PROPOSED

Species at Risk Act
Recovery Strategy Series

Recovery Strategy for the Butternut (*Juglans cinerea*) in Canada

Butternut

2010

Environment Canada Environnement Canada

Canada

About the *Species at Risk Act* Recovery Strategy Series

What is the *Species at Risk Act* (SARA)?

SARA is the Act developed by the federal government as a key contribution to the common national effort to protect and conserve species at risk in Canada. SARA came into force in 2003, and one of its purposes is *"to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity."*

What is recovery?

In the context of species at risk conservation, **recovery** is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed, and threats are removed or reduced to improve the likelihood of the species' persistence in the wild. A species will be considered **recovered** when its long-term persistence in the wild has been secured.

What is a recovery strategy?

A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets goals and objectives and identifies the main areas of activities to be undertaken. Detailed planning is done at the action plan stage.

Recovery strategy development is a commitment of all provinces and territories and of three federal agencies — Environment Canada, Parks Canada Agency, and Fisheries and Oceans Canada — under the Accord for the Protection of Species at Risk. Sections 37–46 of SARA (www.sararegistry.gc.ca/approach/act/default_e.cfm) outline both the required content and the process for developing recovery strategies published in this series.

Depending on the status of the species and when it was assessed, a recovery strategy has to be developed within one to two years after the species is added to the List of Wildlife Species at Risk. A period of three to four years is allowed for those species that were automatically listed when SARA came into force.

What's next?

In most cases, one or more action plans will be developed to define and guide implementation of the recovery strategy. Nevertheless, directions set in the recovery strategy are sufficient to begin involving communities, land users, and conservationists in recovery implementation. Cost-effective measures to prevent the reduction or loss of the species should not be postponed for lack of full scientific certainty.

The series

This series presents the recovery strategies prepared or adopted by the federal government under SARA. New documents will be added regularly as species get listed and as strategies are updated.

To learn more

To learn more about the *Species at Risk Act* and recovery initiatives, please consult the Species at Risk (SAR) Public Registry (www.sararegistry.gc.ca).

Recovery Strategy for the Butternut (*Juglans cinerea*) in Canada [Proposed]

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DECLARATION

This recovery strategy has been prepared in cooperation with the jurisdictions responsible for the butternut. Environment Canada has reviewed and accepts this document as its recovery strategy for the butternut, as required under the *Species at Risk Act* (SARA). This recovery strategy also constitutes advice to other jurisdictions and organizations that may be involved in recovering the species.

The goals, objectives, and recovery approaches identified in the strategy are based on the best existing knowledge and are subject to modifications resulting from new findings and revised objectives.

This recovery strategy will be the basis for one or more action plans that will provide details on specific recovery measures to be taken to support conservation and recovery of the species. The Minister of the Environment will report on progress within five years, as required under SARA.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Environment Canada or any other jurisdiction alone. In the spirit of the Accord for the Protection of Species at Risk, the Minister of the Environment invites all responsible jurisdictions and Canadians to join Environment Canada in supporting and implementing this strategy for the benefit of the butternut and Canadian society as a whole.

RESPONSIBLE JURISDICTIONS

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Parks Canada Agency
Government of New Brunswick
Government of Ontario
Government of Quebec

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STRATEGIC ENVIRONMENTAL ASSESSMENT STATEMENT

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*. The purpose of the SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below.

This recovery strategy will clearly benefit the environment by promoting the recovery of butternut. The potential for the strategy to inadvertently lead to adverse effects on other species was considered. The SEA concluded that this strategy will clearly benefit the environment and will not entail any significant adverse effects. Refer to the following sections of the document in particular: Recovery Goals, Recovery Objectives; Effects on other species; and the Approaches Recommended to Meet Recovery Objectives.

RESIDENCE

SARA defines residence as: *a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating* **[Subsection 2(1)]**.

Residence descriptions, or the rationale for why the residence concept does not apply to a given species, are posted on the SAR Public Registry: www.sararegistry.gc.ca/sar/recovery/residence_e.cfm.

PREFACE

The *Species at Risk Act* (SARA, Section 37) requires the Minister of Environment Canada to prepare recovery strategies for listed extirpated, endangered or threatened species. Butternut was listed as Endangered under SARA in July 2005. Environment Canada led the development of this recovery strategy in cooperation with the National Butternut Recovery Coordinating Team, the governments of Ontario, Quebec and New Brunswick, and Parks Canada Agency. All responsible jurisdictions reviewed and supported the request to post the strategy.

EXECUTIVE SUMMARY

Butternut (*Juglans cinerea* L.) is a species of tree designated as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and was listed in July 2005 as Endangered on Schedule 1 of the *Species at Risk Act* (SARA) in Canada. Butternut is an uncommon but widely distributed species that occurs in central and eastern North America. In the past 40 years butternut has undergone serious declines, primarily due to a non-native fungal pathogen which causes a fatal stem and branch disease known as butternut canker (*Sirococcus clavigignenti-juglandacearum*, N.B. Nair, Kostichka & Kuntz). Butternut canker is currently known to exist throughout the range of butternut in Ontario and Quebec, with limited distribution, at present, in New Brunswick. The fundamental threat and principal one noted within the COSEWIC Status Report (Nielsen et al. 2003) is butternut canker. In some provinces, additional pressures on the landscape compound the threat of the canker whereas in others, those threats are not significant at the population level.

There are unknowns regarding the feasibility of recovery of the butternut. These unknowns relate to whether there are trees in Canada which are resistant to the butternut canker. Therefore, in keeping with the precautionary principle, a recovery strategy has been prepared as per section 41(1) of SARA, as would be done when recovery is determined to be feasible. This recovery strategy addresses the unknowns surrounding the feasibility of recovery. The long-term recovery goal (>20 years) for butternut is to ensure conditions that will allow for the restoration of viable, ecologically functioning, and broadly distributed populations within its current range in Canada. Short-term objectives are:

1. By 2011, develop stewardship and outreach products informing Canadians of the identification, conservation status, conservation mechanisms and management of butternut and on the identification, assessment and management of butternut canker.
2. By 2012, collect information on the distribution, abundance and status of butternut and its health across its range in Canada and make it available in a National Database Management System (that is compatible with existing regional Conservation Data Centres).
3. By 2014, identify local populations of butternut across its native range and maintain them through focused stewardship in order to increase the likelihood of finding resistance (environmental, genetic, or a combination of both).
4. By 2014, where the disease is widespread, select, graft and archive at least ten putatively resistant trees in each ecodistrict in support of a future breeding and/or vegetative propagation program to produce resistant trees for restoration, and in support of future critical habitat identification.
5. By 2019, address priority knowledge gaps and research necessary for implementing recovery activities (including research into genetic/environmental resistance and level of adaptive genetic variation).

The recovery strategy has a strong outreach and stewardship approach and stresses research activities, inventory and monitoring across the butternut range. This strategy emphasizes national and international cooperation, to alleviate redundancy and facilitate sharing of recovery solutions. Where possible, the recovery strategy should be integrated into the management plans

of protected areas in which the species occurs and into broader scale conservation and restoration initiatives across New Brunswick, Ontario and Quebec.

Critical habitat is not identified in the recovery strategy. A schedule of studies to gather the information needed to identify critical habitat is included.

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1.1 Species Assessment Information from COSEWIC

Common Name: Butternut

Scientific Name: *Juglans cinerea*

COSEWIC Status: Endangered

Last Examination and Change: November 2003

Canadian Occurrence: New Brunswick, Ontario, Quebec

Reason for designation: A widespread tree found as single trees or small groups in deciduous and mixed forests of southern Ontario, Quebec, and New Brunswick. Butternut canker, which has caused high rates of infection and mortality in the United States, has been detected in all three provinces. High rates of infection and mortality have been observed in parts of Ontario and are predicted for the rest of the Canadian population.

COSEWIC Status History: Designated Endangered in November 2003. Assessment based on a new status report.

1.2 Description of the Species

Butternut is a deciduous medium-sized tree with a broad spreading irregularly shaped crown. Mature trees are seldom more than 30 m in height and 91 cm in diameter (Rink 1990). The leaves are pinnately compound with 11-17 leaflets between 9 to 15 cm long (Landowner Resource Centre 1997) that are opposite and almost stalkless (Farrar 1995). Leaves are yellowish-green, densely hairy on the underside and twigs are stout, hairy, and yellowish orange in colour (Farrar 1995) with a chambered pith (Hosie 1990). The terminal bud is elongated, about 1.0 to 1.5 cm long, somewhat flattened and blunt tipped with lobed outer scales (Farrar 1995). Lateral buds are much smaller and rounded, often with more than one bud above the leaf scar (Hosie 1990). The upper margins of the leaf scars are flat and bordered with hair (Farrar 1995). On younger trees, the bark is grey and smooth while older individuals have bark that becomes separated by narrow, dark fissures into wide, irregular, flat-topped, intersecting ridges (Farrar 1995). The fruit is a single-seeded edible nut with a dense layer of short sticky hairs covering the husk and an inner shell with jagged ridges (Nielsen et al. 2003).

The species is similar to black walnut (*Juglans nigra*) but can be distinguished by such characteristics as its hairy twigs and leaves, downy fringe above the bud scar, terminal leaflet that is as large as the lateral leaflets, a dark pith and ovoid hairy fruit with jagged ridges on the shell of the nut. In contrast, black walnut has smooth or only slightly hairy twigs and leaves with the terminal leaflet missing or smaller than the lateral ones; the fruit is globular, nearly hairless, and has rounded ridges on the surface of the shell (Nielsen et al. 2003).

1.3 Populations and Distribution

Butternut is native to central and eastern United States and reaches its northern limit in southeastern Canada (Figure 1). The Global status is between 'vulnerable' and 'apparently secure' and its rounded designation is Vulnerable (NatureServe 2005). In the United States, the national status is also between 'vulnerable' and 'apparently secure'. It is found in 32 states where the status varies from 'critically imperilled' to 'apparently secure'. In Canada, butternut is ranked N3N4 (vulnerable to apparently secure) and is native to Ontario, Quebec and New Brunswick. It has been introduced as an exotic ornamental in Manitoba, Nova Scotia and Prince Edward Island. The extent of occurrence is estimated at 121 000 km^2. There are an estimated 13 000 – 17 000 trees in 500 locations reported by landowners in Ontario, but how accurately this reflects the true Ontario population today is not known because there has not been a sufficient, comprehensive survey. The species' abundance has not been estimated in Quebec but it has been observed at 378 forest sampling plots, of which 39 have over 25% basal area of butternut (Nielsen et al. 2003). In New Brunswick, there are a total of 151 recorded butternut sites (Butternut Canker in New Brunswick Workshop, February 2004) with a conservative estimate of 7 000-17 000 trees (based upon forest development survey information, permanent sample plots and personal experience of field staff from the New Brunswick Department of Natural Resources, unpublished report). Again, how accurately this estimate reflects the true population in New Brunswick is unknown because there has not been a comprehensive survey.

In Canada, COSEWIC designated the species as Endangered in November 2003, due to the observed and projected decline from butternut canker, a fungal disease that causes mortality. The rate of change in geographical distribution in Canada is unknown; however, in two preliminary butternut surveys done in Ontario as many as 44 - 47 % of sites have trees in poor condition. In Wisconsin, the proportion of infected trees is as high as 91% (Cummings-Carlson 1993).

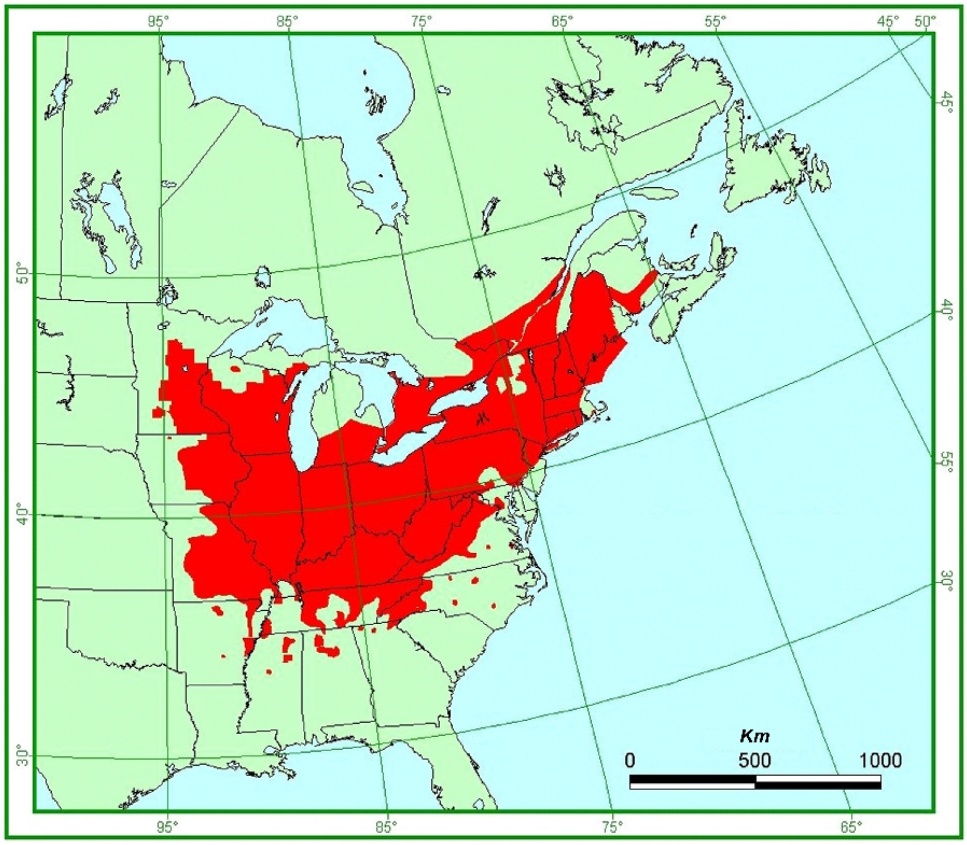

Figure 1. Butternut range in North America (modified from Rink 1990 and Farrar 1995).

Table 1. Summary of the N-ranks and S-ranks for the states and provinces in which butternut occurs (NatureServe 2005).

Country	National Rank	Provincial/State Rank
United States	N3N4	Alabama (S1), Arkansas (S3), Connecticut (SNR), Delaware (S3), District of Columbia (S1), Georgia (S1S2), Illinois (S2), Indiana (S3), Iowa (SU), Kansas (SNR), Kentucky (S3), Maine (SU), Maryland (S2S3), Massachusetts (S4?), Michigan (S3), Minnesota (S3), Mississippi (S2), Missouri (S2), New Hampshire (S3), New Jersey (S3S4), New York (S4), North Carolina (S2S3), North Dakota (SNR), Ohio (S3), Pennsylvania (S4), Rhode Island (SU), South Carolina (SNR), Tennessee (S3), Vermont (SU), Virginia (S3?), West Virginia (S3), Wisconsin (S3?)
Canada	N3N4	Manitoba (SNA), New Brunswick (S3), Ontario (S3?), Prince Edward Island (SNA), Quebec (S3S4)

S1: Critically Imperilled, S2: Imperilled, S3: Vulnerable; S3?:inexact numeric rank; S4: Apparently Secure, SNR: Not Ranked/Under Review; SU: Unrankable; SNA: Status Not Applicable; N3: Vulnerable; N4: Apparently Secure.

1.4 Needs of the Butternut

1.4.1 Description of biological needs, ecological role and limiting factors

Butternut is a relatively short-lived species, as compared to other temperate tree species, rarely surviving more than 75 years (Herbert 1976). Butternut flowers from April to June, depending on location. The species is monoecious[1] and wind-pollinated. Flowers of both sexes on an individual tree usually mature at different times (Rink 1990). The fruit matures in September and October in the year of pollination and usually remains on the tree until after leaf fall (Rink 1990). Seeds are dispersed by gravity, water, squirrels and other small mammals. Although seeds can remain dormant for 2 years (OMNR 2000), they usually germinate the spring after falling (Rink 1990). Trees mature and bear seed at age 20 and peak at age 30 to 60. Good seed crops occur every 2-3 years with light crops during intervening years. Low viable seed yields are usually caused by insect damage or lack of pollination (Rink 1990), although the butternut pathogen is also known to infect seeds (Orchard 1984, Innes 1997) and presumably has an impact on viability.

Butternut canker is a serious threat and limiting factor for the species. Although healthy butternut trees have grown amongst diseased trees (Ostry et al. 1994), the situation is extremely rare. It has not yet been shown that this putative[2] resistance reflects actual genetic differences or if resistance is a result of the environment (e.g. ideal site conditions), or a combination of both genetics and environment. In general, butternut genetic diversity is limited (Ostry 1998, Morin et al. 2000). The proportion of the total genetic diversity that is due to differences among populations was estimated (on the basis of isozyme analysis) to be 7.8% in seven populations from Quebec, one population in New Brunswick and the population in Vermont, but dropped to 2.9% when one population from Vermont was excluded (Morin et al. 2000). A combination of factors, including influence of the butternut canker, a genetic bottleneck occurring during the Pleistocene glaciation, and low migration distances of the gravity-dependent seed is thought to have contributed to low diversity in butternut (Morin et al. 2000). Even still, there is reason to suspect that adaptive variation exists for this species. Genetic diversity estimates based on isozymes provide a measure of overall diversity for genes. In most cases there is not a known relationship between isozymes and adaptive traits, thus adaptive genetic variation may exist in the species and within populations even when measured genetic diversity based on isozyme analysis is very low.

1.4.2 Description of habitat needs

Butternut can tolerate a large range of soil types. It typically grows best on rich, moist, well-drained loams often found along stream banks but can also be found on well-drained gravelly sites, especially of limestone origin. Butternut is intolerant of shade and competition, requiring sunlight from above to survive (Rink 1990) but it has the ability to maintain itself as a minor component of forests in later successional stages. As a result, the species is typically scattered throughout a stand and occasionally, groups of butternuts can be found along forest roads, forest edges or anywhere sunlight is adequate to support regeneration through seed. Common

[1] Male and female organs are found on the same plant and, in the case of butternut, in different flowers
[2] Commonly thought or deemed; supposed; reputed.

associates include basswood (*Tilia americana* L.), black cherry (*Prunus serotina* Ehrh.), beech (*Fagus grandifolia* Ehrh.), black walnut, elm (*Ulmus* sp.), hemlock (*Tsuga canadensis* L.), hickory (*Carya* sp.), oak (*Quercus* sp.), red maple (*Acer rubrum* L.), sugar maple (*Acer saccharum* Marsh.), tulip-tree (*Liriodendron tulipifera* L.), white ash (*Fraxinus americana* L.) and yellow birch (*Betula alleghaniensis* Britt.) (Rink 1990). There have been reports of butternut as an associate of American ginseng, *Panax quinquefolius* (OMNR 2000). The climate for butternut varies greatly within its range: mean annual temperature ranges from a maximum of 16°C to a minimum of 4°C and frost-free periods extend from 105 days in the north to 210 days in the south (Rink 1990).

1.5 Threats

The fundamental threat and principal one noted within the COSEWIC Status Report (Nielsen et al. 2003) is butternut canker. In some provinces, additional pressures on the landscape compound the threat of the canker whereas in others, those threats are not significant at the population level. Threats to the survival of the species* and the habitat** are presented in order of significance.

*i. Butternut Canker**

The most serious and widespread pressure on butternut is a non-native fungal pathogen that causes butternut canker (*Sirococcus clavigignenti-juglandacearum* N.B. Nair, Kostichka & Kuntz). Fungal infection of butternut causes necrosis of cambial tissue which disrupts nutrient flow. It may take trees more than 40 years to die, but in many cases, death has rapidly followed infection. Mortality after infection appears to be directly related to the size of the tree due to the girdling effect of the cankers as they grow and coalesce (i.e., larger trees generally take longer to succumb to the disease). Thus, as larger trees disappear from the landscape, average time-to-mortality following infection will become shorter and shorter. Following dieback, this species does not leave live root sprouts, usually does not leave viable seed, and stem cankers damage the commercial value of the wood. Once killed the trees rarely sprout and when they do, the sprouts are not known to reach any appreciable size or produce seed (Ostry unpubl.data). Butternut canker is transmitted from tree-to-tree by asexually produced spores (pycnidiospores) carried by wind and rain droplets/aerosol (Tisserat & Kuntz 1983). The fungus can also survive in infected seed stratified at 4°C for up to 18 months (Schultz 2003). Beetles, including some long-horned beetles (Cerambycidae) and weevils (Curculionidae), are known to play a role in fungal transmission (Halik and Bergdahl 2002). Cankers resulting from natural infection have been found over 100 m from the nearest cankered tree (Tissart & Kuntz 1983). The susceptibility of butternut to the canker is heightened due to its natural history characteristics (e.g. relatively short life span and dependence on openings within the forest canopy for regeneration). Note that care needs to be exercised in evaluating trees for butternut canker so that trees with dead branches are not automatically considered diseased. Another fungus, *Melanconis oblongum* (Ellis & Everh.) A.H. Graves (anamorph: *Melanconium oblongum* Berk) is often found fruiting on dead butternut branches and is often confused with butternut canker but is not lethal (Ostry et al. 1994). Both butternut canker and *M. oblongum* can be found fruiting on the same branch.

Butternut canker was first collected in Quebec in 1990 (Innes and Rainville 1996), in Ontario in 1991 (Davis et al. 1992) and then in New Brunswick in 1997 (Harrison et al. 1998). Butternut canker is currently known to exist throughout the range of butternut in Ontario and Quebec, with limited distribution, at present, in New Brunswick (Hopkin et al. 2001) (Figure 2). Currently the rates of infection and mortality in Canada are not known, however, in some U.S. states butternut canker has infected as many as 91% of the live butternut in all age classes (Ostry 1997). The disease was first reported from Wisconsin in 1967 (Renlund 1971), but was likely present for several years before then (Kuntz et al. 1979).

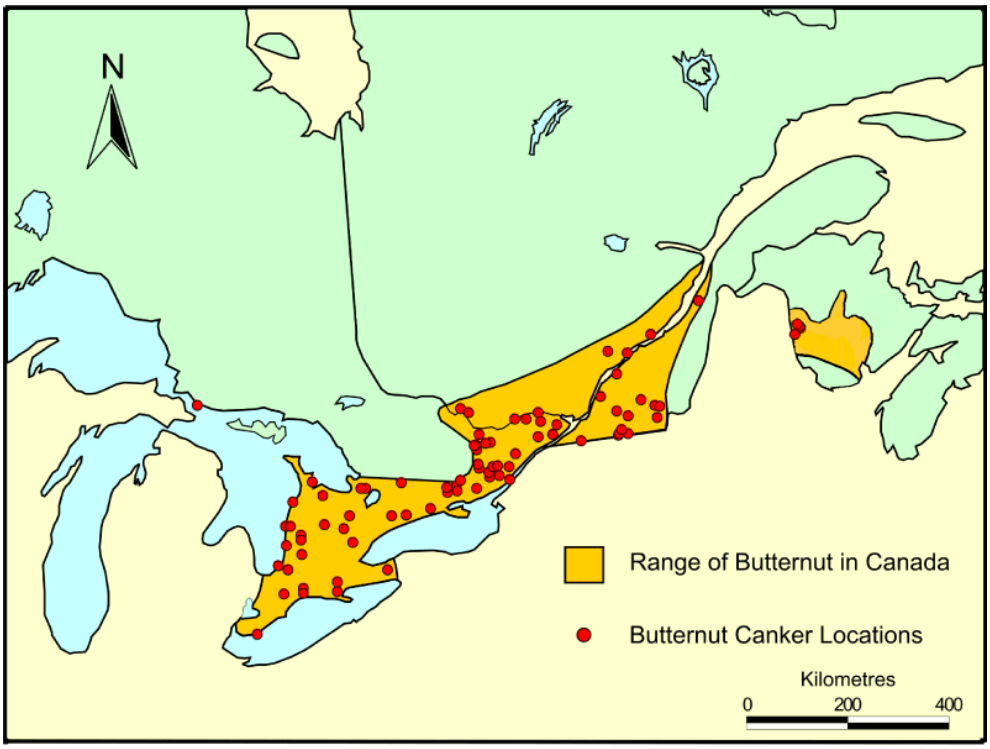

Figure 2. Butternut range and known butternut canker locations in Canada (adapted from maps and information provided by Natural Resources Canada, Canadian Forest Service).

*ii. Harvesting of Trees**

In the absence of the canker, harvesting of butternut would not be a threat to the species. However, in anticipation of mortality from the disease, in some areas, the threat of harvesting may be a more immediate threat than the canker itself. Harvesting of butternut by landowners in anticipation of mortality has already been documented in the U.S. (Ostry and Pijut 2000) and an increased incidence of butternut is already evident in the market (e.g. at log auctions) in Ontario (Boysen unpubl. data). At times the wood has been in great demand as it is sought after as a specialty wood for cabinet-making and other types of woodworking. Currently this threat is greatest in the Ontario portion of the species range but is anticipated to grow with the continued spread of the disease and growing awareness of the disease amongst landowners. Indiscriminate removal of trees that have canker is unwarranted because surviving individuals may have some level of resistance even if they are not canker-free. This threat will result in the loss of individual trees, including putatively resistant trees, and at least in parts of its range, the loss of

populations on the landscape. The harvesting of non-infected and putatively resistant trees may reduce genetic diversity that could ultimately be important for recovery of the species. If genetic resistance exists, it appears to be rare and should be preserved as much as possible on the chance it may contribute to recovery of the species.

*iii. Habitat loss and degradation***

In most regions, habitat loss is not a major limiting factor for butternut, however, loss of forested habitat to agriculture and urban development remains a stress on the species where forest cover in general is limited (e.g. southwestern Ontario). Butternut also requires specific light and site conditions to successfully regenerate. Unless silviculture practices include a focus on providing conditions required to maintain current populations and achieve natural regeneration of butternut, it is unlikely that there will be increased reproduction in future (Skilling et al. 1993). Much research and work has already been done in this area (Ostry et al. 2003, Ostry et al. 1994, OMNR 2000, Lupien, 2006) and the latest information needs to be communicated to landowners and managers for maintaining butternut on sites which are optimum for growth and reproduction.

*iv. Other diseases, insects and exotics**

There are a number of insects and diseases that threaten butternut survival. The extent of the damage varies, but most are not capable of causing mortality on their own. In combination with butternut canker however, these factors increase the stress of individuals, which may result in mortality (see Nielsen et al. 2003 for more details on each):

- Leaf spot (*Marssonina juglandis* (Lib.) Magnus)
- Armillaria root disease (*Armillaria gallica* H. Marxm.& Romagn.)
- Butternut curculio (*Conotrachelus juglandis Lec.*)
- Fall webworm (*Hyphantria cunea* (Drury))
- Walnut caterpillar (*Datana integerrima* G&R)
- Walnut shoot moth (*Acrobasis demotella* Grote)
- Bunch broom disease (caused by phytoplasmas[3])
- *Fusarium* canker
- *Phomopsis* canker

*v. Excessive seed predation**

The seeds of butternut are highly desired by small mammals, birds and other seed predators but these animals are essential to butternut survival because they aid in the dispersal of seeds. However, if predator populations are unnaturally augmented (e.g. in urban and agricultural landscapes), the regeneration of butternut may be compromised. For example, common grackles are reported to destroy immature fruit (Rink 1990) and often have elevated populations in urban and agricultural landscapes (Graber and Graber 1963, Emlen 1974). The nut is also retailed by humans to some extent, in the Montreal area, as a commodity rich in unsaturated fat. The impacts of seed predation are thought to have minimal effect on the survival of butternut and this threat is only speculative at this point.

[3] Small bacteria enveloped by a single membrane that do not possess a cell wall like typical bacteria

vi. Hybridization with exotic Juglans *species**

Hybridization with exotic *Juglans* species is a potential threat for butternut and has been confirmed in the southern and eastern U.S. throughout its' native range (Ostry unpubl. data). Of the species with which butternut can hybridize, none occurs naturally within Canada. However, several of these species have been planted for nut production or landscaping and hybridized successfully with butternut. For example, a hybrid form with heartnut *(Juglans cordiformis)* produces buartnut (Millikan *et al.*1991), with Japanese walnut *(J. ailantifolia)* produces *J. x bixbyi;* and with English walnut (*J. regia)* produces *J. x quadrangulata.* Butternut has also successfully hybridized with little walnut (*J. microcarpa)* and Manchurian walnut *(J. mandschurica)* (Rink 1990). How pervasive hybridization is in butternut's Canadian range is unknown.

1.6 Actions Already Completed or Underway

New Brunswick. A butternut conservation strategy was developed by the New Brunswick Gene Conservation Working Group (Nielsen et al. 2003). The Working Group identified knowledge gaps and set goals to identify and locate butternut populations in the province; assess the frequency of canker infection and estimate mortality; develop *ex situ* storage methods, and examine the genetic diversity of butternut and check for the presence of hybrids. They have already successfully cryopreserved[4] the embryonic axes[5] on the fruit. An educational program was also set up by Natural Resources Canada, Canadian Forest Service (Atlantic Region) and the New Brunswick Federation of Woodlot Owners to enable woodlot owners to identify the tree and symptoms of the disease. *Ex situ* conservation initiatives were undertaken by the National Tree Seed Centre in order to preserve valuable butternut germplasm (e.g. embryonic axes, buds and cells). A database was set up by the Canadian Forest Service (Atlantic Forestry Centre) to maintain information provided by the public on location and health of trees. One plot has been established by the CFS Atlantic Forestry Centre to monitor development of the disease over time, and additional areas have been surveyed. New Brunswick Department of Natural Resources obtains information that assists in determining butternut range in the province through three ongoing core programs (Photo Interpretation, Forest Development Survey and Permanent Sample Plots). They also sponsored a butternut canker workshop in 2004. Research conducted by the Canadian Forest Service in 2004, 2007, and 2008 confirmed the presence of butternut canker at new locations in New Brunswick, expanding the known range of canker over 100km south of the original location.

Ontario. The Ontario Ministry of Natural Resources initiated a butternut conservation project for southern Ontario in 1994 that included such activities as reviewing the scientific literature, conducting field inventories, documenting populations, grafting scions[6] and collecting data from potentially resistant individuals (Nielsen et al. 2003). Their objectives were to identify, graft and maintain potentially resistant individuals in order to establish a breeding program and ultimately

[4] Long term preservation of viable cells and tissue in liquid nitrogen.
[5] Component of the embryo made up of the future shoot (epicotyl) and future root (hypocotyl)
[6] Horticultural technique where the upper part (a young branch or scion) of one plant grows on the root system (rootstock) of another plant and they appear to grow as a single plant.

a species recovery program; and to develop a long-term conservation strategy for southern Ontario. Communications with private woodlot owners by letter, displays, presentations, and newsletters resulted in information on butternut locations and health. A large number of people demonstrated interest in an inventory, and over 500 surveys were returned. These were used to form the basis of a database documenting the location, health status and potential resistance of the trees. Field reconnaissance was conducted in 1995 involving 140 sites; of these 140 sites, 10 sites had a high incidence of disease and each of these sites had one tree exhibiting good vigour. Trees exhibiting good vigour from the 10 sites were then selected for scion collection and grafting in spring of 1996. At two of the three sites selected for graft outplanting, the survival rate was low due to vandalism and graft/climate incompatibility. In 1999 and 2000, small plantings were established at four demonstration sites using seeds from various regions of southern Ontario to explore adaptive genetic variation. Educational brochures, and a website about the canker, maintenance and reproduction of the species (www.fgca.net/conservation/sar/butternut.aspx), were produced to further communications with woodlot owners. A butternut recovery team has also been formed in Ontario and recent efforts include a standardized tree assessment form developed and distributed to stakeholders and a regional program to collect seed from healthy trees in support of a planting program (within the Rideau watershed). Inventories and health assessments are ongoing in Provincial Parks.

Quebec. In 1994 the Canadian Forest Service and the Ministère des Ressources naturelles et de la Faune assessed the genetic variability of butternut, researched the biology of the pathogen and tried to establish an *in situ* and *ex situ* conservation strategy (Innes 1997). Seeds were collected at several sites throughout Quebec and were planted at a nursery in Berthier. The following year the canker was observed on one-year-old seedlings. This was the first mention of the disease at a nursery – the seedlings were apparently contaminated by infected nuts through the scar at the point of attachment of nut to stem. All the seedlings were given a thorough inspection to eliminate all those with symptoms of the disease. In spring 1996, butternut seedlings that appeared to be free of the disease were planted at four plantations in Quebec, three of them outside the natural range of the species and a fourth inside the range. Annual inspections completed in the first and second year after planting revealed 4% and 3.1% infection of seedlings, respectively. Seedling production was stopped following these observations to avoid spreading the pathogen. The Ministère des Ressources naturelles et de la Faune then experimented with a variety of techniques for decontaminating the nuts. Some have proven effective, but improvements are needed (Rainville et al. 2001). A one year project, led by Natural Resources Canada with participation from Environment Canada, Parks Canada Agency, the Department of National Defence, Gatineau Park and several aboriginal communities, is underway to inventory and assess the health of butternut on federal lands.

1.7 Knowledge Gaps

In all provinces, information is still required to assess the distribution and abundance of butternut itself, the disease incidence and severity, and the identification of putatively resistant trees. Standardized data collection and management should be attempted to facilitate inter-jurisdictional cooperation and comparisons. The network of Conservation Data Centres currently in place can play a major role; however, more detailed databases that hold disease assessment and monitoring information are also required. Knowing whether or not resistance to

butternut canker exists, and if indeed it does, the mechanisms of resistance (e.g. genetic (G), environmental (E), and/or both (GxE), are also crucial elements necessary for recovery success. Many questions pertinent to long-term butternut survival (e.g. what are ecologically functioning population levels?) remain unknown.

2. RECOVERY

2.1 Rationale for Recovery Feasibility

Based on the following four criteria outlined by the Government of Canada (2009), there are unknowns regarding the feasibility of recovery of the butternut. At present, it is unknown if trees exist in Canada which are resistant to the butternut canker, yet this information is key to the recovery of this species and will be important in determining recovery feasibility over the long term for butternut. Therefore, in keeping with the precautionary principle, this recovery strategy has been prepared as per section 41(1) of SARA, as would be done when recovery is determined to be feasible. This recovery strategy addresses the unknowns surrounding the feasibility of recovery.

1. Individuals of the wildlife species that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance. YES

2. Sufficient suitable habitat is available to support the species or could be made available through habitat management or restoration. YES

3. The primary threats to the species or its habitat (including threats outside Canada) can be avoided or mitigated. UNKNOWN

4. Recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable timeframe. UNKNOWN

As individuals and habitat are still plentiful for butternut across its range, the recovery of butternut will largely depend on the identification of a canker-resistant strain of the species, from either Canada or the United States, the conservation of genetic material, and a program to restore a viable population that can fulfill butternut's ecological function[7].

[7] Ecological function is the role played by the species or population in the interrelation between living or non-living components of ecosystems. Although the ecological function of butternut is at this time, only partially known, the long term recovery goal is to have a distribution and abundance of butternut trees that will support its ecological role (such as a food source for wildlife) within forest ecosystems.

2.2 Long-term Recovery Goal (> 20 years)

The long-term recovery goal (>20 years) for butternut is to ensure conditions that will allow for the restoration of viable, ecologically functioning, and broadly distributed populations within its current range in Canada.

Butternut populations may not be currently viable due to high rates of infection and mortality caused by the butternut canker. Therefore, restoration of viable populations depends on populations being disease-free. At present, the conditions required to achieve and ensure disease-free populations are unknown. Thus it is not possible at this time to further quantify the recovery goal or population and distribution objectives.

2.3 Short-term Objectives

The short-term objectives are:

1. By 2011, develop stewardship and outreach products informing Canadians of the identification, conservation status, conservation mechanisms and management of butternut and on the identification, assessment and management of butternut canker.

2. By 2012, collect information on the distribution, abundance and status of butternut and its health across its range in Canada and make it available in a National Database Management System (that is compatible with existing regional Conservation Data Centres).

3. By 2014, identify local populations of butternut across its native range and maintain them through focused stewardship in order to increase the likelihood of finding resistance (environmental, genetic, or a combination of both).

4. By 2014, where the disease is widespread, select, graft and archive at least ten putatively resistant trees in each ecodistrict[8] in support of a future breeding and/or vegetative propagation program to produce resistant trees for restoration, and in support of future critical habitat identification.

5. By 2019, address priority knowledge gaps and research necessary for implementing recovery activities (including research into genetic/environmental resistance and level of adaptive genetic variation).

[8] Boundaries defined by either the Ecological Stratification Working Group (1995) or another similar provincial approach (e.g. Crins 2002).

2.4 Approaches Recommended to Meet Recovery Goals and Objectives

2.4.1. Broad strategies over the short and long term

There is no question that many uncertainties exist surrounding the extent of butternut canker and the species' ability to resist the disease. Although full scientific certainty of many of these questions may never be achieved, the approaches listed within this strategy should assist in the recovery of the species. Some measures should be set in place immediately with the understanding that the broad strategy is dynamic and that the results of monitoring, management and research will continually supply information for ongoing development of the recovery strategy.

Further details of strategies and approaches that should be taken to address threats and achieve goals and objectives are outlined in Table 2. These approaches include both short and long term items with set priorities to help guide action planning for this species.

Table 2. Strategies and approaches to meeting long term recovery goals (>20 yrs) and short term recovery objectives.

Priority	Objective No.	Broad Strategy to Recovery	Threat(s) addressed	General Description of Research and Management Approaches	Anticipated Effect
High	2	Inventory and monitoring	Butternut canker	• Develop and implement a monitoring protocol with standardized methods for collecting tree and stand information, assessing and monitoring health, etc. during butternut inventories. • Collaborate with key partners to establish a data repository (Database Management System [DBMS]) compatible with the existing regional Conservation Data Centres (CDCs)	• Standardized inventories initiated on public and private lands • Data entered into the DBMS and made available
High	1, 3	Stewardship / Communication / Outreach	Harvesting Habitat loss and degradation	• Build partnerships and enforce regulations that conserve the species • Educate landowners and other stakeholders on needs of butternut and effects of canker • Encourage landowners to assess extent of disease and abstain from harvesting putatively resistant trees • Develop silviculture guidelines, incorporating new knowledge, in cooperation with private landowners	• A network of stakeholder organizations and interested groups established and involved in recovery implementation, including habitat conservation and restoration • Landowners and land managers involved in monitoring and assessment • Coordinated and consistent approach to silviculture practices for butternut
High	4	Inventory (Locate putatively disease resistant materials)	Butternut canker	• Locate and monitor putatively resistant trees • Develop reliable operational methods for screening putatively resistant material	• 10 putatively resistant trees located and monitored within all ecodistricts
High	5	Research (Canker resistance through genetics)	Butternut canker, Hybridization	• Investigate genetic basis to resistance and whether individuals can be bred for resistance • Determine whether putatively resistant trees are hybrids and develop a marker to assist in hybrid identification	• Baseline information on genetics and identification of resistant materials collected across regions • Genetic diversity inventory initiated
High	1, 2, 3, 4	Gene conservation (Strategic propagation to help maintain gene pool)	Butternut canker	• Coordinate a seed collection program from vigorously surviving trees • Establish and monitor breeding orchards using appropriate propagation techniques and protocols, including vegetative propagation • When possible, store backup seed/germplasm of putatively resistant butternut	• Increased knowledge on the efficacy of planting and propagation as conservation tools • Genetic materials of putatively resistant trees stored for use in conservation activities, and provided to land owners and land managers if appropriate

Priority	Objective No.	Broad Strategy to Recovery	Threat(s) addressed	General Description of Research and Management Approaches	Anticipated Effect
Medium	5	Research (Integrated pest management)	Butternut canker	• Research mechanisms to kill or control canker, and/or to provide resistance (i.e., inoculation) to individuals • Identify and communicate proper disposal methods for infected materials to minimize spread of disease	• An array of control means assessed and effective methods promoted through an integrated pest management strategy to protect and control against the disease
Medium	5	Research (knowledge required for long-term survival)	All	• Investigate key knowledge gaps, including genetic variation and population ecology, and interactions between threats • Continue to gather traditional aboriginal and landowner knowledge about butternut • Population Viability Analysis (PVA) to determine minimum viable population	• Research needs elaborated on and prioritized in a National Action Plan • High priority research completed or underway and adaptively applied in recovery efforts
Medium	3	Policy/legislation improvements	Harvesting, Habitat loss and degradation	• Develop policies or revise legislation to specifically address threats to the survival of butternut	• Butternut addressed in legislated and policy driven protection mechanisms • Forest Certification agencies (e.g. Forest Stewardship Council) addressing butternut conservation in Canada
Low	5	Research	Seed predation and Hybridization	• Assess the level of seed predation as a threat to butternut recovery • Assess if hybridization is a serious limiting factor for butternut recovery currently in Canada or if it has the potential to become one.	• The implications of seed predation and hybridization are assessed and better understood in the context of butternut recovery in Canada

2.5 Performance Measures

Performance measures for evaluating success in meeting the stated recovery objectives include the extent to which each objective has been met, using the measurable targets detailed in Table 3.

Table 3. Performance measures of short term recovery objectives.

Recovery Objective	Performance measure
1. By 2011, develop stewardship and outreach products informing Canadians of the identification, conservation status, conservation mechanisms and management of butternut and on the identification, assessment and management of butternut canker.	o Disease assessment guidelines developed and distributed to landowners, land managers, policy makers, and relevant Canadians o Major stakeholders and other relevant groups participating in multiple recovery activities o Guidelines developed and distributed to landowners including information on butternut identification, disease assessment and general silviculture practices, including methods for minimizing the spread of the canker
2. By 2012, collect information on the distribution, abundance and status of butternut and its health across its range in Canada and make it available in a National Database Management System (that is compatible with existing regional Conservation Data Centres).	o Standardized inventory, assessment, and monitoring protocol complete o National database created and information readily accessible by Recovery Implementation Groups o Inventory and monitoring initiated
3. By 2014, identify local populations of butternut across its native range and maintain them through focused stewardship in order to increase the likelihood of finding resistance (environmental, genetic, or a combination of both).	o Information on local populations available in the National DBMS and regional Conservation Data Centres o Butternut management information incorporated into tree marking training courses (e.g. OMNR tree markers) and silviculture guidelines, where possible. o Information/pamphlets on butternut management issues available in forums utilized by tree markers, loggers and wood buyers (i.e. Tree Marker Newsletter) o Number of populations known to be maintained for butternut increased over 2007 numbers
4. By 2014, where the disease is widespread, select, graft and archive at least ten putatively resistant trees in each ecodistrict in support of a future breeding and/or vegetative propagation program to produce resistant trees for restoration, and in support of future critical habitat identification.	o Identification and mapping of 10 putatively resistant individuals within ecodistricts that have high incidence of canker infection. o Putatively resistant trees identified, grafted and archived at sites across the range of butternut o Partnerships and endowments established to manage and monitor the archives. o Information for trees assessed with survival potential greater than 15 years are available in a national database. o If resistance is proven, identify sites as critical habitat; in the interim, if putative resistance at the population level is apparent, consider identifying sites as critical habitat.
5. By 2019, address priority knowledge gaps and research necessary for implementing recovery activities (such as research into genetic/environmental resistance and level of genetic adaptive variation).	o Research priorities established by 2010 (e.g. butternut canker resistance, genetic diversity, etc.) and communicated to research facilities and funding sources through a National Action Plan o Resistance testing ongoing o Highest priority research initiated o Bi-annual meeting to exchange information

2.6 Critical Habitat

2.6.1 Identification of the species' critical habitat

Butternut presents a unique challenge in terms of the identification of critical habitat for several reasons. Firstly, compared to the canker, habitat-related issues are not considered significant threats to butternut survival as presented in the COSEWIC status report (Nielsen *et al*, 2003). This means that unless resistant trees exist, the species' extirpation from Canada may still occur despite conserving as much butternut habitat as possible. Secondly, although diseased, butternut is currently relatively abundant and widespread throughout its range. Habitat loss and degradation and/or conversion of habitat for alternate land uses are considered a concern for parts of the butternut's range only. Thirdly, the recovery of butternut depends on resistance to the butternut canker. The mechanisms of resistance are unknown at this time, making the habitat needed to support or facilitate resistance difficult to identify. These factors, combined with the fact that there is not a clear understanding at the population level of what is needed to recover the species, indicate that there is currently not sufficient information to identify critical habitat.

Studies required to prove there is indeed resistance within butternut populations to the butternut canker and to determine if there are habitat features or environmental conditions that contribute to or support resistance will require several years to complete. In the interim, if putative resistance is apparent at a population level at a specific site, the site may be considered for the identification of critical habitat.

2.6.2 Schedule of studies to identify critical habitat

The following activities are required before critical habitat can be adequately identified for butternut. An Action Plan with input from each jurisdiction will guide the main activities in this Schedule and ensure consistency across jurisdictions. The disease is not equally impacting each region and, therefore, involvement in critical habitat activities will vary between regions. For example, where the disease is more widespread (e.g. Ontario), Recovery Implementation Groups will try to locate and identify non-diseased and vigorously growing diseased trees, whereas in other areas where the disease is not widespread (e.g. New Brunswick), health/putative resistance to the disease can not be assessed. Due to the unpredictable nature of research and complex nature of the disease, a window of 10 years for completing activities 3-5 in the Schedule of Studies is recommended. As the Action Plan for the butternut will be posted prior to the completion of the schedule of studies it will be updated when critical habitat can be identified.

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Table 4. Schedule of studies: Recommended research activities for the identification of critical habitat of butternut in Canada.

Activity #	Detailed Description of Research Activity (2007-2019)	Completion Date
1	Stratify butternut populations by province and ecodistrict, using a coordinated approach[9] and within each ecodistrict, locate and assess the health of trees (see Appendix for Health Assessment criteria). If putative resistance is found at a population level, consider identifying the area as critical habitat as an interim measure until the following studies are completed.	Ongoing
2	In ecodistricts where the disease is widespread, identify a minimum of 10 putatively resistant, healthy trees and monitor trees to determine if environment (site) contributes to resistance.	2014
3	Develop a method to test putative resistance (e.g. through inoculation of the fungus to seedlings or grafted material), while considering the potential interaction of genetic and environmental conditions in resistance.	2019
4	Test material from the 10 putatively resistant individuals per ecodistrict for disease resistance.	2019
5	If resistance is proven, identify areas where resistant trees are found as critical habitat.	2019

2.7 Effects on Other Species

The conservation of butternut *in situ* will have positive effects and support the diversity of species using butternut, its habitat and its other ecological functions (as yet undefined). As a result, this strategy will contribute to Canada's commitment to conserve biodiversity under the Convention on Biological Diversity and the Canadian Biodiversity Strategy. Negative consequences to other species, natural communities or ecological processes are expected to be minimal. For example, forest management techniques geared toward higher light conditions may have a negative impact for species requiring less light. Adverse effects from such forest management approaches are not suspected to be significant since butternut is typically scattered throughout a forest and efforts to increase light will be relatively small and localized.

2.8 Recommended Approach to Recovery Implementation

The Recovery Strategy and Action Plan must follow the adaptive-management approach, whereby new information feeds back into the plan on a regular basis in order to take advantage of new tools, knowledge, challenges, and opportunities. Wherever possible, recovery actions recommended in this strategy should be considered in the development of management plans by agencies and organizations that own and manage land on which the species resides. The Regional Recovery Implementation Groups should be consulted prior to undertaking activities that may affect occupied butternut habitat.

[9] Regions should use boundaries defined by either the Ecological Stratification Working Group (1995) or other provincial approaches that are similar (e.g. Crins 2002).

Since the primary threat to butternut (e.g. canker) is a threat to the species, not the habitat, the best approach to recovery is a single-species focus (including the maintenance of its' ecological function). Nonetheless, habitat conservation is still a component of this strategy – for the goal of preserving putatively resistant trees. In meeting this objective, this strategy will likely assist in conserving a variety of habitats including rich southern deciduous and mixed forests, which may enhance recovery for other species at risk in similar habitat (e.g. American ginseng) and provide habitat for forest biodiversity in general. The American ginseng and the Carolinian Woodlands Recovery Teams have similar habitat protection objectives and working with these teams and others in subsequent Action Plans may prove efficient in achieving recovery goals.

Some of the research recommended in this strategy involves collaboration with butternut researchers across Canada and the United States. To date American butternut researchers and managers have been very supportive of the efforts in Canada. Cross-border initiatives such as *Conserving Borderline Species: A Partnership between the United States and Canada* and the *Framework for Cooperation Between the U.S. Department of the Interior and Environment Canada in the Protection and Recovery of Wild Species at Risk* (Environment Canada 2001) highlight the potential for data exchange and resource sharing with respect to rare plants.

2.9 Statement on Action Plans

Environment Canada, along with the National Butternut Recovery Team, will prepare an Action Plan by 2014 and will coordinate recovery efforts across jurisdictions to ensure collaboration and avoid redundancy in efforts.

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APPENDIX. Criteria for assessing A) health/vigor and B) putative resistance (modified from Ostry et al. 1994).

A. Assessment criteria that indicate if a mature individual[10] is 'healthy' or vigorously surviving. Trees that do not meet these criteria are considered 'unhealthy' or with poor vigor and are expected to survive <10 years.

Determination of tree health/vigor can be achieved by examining the percentage live crown and percentage of the main stem affected by cankers and applying the 70-20-50 rule (modified from Ostry et al. 1994). Candidates that are considered 'healthy' include:

- All trees 10 cm or greater dbh (diameter breast height, 1.3 m), with more than 70% live crown and less than 20% of the main bole circumference (including root flare) affected by cankers; and
- All trees 10 cm or greater dbh, with at least 50% live crown, and no cankers visible on the main stem or root flares.

B. Assessment criteria that indicate if a mature individual is putatively resistant to butternut canker.

Occasionally vigorously surviving trees are found near diseased and dying trees. Although these trees may have escaped the fungus, it is possible they have resistance to the disease. Trees that are disease-free, or are apparently able to reduce or inhibit canker expansion, may have value in future tree improvement efforts and should be retained.

- A candidate tree for putative resistance must be in a stand that exhibits a high incidence of the disease and should be within 30 meters of a diseased tree so that it has had a reasonable chance of exposure to the pathogen.
- The candidate tree should be at least 25 cm dbh and must be free of cankers, or if cankers are present, the tree must have overgrown them.

[10] Determination of health can be made on mature trees (>10cm dbh) only.

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