so they build up on the ground providing the fuel for a fire to spread. Secondly, oak leaves curl up along the margin so they dry quickly and allow oxygen to mix with the leaves (e.g., they don't get matted down as maple leaves do). Dry, fluffed up leaves is the perfect fuel for fire. Thirdly, the wood of oak, hickory, pine and chestnut remains dry it accumulates on the forest floor. Like the leaves, the wood is slow to breakdown and does not become soft and wet easily on the ground. Finally, the sun-loving grasses, ferns and flowers that occupy the ground layer, are flammable in early spring or during a drought.

4.2 Drought: Topography, Soils, and Climate

Drought, or lack of available moisture, is another important environmental stress that has led to the development of non-forest habitats. Drought is not merely a climatic factor (e.g., low precipitation); topography and soils also determine moisture availability and play a role in fire spread.

Oak savannas occurred on dry soils (sand and gravel), resulting in sparse tree growth and drought-resistant tallgrass prairie grasses and flowers. Oak savannas also occurred on soils that flooded in the spring (such as lakeplains and floodplains) where flooding and wildfire interactions kept the tree cover reduced. Oak savannas typically occurred on flat and rolling tablelands where fire spread was rapid and frequent.

Oak woodlands grew across a broad range of moisture conditions, from dry (e.g., Black Oak / White Pine woodlands) to mesic (moist, between dry and wet) (e.g. Bur Oak Woodlands) to moist (e.g., Pin Oak / Swamp White Oak woodlands). The oak woodlands that occurred on richer, moister soils were converted to agriculture long ago or, in the absence of fire, were invaded and altered by fire-intolerant trees and shrubs. As a result, oak woodlands on mesic soils are exceptionally rare in southern Ontario today. Most of the remaining high quality oak woodlands occur on dry, often sandy, nutrient-poor soils because they were unsuitable for agriculture and the dry soils slowed succession to forest and were left intact. The best quality mesic soil remnants occur on First Nations lands as the people have continued to use fire to manage their environment. Oak woodland and forest occurred in areas such as on slopes where fire frequency and intensity was reduced.

Figure 16: Oak Woodland remnant on a slope. Photo- Ministry of Natural Resources and Forestry

During the past 13,000 years the climate of eastern North America has varied greatly, with a warming period until about 8,000 - 7,000 years ago and a cooling trend beginning around 3,500 years ago. In general, as climate warms, precipitation decreases and fire frequency and intensity increases. As climate cools, precipitation increases, fire frequency and drought decrease and this favours the spread of forests. Pollen studies have shown that the composition and location of oak woodland changed continually in response to climate change over time.

4.3 Grazing Wildlife

Populations of grazing wildlife such as deer, rabbits, rodents and insects, also stress the environment. These animals consume great amounts of plants from grasses to trees. Each animal consumes its favourite food, clearing small or large patches of vegetation as they moved through. The openings prevented the habitat from stagnating or becoming too dense and shady. As wildlife populations waxed and waned, so too did the plants, creating a dynamic mix.

The Passenger Pigeon and Eastern Elk, two extinct species that once lived in oak savannas and oak woodlands, probably had a large impact on these habitats in southern Ontario. The extinction of these species has an unknown impact as well.

5.0 New Threats to Oak Woodlands

5.1 Fire Suppression and the Spread of Fire-intolerant Plants

Figure 17: Dense shrub thickets form in unmanaged oak woodlands. Photo Graham Buck

As described in the previous section, historically fire was a common occurrence in southern Ontario. However, for about the last 100 years, fire has ceased to be a significant component of the landscape as humans suppress and prevent fires. To farmers and settlers, fire means loss of crops and shelter. The result has been a dramatic decline of fire-adapted plant communities.

Fire suppression has allowed fire-intolerant shrubs and trees to invade the open spaces between the trees. While there is enough light in the spring to allow the spring-blooming flowers to survive, the summer and fall-blooming wildflowers are completely shaded out. These late-bloomers are relegated to the edges or along pathways or openings where sunlight can still reach the soil.

Fire-intolerant forest tree species such as Sugar Maple, White Ash, Black Cherry and Basswood can invade quickly and change the structure of oak woodland ecosystems. The dense canopy of these forest trees increases the amount of shade, which increases the moisture level at the ground layer by reducing wind flow and sunlight penetration. The leaf and branch litter of these trees also make the site less flammable because they breakdown quickly and become easily soaked and matted when wet. As well, these forest trees can grow taller than the oaks and shade them out. Oak seedlings require light to germinate and the oaks are replaced fully by forest and shade-tolerant trees.

5.2 Inappropriate Tree Planting

In southern Ontario, the catastrophic soil erosion problems and flooding that occurred in the 1920s and 1930s prompted many agencies to restore tree cover through organized tree-planting programs. Thousands of acres were planted into trees with mostly nursery-grown pine and spruce. Prairies, savannas and oak woodlands were not well understood in the past and sometimes mistaken as habitats in need of further tree cover. Some sites were inappropriately planted with these conifers, to the demise of the native plant species.

5.3 Non-native Plants

Over 500 species of non-native plants have been introduced into North America since European settlement and a handful of them have become problem, invasive plants. Examples

of problem shrubs and trees include Black Locust, European or Common Buckthorn, Tartarian Honeysuckle, Russian and Autumn Olive, Barberry, Privet and Multiflora Rose.

Figure 18: European or Common Buckthorn. Photo Larry Lamb

These plants come from Europe and Asia and have spread widely throughout North America, to the detriment of native plants. The invasive shrubs form a dense shrub layer that crowds and shades out native plant species. Non-native plants alter the habitat by changing light, moisture and nutrient levels. Some shrubs release chemicals into the soil that prevent other plant species from growing in the vicinity. Because of the deep shade they create, non-native shrubs prevent ground cover plants from growing, leaving the bare soil susceptible to erosion, especially on slopes.

Native flowers must compete with non-native shrubs for pollinators, resulting in reduced seed set. The fruits of exotic shrubs often do not offer migrating birds the high-fat, nutrient-rich food sources supplied by native plant species that are needed for long flights. Structurally, exotic shrubs differ from native shrubs and do not offer the same nesting opportunities for birds as do native shrubs.

5.4 Non-native Animals – Gypsy Moth

Figure 19: Gypsy Moth Caterpillar-MNRF

The Gypsy Moth is a non-native insect that has been in North America for several decades. The caterpillar of this moth feeds on oak leaves and can kill trees after repeated outbreaks. Oaks growing in nutrient poor sites are most susceptible. However, not all impacts of Gypsy Moth and other oak tree defoliators are negative. Thinning of densely stocked stands, causing the release of understory plant species, can be considered beneficial.

Fortunately, the larvae of Gypsy Moth are eaten by a wide range of native mammals and birds (e.g., White-footed Mouse, Skunk, and Raccoon, American Robin, Eastern Towhee, Black-capped Chickadee, and Blue Jay). These predators are important in maintaining low population levels of Gypsy Moth.

Other natural control mechanisms include insect parasitoids that kill the moths by laying their eggs inside this pest, pathogens such as the nuclear polyhedrosis virus (NPV), *and Entomophaga mamaiga*, a fungus specific to the Gypsy Moth that can cause extensive mortality under some environmental conditions. Extreme conditions of prolonged cold (<30^{o} C) can kill unprotected eggs.

Arial spraying of *Bacillus thuringiensis* (*Bt*) is not recommended because it can damage native oak woodland insects. The *Bt* variety used against Gypsy Moth, *Btk* (*Bt kurstaki*), is toxic primarily to other caterpillars which are the larvae of native species of moths and butterflies, many of which are rare. There are several moths and butterflies that live in oak woodland and forests including the big and beautiful Cercropia. *Btk* may also affect other organisms, such as bats that feed on caterpillars in oak woodlands.

6.0 Restoring Oak Woodland

Because of fire suppression, inappropriate tree planting, the spread of non-native plants and animals, many original oak woodlands are in a degraded condition and require restoration to bring them back to their previous health. Some oak woodlands have been so neglected that they are barely recognizable, but many indictor species still survive to guide us. Fortunately, there are many restoration techniques that can be applied to bring these rare plant communities back from the brink.

Time is running out to restore the last remaining oak woodland remnants. The fire-adaptive plants are gradually diminishing; older seed-bearing trees are succumbing to age, and understory and ground layer conditions are becoming more forest-like. This state of affairs can be reversed and work is underway at many Provincial Parks, Conservation Authority Properties and other public lands where the remnants have been identified. However, more effort is required including private lands. The section describes the restoration techniques that can be used to restore oak woodland habitats. Some approaches are hands-on and some are hands-off.

6.1 Recognizing Oak Woodland

The first step in preserving oak woodland is being able to recognize it. Throughout southern Ontario ecologists are re-discovering and mapping remnant oak woodlands.

The principle characteristic of oak woodland is an open oak dominated canopy. Open means that there should be only 35% to 60% of the sky blocked by the leaves and branches of the canopy trees. Prior to European settlement and fire suppression, oak woodland ecosystems contained anywhere from 22 to 155 trees per hectare. The old, open-grown oaks had some branches growing low to the ground. In contrast, trees that have developed in a shady forest generally lack lower branches as they reach to the canopy for light. Even if the oak woodland has been heavily invaded by other trees, the spreading shape of the older oaks may be visible still.

Figure 20: Ash closing a canopy opening of an oak woodland remnant. Photo; Graham Buck

However, canopy cover and oak branching by themselves may not be the best means by which to recognize oak woodland. A plant inventory is also needed with a focus on so-called "indicator species". Table 1 lists the indicator plant species for southern Ontario oak woodland habitats and Table 2 lists oak woodland-oak forest plants of southern Ontario. These plant lists can help to determine if a remnant oak woodland flora still exists at a particular site. An ecologist or botanist experienced with oak woodland plant identification should be consulted to perform the inventory.

Figure 21: Healthy Oak Woodland groundcover. Photo Graham Buck

Once the remnant oak woodland has been identified, a restoration plan should be created. This will usually involve a full inventory with special attention to what needs to be done to restore the system. The best approach is to create a plan that proceeds slowly and considers all of the tools that are appropriate for the site, and the objectives of the project. This allows you to see the impact of the restoration as you progress.

Figure 22: Removal of non-native plants - cut stump treatment. Photo: USDA Forestry Service

Often, the first step in oak woodland restoration is the removal of exotic or non-native trees and shrubs (see section 6.4). All non-native plants should be removed from the site. That being said, the problem is often quite large so a step-wise approach is often needed. Priority should be given to the removal of the largest, seed-bearing plants first.

A detailed description of methods to remove non-native plants is contained in the Appendices. Unfortunately, mechanical methods such as cutting and pulling are ineffective against many invasive plants. Shrubs such as buckthorn re-sprout vigorously after cutting. In addition, extensive pulling of plants disturbs the soil and allows weed seeds in the soil to germinate, creating a larger problem.

A proven herbicide is often needed to kill these plants. Several techniques are available that use very small amounts of herbicide, targeted directly to the stem of the unwanted plant. Basal bark treatment entails applying herbicide to the bark of a standing tree. Cut stump treatment

involves cutting the tree or shrub down and applying herbicide to the stump area. Spraying the leaves (foliar application) is usually used as a last resort as it uses the greatest amount of herbicide and the spray drift may hit native plants.

6.3 Allow Natural Regeneration or Introduce Native Seeds

Immediately following the removal of the non-native shrubs and trees, the ground may look quite bare, however it is not necessary to add seeds or plants. Often, the increase in sunlight reaching the woodland floor will trigger the growth of the native ground vegetation. The seeds of these native plants have been lying dormant in the soil for several years, awaiting favourable conditions (e.g., sunlight, space) to grow. In time, the native plants will grow dense enough to support a prescribed burn.

Sometimes, after waiting two or more years, it will become apparent the recovery of the native flora is not going to happen on its own. Some sites are too fragmented or have been disturbed for too long to recover naturally within a reasonable time. In these cases, it is important to re-introduce native plant species by seeding or planting plugs. Use common species found in the area (e.g., native woodland grasses, sedges, asters and goldenrods) and widespread throughout southern Ontario. Seeding or planting conservative and rare species is not recommended. Purchase seed or plugs from a reputable native plant nursery.

Sometimes the open, disturbed areas that are left behind after killing invasive shrubs can be invaded by other non-native or undesirable species such as Garlic Mustard. Garlic Mustard can be treated by spraying early in spring before the native plants emerge, or late in the fall and winter, when native plants are dormant. Prescribed burning (see section 6.4) is also effective at killing Garlic Mustard, but follow up control is almost always required to eradicate the patches that didn't burn.

Figure 23: The ground is bare immediately after the invasive shrubs are cut and removed, during the fall or winter. Photo Graham Buck

Figure 24: Following one or two growing seasons the native ground cover can return. Photo Graham Buck

6.4 Introduce Prescribed Burns

Once the invasive species have been eliminated or sufficiently reduced and the ecosystem is recovering, fire should be reintroduced through prescribed burning. Fire is the best tool for recreating the oak woodland structure and composition. Section 5.1 described the historic frequency of fire and its role in shaping the oak woodland.

Fire, and the blackened ground that results, improves the health of oak woodlands undergoing restoration by:

- warming and drying of the soil which, in turn, increases root development,
- providing a stimulus to new above-ground shoots,
- removing dead vegetation and providing more sunlight to the new shoots,
- stimulating seed germination of seeds in the seed bank,
- making nutrients more available (without fire, the dead vegetation will break down slowly and the nutrients will be tied up for several years), and
- killing plants that are not adapted to fire.

Since large wildfires are a thing of the past in southern Ontario, prescribed burns are the only option for long-term management of a large site. Prescribed burns must be used only in accordance with local fire bylaws and with any necessary permits.

Figure 25: Trained volunteers participating in an MNR prescribed burn. Photo Graham Buck

Timing of the burn is critical. In southern Ontario, there are specific times that are suitable for effective prescribed burning. Spring burns are most common, usually mid-March to late-April. However summer burns are a natural component of healthy oak woodland and should be completed too, especially during periods of drought. Burning at the wrong time can harm the native species or promote the growth of undesirable species. Prescribed burning is best done by a professional. Contact your local Conservation Authority, Ministry of Natural Resources office or Tallgrass Ontario for assistance with prescribed burning (see the back of this guide for a list of contacts). These agencies may also have information on upcoming Prescribed Burn Worker and Burn Boss training programs. Many landowners and agency staff have taken these courses to assist with burns in their communities.

6.5 Tree Thinning

In some cases, it may be necessary to cut some mature trees in an oak woodland, primarily forest tree species. Following a long period without fire, trees can dominate a site, creating too much shade. It may be necessary to thin the trees to open up the canopy to bring sunlight to the woodland floor. The trees may be native Ontario forest trees (e.g., Sugar Maple, White Ash), but they are not part of the oak woodland ecosystem and will eventually replace the oaks if left unchecked.

In these cases the undesirable trees may be too large to control with fire. Selecting the trees to remove is a difficult process so an expert should be brought in to assist in the process. Trees such as Sugar Maple and ash can be cut with a chainsaw by a skilled arborist and sold to offset the cost. Trees that sucker when cut or have no economic value should be cut and treated with a proven herbicide to ensure they do not re-grow (see Appendix A and B).

Figure 26: Frilling is used to kill larger trees. Photo USDA Forestry Service

Tree thinning followed by prescribed burning is more effective at restoring oak woodlands than burning or thinning alone. Fire alone is not able to create the canopy openings necessary for the growth of oak seedlings and oak woodland ground vegetation. Thinning alone results in large canopy openings, which results in stimulation of tree saplings and shrubs in the understory. Thinning, followed by periodic prescribed burns a few years apart, is necessary to control the accelerated tree and shrub growth.

6.6 Shrub Thinning

Dense, native shrub thickets, such as Gary Dogwood, can develop in oak woodlands where fire has been absent for many years. Prescribed burning will be effective at reducing these shrub thickets if there are enough fine fuels (e.g., grasses and sedges) to carry a fire. Where the fine fuels are insufficient to carry a fire, fuel augmentation is an option. Placing dry straw within the shrub thickets just prior to burning will allow fire to burn through the thicket. Another option is to cut the shrub thickets with a brush saw a year or two prior to burning. This may allow a build-up of the grasses by the time of the next burn. The shrubs will sucker back, but fire will be able to control the suckers and reduce the coverage.

To reduce the vigour of shrubs in oak woodlands, prescribed burns should be carried out after leaf-out (e.g., after the leaves have sprouted on the shrubs). For spring burns, this is typically in late April. Spring burns conducted before leaf-out are not as effective at controlling shrubs and may, in fact, increase them due to prolific suckering. Summer burns conducted during extended dry periods are very effective at reducing shrub thickets and promoting spring flowering plants that maybe negatively impacted by spring burns.

7.0 Creating Oak Woodland Habitats

Across southern Ontario, landowners are taking an active role in restoring some of the lost natural habitat. Planting or creating oak woodland is just as realistic an undertaking as planting a prairie or forest. Converting evergreen plantations to oak woodland has great promise.

7.1 Conversion of Evergreen Plantations to Oak Woodlands

Thousands and acres of erosion-prone land were planted with evergreens over the last 50 - 80 years. Most have not become good forest habitat, but instead are simply stands of rows of even-aged trees with no understory. Intervention will allow them to evolve more quickly into a more diverse habitat. Evergreen plantations are good sites to create oak woodlands (and some may have been oak woodlands historically) as they are often situated on dry or sloping land, ideal conditions for oak woodland.

Specific management is required to direct the formation of oak woodland. Plantations located close to hardwood or mixed forest seed sources may have a significant understory of Sugar Maple, American Beech, ash, oak, Black Cherry, and White Pine. In these instances, a mixed hardwood forest is the most likely outcome through succession. To change this, intervention is needed.

It is necessary to change the dominant species present in the stand. Stand conversions utilize natural succession along with other management tools such as burning, tree planting and seeding. Stand conversions may also involve a complete or partial removal of the established trees, the re-arrangement or elimination of slash and debris following harvest, the use of site preparation equipment in advance of seeding or planting, and may also require follow-up tending treatments to assist in the continued growth of the desired trees established.

In plantations that are not adjacent to oak habitats, the oak trees and shrubs will have to be introduced to the plantation. It is cheapest to undertake “direct seeding” by planting locally-collected or purchased nuts and seeds from a reputable native plant nursery. However, in plantation, direct seeding is less effective than tree and shrub planting due to heavy predation by rodents. Forest openings larger than one hectare (2.5 acres) or old fields relatively free of competing vegetation provide the best opportunities for successful direct seeding of oak. Direct seeding acorns have the benefits of not disturbing the tap root during planting, creating a more natural looking community, improving wildlife habitat and overwhelming the wildlife that kill oak trees. In order to offset the mortality rate, large quantity of acorns need to planted.

The most difficult part of the stand conversion process is creating the diverse ground flora. With enough advanced notice, an oak woodland seed mix maybe available from a local restoration company. However, experienced landowners can collect their own seeds, avoiding introducing seeds of provincially rare plants or seeds brought in from outside the area. It is not necessary to seed the plantation. One can plant islands or plots of ground-cover, composed of a diverse mix of native flowers and grasses. These islands will naturally enlarge themselves in time as the plants self-seed and spread through the newly created oak woodland.

Appendix A: Summary of Control Methods for Common Invasive Species

Species	Mechanical Control	Chemical Control		
	Mechanical Control (Cutting, Pulling, Mowing, Burning)	**Basal Bark Treatment**	**Cut Stump and/or Frilling Treatments**	**Foliage Application**
European Buckthorn (*Rhamnus cathartica)*	Small shrubs can be pulled. Only feasible to control low densities.	- Best approach for large infestations. - 25% triclopyr mixed into oil carrier (75%)	20% glyphosate and water or 20% triclopyr and water or 12.5% triclopyr in oil	3% glyphosate in water; best when used on and suckers
Bush Honeysuckle (*Lonicera spp..*	Small shrubs can be pulled. Only feasible to control low densities.	- Best approach for large infestations. - 25% triclopyr mixed into oil carrier (75%)	20% triclopyr and water or 12.5% triclopyr in oil	3% glyphosate in water; best when used on and suckers
Russian and Autumn Olive *(Elaeagnus spp).*	Small shrubs can be pulled. **Not recommended** for larger shrubs because root fragments will be left behind that will re-grow.	- Best approach for large infestations. - 25% triclopyr mixed into oil carrier (75%)	- 50% triclopyr (May - Sept.) - Follow up of a 25% triclopyr solution applied to the foliage of the resprouts is necessary.	
Black Locust *(Robinia pseudoacacia)*	**Not recommended.** Mechanical control and fire stimulates suckering.	- 15% triclopyr - Useful for suckers or small trees.	- 25% triclopyr or 15% glyphosate. - Regular follow-up treatment for a few years necessary to kill root suckers that develop several meters away from tree. For suckers, use 15% triclopyr basal bark treatment.	3% glyphosate in water
Multiflora Rose *(Rosa multiflora)*	**Not recommended.** All the roots must be removed because new plants can grow from severed roots.	Best approach for large infestations. - 25% triclopyr mixed into oil carrier (75%)	- 20% glyphosate or 50% triclopyr - Use long-handled pruners to avoid thorns.	3% glyphosate in water
Barberry *(Berberis spp.)*	**Recommended.** Hand-pulling is an extremely effective because the shrub has shallow roots and leafs out early. Herbicides are suggested only for plants that are difficult to remove mechanically.	Best approach for large infestations. - 25% triclopyr mixed into oil carrier (75%)	25% glyphosate or 25% triclopyr	3% glyphosate in water
Privet *(Ligustrum sp).*	- Pulling recommended for small plants. - Pulling not recommended for larger shrubs because it will leave behind root fragments and re-grow.	Best approach for large infestations. - 25% triclopyr mixed into oil carrier (75%)	25% glyphosate or 25% triclopyr	3% glyphosate in water
Garlic Mustard (Alliaria petiolata)	**Pulling not recommended** as soil disturbance may cause more seeds to germinate. Pulled plants must be removed as the flower heads continue to mature and form seed. Cutting flower stalk off before seed-set is effective but timing is critical.			- 3% glyphosate in water, late fall or late winter when native plants are dormant.

Appendix B

Chemical Treatment Methods for Vegetation Control

Girdle or Frill -- Hack and Squirt Method

Target: Medium to large trees (<20 cm diameter breast height).

Procedure:

- With an axe, cut the bark and phloem (inner tissue) in a 1 inch wide by ½-1 ½ inch deep slash.
- Squirt 2,4-D (e.g., Killex) into the cut. 2,4-D is selective and does not kill monocots (grasses, rushes, and many wildflowers such as Solomon's Seal, False Solomon's Seal, Trillium, Jack-in-the-Pulpit)
- Glyphosate (e.g., Round Up) is not as effective and is non-selective and will kill other herbaceous plants.
- Triclopyr (e.g., Garlon 4 or Release) works better than 2,4-D but is expensive and difficult to purchase. A forestry or landscape pesticide applicator's license is required.

Notes: By cutting off the phloem, the tree cannot transport food and water from the roots to the plant top. A chemical is applied to speed up the death of the tree.

Basal Bark Treatment

Target: Shrubs such as buckthorn

Procedure:

- On standing shrubs, apply herbicide to the bark, approximately 6 inches high around the base of the stem.
- Use a backpack sprayer with a wand or spray gun fitted with a narrow-angle flat fan, cone, or adjustable tip. A wick applicator or paint brush can also be used.
- Use herbicides that are soluble in oil (e.g., Garlon 4) and mix with a commercially available basal oil and penetrant.
- Can be done in the winter.
- For large or thick infestations, work in 30 x 30 m plots, to make the work more manageable. Add a dye to see which stems have been treated.
- Fairly expensive, since it must be contracted out unless the landowner has a pesticide applicators license to purchase and apply the controlled product.

Cut Stump Treatment

Target Medium to large deciduous trees and shrubs

Procedure:

- Cut tree or shrub using a chainsaw or brush saw, handsaws or cutting blades.
- Cut the stems as close to the ground as possible. Leave a small amount of stem showing above the soil layer.
- Pull all cut stems away from the base and remove sawdust from stumps.
- Apply herbicide (e.g., Garlon) to the stumps as quickly as possible after cutting using a backpack sprayer, utility spray bottle, wick applicator, lab wash bottle, or paintbrush. Apply a basal spray mixture of herbicide, oil, and penetrant to stumps that have remained untreated for over 2 hours.
- Treat each cut stump carefully with the recommended herbicide mixture (see Appendix A). Add a red or blue dye to the herbicide mixture so the treated stumps can be distinguished from untreated ones. Dyes can be obtained from an agricultural chemical supply house.

- Treat every stump cut. For stumps over 3 inches in diameter, completely wet the stump and outer edge with the herbicide. If a spray bottle is used, do not spray the whole base as this wastes herbicide and spreads it around. Instead, place the tip of the spray bottle onto each cut stump, pressing gently to bring up several drops of solution while spreading the drops around the cut stump with the tip of the bottle.

Notes:

- This procedure is an economical use of herbicide and confines the chemical to the stump itself, but is more labour intensive than basal bark treatment.
- Best done in fall or winter when non-target plants are dormant. Not suitable for the growing season in high quality natural areas since drip from the bark can kill the vegetation around the target plant.
- Effective on plants of any size.

Foliar (Foliage) Application

Target: Shrubs (but only where they occur in small numbers such as along trails, roads, and woodland edges).

Procedure:

- Typically used when the shrubs are cut or burned and there is subsequent suckering. Most be applied to leaves when the shrub is actively growing (avoid droughts and late fall).

Notes:

- Foliar spraying can also be used to control suckers from a cut stump because the herbicide can be sprayed in early spring or late fall, when the leaves of shrubs such as Tartarian Honeysuckle are green but other sensitive vegetation is dormant.

Appendix C

Mechanical Control of Problem Plants

Burning

- Repeated prescribed burns will control some unwanted plants.

Grazing

- Grazing animals such as cattle and goats can consume weeds in the understory. However, much trial and error is needed to ensure the native species are not over-consumed.

Mowing

- Some unwanted flowering plants can be controlled by timely mowing. Cut/mow the understory plants before the unwanted plants set seed.

Hand pulling, digging or pulling using a Weed Wrench™.

- Pulling and digging disturbs the soil while encouraging re-infestation or colonization by other weeds.
- To prevent disruption, loose soil should be tamped down to make a firm surface.
- Saplings or shrubs with a trunk diameter of less than 3.5 inches can be pulled with a Weed Wrench.
- Digging out larger plants is extremely labour intensive and is not recommended since it can leave behind root fragments that can resprout.