Conservational Strategies: A Study of Red Mulberry (Morus Rubra)

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Abstract

Red mulberry (*Morus rubra*) cultivation in Canada confronts multifaceted challenges, including habitat loss, climate variability, and intensification of agricultural practices, which collectively jeopardize its population and genetic diversity. This study investigates the conservation strategies employed for the protection and recovery of red mulberry populations across Canada. Through a comprehensive analysis of existing recovery plans, management initiatives, and research efforts, this research aims to assess the effectiveness of current conservation practices and identify areas for improvement. The research adopted qualitative methods i.e. descriptive and analytical methods are used for the synthesis of the literature review. For analysis, the content analysis method is applied. The research highlights the significance of long-term monitoring programs to track population trends, assess the success of conservation interventions, and adapt management strategies accordingly. The research endeavours to promote the sustainable conservation of this ecologically and culturally valuable species, ensuring its persistence for future generations.

Keywords: *Morus Rubra*, Canada, conservational strategies.

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Introduction:

Plant biodiversity in general and crop diversity in particular are essential for climate resilience and agricultural output. Crop genetic erosion, also known as the loss of crop diversity, is a serious issue for agriculture's future. However, the amount of this loss varies depending on the species, the region, the taxonomic and geographic scale, and the method used to measure it. (Khoury et al., 2021).

According to Agriculture and Agri-Food Canada (2021), berries are the most economically significant fruit crop in Canada. The combined farm gate value of blueberries, grapes, cranberries, and strawberries was $744 CAD million in 2020. (Agriculture and Agri-Food Canada, 2021)

Indigenous Peoples of North America also rely heavily on berries as a source of food, language, traditional knowledge, and cultural expression. We highlight berries not just because they are a staple food and have significant economic and nutritional value, but also because they are eaten fresh, offering a special chance for people to build relationships with plants and food systems. Berries are a good case study for the conservation of food plant variety because of the prevalence of plant awareness disparity, which occurs when people do not recognize plants in their surroundings (Parsley, 2020).

Red mulberry (*Morus rubra*) cultivation in Canada holds historical and ecological significance, dating back centuries to indigenous communities who revered the tree for its nutritious berries and versatile wood. While once abundant across North America, red mulberry populations have faced decline due to habitat loss, deforestation, and agricultural expansion. In Canada, red mulberry stands as a symbol of biodiversity and cultural heritage, with its presence enriching the landscape and providing habitat for diverse wildlife species (Smith, 2018).

However, the continued cultivation and conservation of red mulberry in Canada are now threatened by various challenges, including climate change, urbanization, and invasive species. The need for conservation-oriented smart crop production strategies is thus paramount to safeguarding the future of red mulberry cultivation. Smart crop production integrates advanced technologies, precision agriculture methods, and ecological principles to optimize resource use, minimize environmental impact, and enhance crop resilience (Klumpp et al., 2020).

In light of these challenges and opportunities, this research sets forth clear objectives to explore conservation strategies for red mulberry cultivation in Canada and provide actionable recommendations for their implementation. By synthesizing existing literature on red mulberry cultivation, conservation practices, and smart crop production techniques, this study aims to contribute to a deeper understanding of sustainable agricultural practices that balance ecological conservation with agricultural productivity (González et al., 2019).

Literature Review:

Red mulberry

The mulberry plant, which is native to the genus Morus and belongs to the family *Moracea*, can be grown in valleys, plains, and mountains as well as in humid, rain-fed environments. There are numerous kinds of this plant found all over the world, but three standout types are the local red mulberry (*Morus rubra*), the East Asian white mulberry (*Morus alba*), and the black mulberry (*Morus nigra*) from Southwest Asia (Wedin,1992).

There are roughly 13 species in the genus *Morus L.* (Family *Moraceae*), which are found in Asia, Africa, North, Central, and South America (Nepal 2008). Regarding the correct identification of two species of Morus found in eastern North America, M. rubra L. and M. alba L., there is a great deal of taxonomic misunderstanding**.** According to Nepal and Ferguson (2012) and Nepal et al. (2012), M. microphylla, which is found in Texas, Arizona, and New Mexico, is the other native mulberry species in the United States. The native species of mulberries is rubra. M. rubra can be found in North America from southwestern Ontario to the Atlantic coast, from the eastern margin of the Great Plains to southern Florida. The Chinese native *M. Alba* presented Throughout M. rubra's habitat, it currently exists as an invasive species that was brought in during colonial times for the silk industry (Wunderlin 1997). Mostly found in riparian zones, the native M. rubra is scarce and vulnerable in several places, including southeastern Canada and the northeastern United States (Ambrose and Kirk 2004; Penskar 2009; USDA 2012).

In addition to being grown, the introduced *M. alba* can be found in both open and wooded settings. Where the two species coexist, hybridization between them is known to occur (Burgess et al. 2005; Nepal 2008). *M. Alba* is possibly a threat to *M. rubra* due to its aggressive growth characteristics, quick range extension, and reproductive advantages over *M. rubra* (Burgess et al. 2005; Nepal 2008). As of right now, the native *M. rubra* is threatened in Vermont and Michigan, endangered in Canada, and endangered in the USA's states of Connecticut and Massachusetts (Sullivan 1993; Nepal 2008; USDA 2012).

Morphological features of red mulberry:

The red mulberry tree grows to a height of 25 meters, and it can occasionally reach the bottomlands, valleys, and forested floodplains' lower forest canopy. The distinctive loose, light greyish-tan elongate plates that make up mature trees' bark. The leaves are whole and alternating.1-3 lobed, 9-24 cm long, almost as wide, with rough, dull outer surface, milky sap, and broad to heart-shaped bases, long, tapering tips, and coarsely toothed margins.(Canada Government, 2014)

Table 1 Morphological feature of Red Mulberry(Canada Government, 2014)

Features	**Real Mulberry**
Tree Size	Height up 25 meters in diameter at breast height (DBH) small to large up to 1m.
Habitat	Riparian areas, natural forested areas
Distribution	Northeastern America (from the Atlantic coast to the eastern edge of the Great Plains, north to S. Ontario Canada
Leaf	Leaf blade 5-40 x 3-28cm, base typically cordate, petiole 2-2.5cm. Leaf surface adaxially rough and dull green, abaxially densely pubescent (hairs all over but more along the veins), veins are more or less matching to the surface. Leaf apex acute, acuminate to sub caudate. Leaf margin regularly serrated (serrations pointed and acute).
Winter bud	Larger (0.4-0.8cm) often with acute apex; the bud scale margins have a darker apical band.
Bark	Grayish bark with flattened, thinner ridges that peel back in older trees.
Branching pattern	Planar (flat) and spreads like less or more horizontal.
Flowers Fruit	Cylindric, 1-4.5 x 0.5-1.5cm, deep purple to red.

Figure 1 Red Mulberry Leaves and fruit

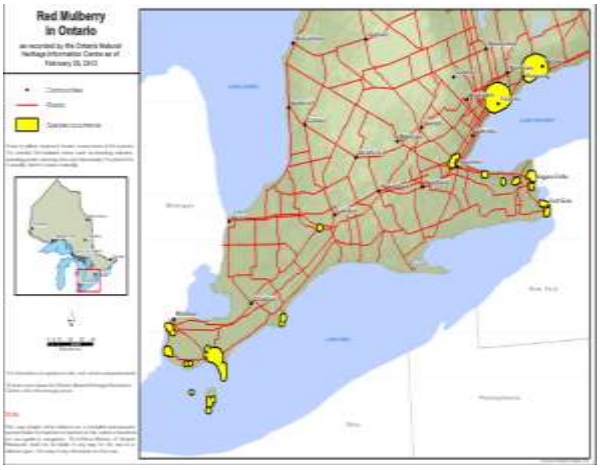

Figure 2 Distribution of M.Rubra in Ontario

Distribution of red mulberry:

From southern Ontario to Vermont and south, the red mulberry is a widely dispersed species in the central and eastern United States and Canada. extending from South Dakota to Texas in the west, and from Florida in the east. It is thought to be extinct in the District of Columbia and rare in Vermont, Massachusetts, and Ontario (NatureServe 2007). Ontario is home to the northernmost point of the red mulberry distribution. The Carolinian Zone in southern Ontario is the only area within the Red Mulberry's national and provincial range. Red mulberry can still be found in 16 locations. These take place in Four general places are identified: alvar forests on the Western Lake Erie Islands, the sand spits of Point Pelee and Rondeau, minor remnants of moist forest near Windsor, and the Niagara Escarpment extending from the Niagara Peninsula to southern Halton. There used to be at least 16 other locations, but habitat degradation has made these disappear. (COSEWIC 2014)

Nutritional composition of M. Rubra

Its nutritional composition analysis shows that it contains 1.26g/100g (fw) protein, 0.85g/100kg(fw) fat, 3.2–5.41g/100g (fw) fructose, 3.3–6.07g/100g (fw) glucose, 19.38mg/100g (fw) anthocyanins, 16.17mg/100g (fw) ascorbic acid, 4.5–57.38, 132mg/100g (fw) calcium, 226mg/100g (fw) phosphorous, 61mg/100g (fw) sodium, 834mg/100g potassium, 115mg/100g magnesium, 3.2–5.04mg/100g (fw) zinc, 0.37mg/100g (fw) nickel, 0.20–0.90 mg GAE/g (fw) total phenols, and 219mg QE/100G (fw) total flavonoids. (Dhiman, Kumar, Mehta, 2020).

Indigenous Uses and Cultural Importance:

The Indigenous peoples of Canada have long revered Red Mulberry for its diverse array of uses, deeply embedded within their cultural practices and traditions. Across various Indigenous communities, Red Mulberry holds a prominent place in medicinal, culinary, and spiritual contexts. (Turner & Peacock, 2005).

Historically, Red Mulberry served as a vital component of Indigenous medicinal practices, with different parts of the tree utilized to treat a spectrum of ailments. (Anderson, 2001) For instance, the bark of

Red Mulberry was often brewed into teas or concoctions to alleviate fevers, while the leaves were used topically to soothe skin irritations and inflammations. The fruits, prized for their rich flavor and nutritional value, were consumed fresh or dried and incorporated into traditional dishes, imparting both sustenance and cultural significance to meals.

Beyond its utilitarian uses, Red Mulberry occupies a symbolic role in Indigenous mythology and worldview, embodying concepts of resilience, interconnectedness, and reciprocity with the natural world. (Warren et al., 1995). Its presence in creation stories, ceremonies, and art underscores its spiritual significance, fostering a profound respect for the land and its resources among Indigenous communities.

For example, among the Haudenosaunee (Iroquois) people, Red Mulberry is considered one of the "Three Sisters," alongside corn and beans, representing a sacred trinity of crops central to their agricultural traditions and cultural identity. This reverence for Red Mulberry reflects a holistic understanding of its intrinsic value beyond its tangible benefits, reinforcing the importance of preserving its presence in the landscape.

Role in Biodiversity and Habitat Preservation:

In addition to its cultural significance, Red Mulberry plays a crucial ecological role in sustaining biodiversity and preserving habitats within Canada's diverse ecosystems. As a native species, Red Mulberry contributes to the intricate web of life by providing essential resources and habitats for a myriad of plant and animal species (Jones & Dickmann, 2002). The dense foliage of Red Mulberry offers refuge and nesting sites for numerous bird species, including warblers, thrushes, and vireos, while its fruits serve as a vital food source during migration and breeding seasons. Moreover, the leaves of Red Mulberry support a diverse array of insect herbivores, forming the foundation of complex food webs that sustain higher trophic levels within forest ecosystems. Furthermore, Red Mulberry's role in habitat preservation extends beyond its direct interactions with wildlife to encompass broader ecosystem functions. The deep root systems of Red Mulberry help stabilize soil, prevent erosion, and enhance water retention, thereby mitigating the impacts of floods and droughts and maintaining the health of riparian zones and watersheds. By fostering healthy ecosystems, Red Mulberry contributes to the resilience of Canada's natural landscapes, buffering against the effects of climate change, habitat fragmentation, and other anthropogenic disturbances. Its presence serves as a cornerstone of biodiversity conservation efforts, highlighting the interconnectedness of species and the importance of preserving native flora for future generations (Gouin, 2008).

Red Mulberry embodies a rich tapestry of historical, cultural, and ecological significance within Canada, reflecting the intricate interplay between human societies and the natural world. Recognizing and honoring the diverse roles of Red Mulberry is essential for fostering sustainable stewardship of the land and promoting the conservation of biodiversity for generations to come.

Threats to the specie:

1- Hybridization

The biggest threat to Red Mulberry populations in Canada is hybridization with White Mulberry. Eastern Asia is where white mulberry was first introduced for the

silkworm industry. It freely crosses with Red Mulberry and has naturalized throughout eastern North America (Farrar 1995, Waldron (2003). In Canada, Red Mulberry populations are almost exclusively found in mixed populations with White mulberries, and hybrids between the two species are not uncommon (Ambrose 1999). Burgess (2004a, Burgess et al. 2005) discovered that 53.7% of the Red Mulberry trees in six southern Ontario core populations—that is, five or more individuals less than one kilometer apart from one another—were hybrids. Approximately 67% of those hybrids shared greater genetic similarities with White Mulberry than Red Mulberry.

It appears that White Mulberry is genetically assimilating Red Mulberry based on the abundance of White Mulberry trees and hybrids throughout the landscape and the genetic makeup of the hybrids. Given the detrimental effects hybridization has on Red Mulberry mating and establishment (Burgess 2004), it is likely that hybridization will occur in the absence of recovery measures.in Canada's eradication of the pure Red Mulberry. Moreover, according to Wolf et al. (2001), habitat disruption encourages hybridization with rare taxa.

2- Habitat loss and Fragmentation

The threat of suitable habitat loss to Red Mulberry is just marginally less serious than that of hybridization. The amount of natural forested habitat in Carolinian areas has significantly decreased due to land clearing for agriculture, industry, urban development, utilities, and transportation routes.The Southwest Ontario Life Zone. Less than 3% of the historical Red Mulberry range is still covered in forest, and much of it is severely fragmented (Larson et al. 1999).

3- Nesting Double-crested Cormorant

Over the previous 30 years, there has been a significant increase in the population of Double-crested Cormorants (*Phalocrocorax auritus)* in Ontario. On Middle Island, large nesting cormorant colonies are endangering the long-term survival of Red Mulberry populations and their habitat (10 trees).

East Sister Island (five trees S. Dobbyn unpub. data 2009, NHIC unpub. data 2010) and the western basin of Lake Erie in 2002–2003 (North-South Environmental Inc. 2004). According to research, cormorants physically destroy branches, strip foliage for nesting material, and deposit excrement on trees, leaves, and soil in their breeding grounds (Korfanty et al. 1999). Both soil chemistry and photosynthesis may be impacted by the latter (Hobara et al. 2001, Hebert et al. 2005).

4- Disease and Causative Stress Factors

Twig blight, twig dieback, cankers, and root rot are reported to affect Red Mulberry trees (Ambrose et al. 1998). Four Red Mulberry communities' health evaluations show that some are in extremely poor health, experiencing population-level reductions that have been characterized as a "gradual, general deterioration" (Spisani et al., 2004; McLaughlin and Greifenhagen, 2002). The previous investigation came to the conclusion that many pathogens were not to blame for the illness's symptoms. Instead, the damaged trees were impacted by two opportunistic root disease pathogens and many opportunistic canker-causing pathogens. These viruses can successfully harm stressed and vulnerable hosts, but they are not known to infect healthy tissues. According to other studies, the species is extremely sensitive to air pollution, and high concentrations probably increase the species' susceptibility to illness (Little 1995).

5- Other Exotic species

Beyond White Mulberry, other invasive species could have a detrimental effect on Red Mulberry and/or its environment. Southern Ontario is seeing an increase in the distribution of some invasive bug species.

The Asian Long-horned Beetle *(Anoplophora*) and the Emerald Ash Borer (*Agrilus planipennis glabripennis*) are two insects that should be taken very seriously since they are invasive and can infest and damage healthy trees**.** The potential effects on Red Mulberry habitat and forest composition from the extension of one or both insect ranges are unknown. (Vaughn and Berhow 1999).

6- **Herbivory**

The fruit of Red Mulberry is an attractive food source of birds and small mammals, which, if eaten and dispersed before it is fully mature, may result in lower regeneration success (Johnson and Lyon 1976). High populations of gastropods can hinder seedling growth. Grazing by eight species of native snails and slugs was observed at Point Pelee National Park (T. Pearce pers. comm. 1992) to effectively eliminate seedlings (Ambrose 1991). Gastropod impacts at other sites are unknown. In areas of high deer populations, browsing of Red Mulberry has been observed and is a further hindrance to the establishment of new seedlings (Ambrose 1993, Thompson 2002b).

Conservational strategies

Many actions for the recovery of the Red Mulberry have been undertaken since 1998. These actions include surveys in areas with existing and historical records, population censuses, and ecological land classification. Other actions involve disturbance of soil, which may result in increased establishment of exotic plants, and the destruction of vegetation. Studies are also being conducted to identify critical habitat for the Red Mulberry, including confirming the status of populations and individual trees and searching for suitable habitat that has not been previously located.(Burgess, K. S. and B. C. Husband. 2002)

Canadian Government designed a proper recovery plan for the conservation of the Red Mulberry (Morus rubra). Threats like habitat degradation, hybridization, nesting cormorants, and general community support and management are addressed at the highest priority level. Strategies unique to each of these high-priority threats are suggested. For instance, it is advised to conserve and restore genetic integrity to combat hybridization, while habitat restoration and population growth are urged to counteract habitat degradation. Implementing conservation plans unique to the impacted islands and informing stakeholders of the need for such management are further steps in controlling the effects of nesting cormorants. It is emphasized that maintaining traditional ecological knowledge and encouraging voluntary actions require community support and management. (Parks Canada Agency. 2011)

Critical habitat protection measures target additional alien species, habitat degradation and fragmentation, hybridization, and other medium-priority threats. It is suggested that monitoring be used as a medium-priority strategy for dealing with all risks, highlighting the significance of collecting population data and identifying variations in abundance, distribution, and health over time. Last but not least, improving our knowledge and comprehension of the species and putting site-based management for core populations into practice are advised at the lowest priority level. It is also determined that

managing the effects of grazing species—such as white-tailed deer and snails—is a low-priority concern. To address these effects, management measures are suggested. (Parks Canada Agency. 2011)

Table 2 Recovery planning for red mulberry (Park Canada Agency 2011)

Priority	**Threats addressed**	**Broad strategies to address threats**	**Recommended approaches**
High	All	Habitat restoration and population enhancement.	Identify appropriate habitat and populations for restoration and population enhancement initiatives.Develop and implement habitat restoration plans and population enhancement procedures.
High	Hybridization	Protect and restore genetic integrity.	Develop and implement White Mulberry control procedures.Develop techniques to enhance pure strain establishment and survival.Determine current genetic composition of all populations, including variation within and between populations and metapopulations, and determine the presence/absence of *M. murrayana*.
High	Nesting Cormorants	Manage the impacts of nesting Double-crested Cormorants and communicate the need for such management.	Implement the Middle Island Conservation Plan (Parks Canada 2008).Determine the overall impact(s) of cormorants on East Sister Island and implement measures to address them.
High	All	Community support and stewardship, and Traditional Ecological Knowledge.	Develop and implement best management practices to reduce or mitigate threats.Develop and deliver outreach initiatives that increase awareness of Red Mulberry, understanding of threats to it, and foster voluntary stewardship actions.Encourage the gathering and transfer of Traditional Ecological Knowledge from Knowledge Holders to others.
Medium	Habitat Loss & Fragmentation, Hybridization, Other Exotics	Critical habitat protection.	Develop and implement critical habitat protection measures.
Medium	All	Monitoring.	Conduct targeted searches in sites to

			update population status information as necessary, as well as at historical sites and in potential habitat.Develop and implement a long-term monitoring program to detect changes in abundance, distribution, demography, health and threats.
Low	All	Enhance knowledge and	Fill the knowledge gaps
		understanding of the species	
Low	All	Site-based management.	Develop site-specific or multi-site plans to direct Red Mulberry recovery for core populations.
Low	Herbivory	Manage the impacts of grazing species.	Develop and implement management actions to address the impacts of grazing species (White-tailed Deer and snails).

Discussion:

Numerous risks to Red Mulberry are covered in the recovery planning table, such as herbivory, hybridization, habitat degradation, and cormorant nesting. This comprehensive strategy guarantees that the recovery planning process takes into account a variety of conservation challenges. The planning table successfully identifies the most pressing conservation issues by grouping threats and suggesting solutions according to priority levels. To maximize the impact of conservation, this prioritization enables resource allocation and action planning to concentrate on high-priority issues first. The focus on stewardship, traditional ecological knowledge, and community support indicates an understanding of how critical it is to include stakeholders in conservation initiatives. Recovery programs can function more effectively and sustainably when local people are involved and traditional knowledge is integrated. This conservational stargate was proposed in 2011 and still, the red mulberry species is considered to be endangered with only 200-300 trees left.

The identification of monitoring as a medium-priority method highlights the necessity of conducting routine evaluations of Red Mulberry populations and associated hazards. Establishing a long-term monitoring program is essential for tracking changes in population density, health, and distribution over time. Furthermore, the application of adaptive management concepts enables conservation methods to be continuously modified in response to feedback and monitoring data. there is less emphasis on integrating scientific research into recovery planning. Collaboration with researchers could strengthen the evidence base for decision-making. The low priority given to expanding knowledge and understanding of the species raises the possibility that research and data collection should be given more attention. For conservation

planning decision-makers to make well-informed choices, filling in information gaps is essential.

In a similar vein, the low priority accorded to site-based management suggests that it may be vulnerable when it comes to dealing with particular challenges at localized scales. Creating management plans tailored to the specific needs of each site is crucial to solving the various problems that distinct populations encounter. There is a need to give some significant importance to disease management and the conduction of scientific research with advanced technologies to make the genome for the red mulberry strong enough to fight diseases that are caused by unknown pathogens.

Conclusion:

In conclusion, the study of conservation strategies for red mulberry (Morus rubra) in Canada underscores the imperative of collaborative, science-based approaches to safeguarding biodiversity. Addressing challenges such as habitat loss, hybridization, and herbivory, while capitalizing on opportunities for habitat restoration, genetic integrity preservation, and community engagement, forms the cornerstone of effective conservation action. By prioritizing these strategies and integrating them into comprehensive management plans, we can enhance the resilience of red mulberry populations and mitigate the impacts of anthropogenic threats. Moreover, incorporating traditional ecological knowledge and engaging local communities are essential elements for the success of conservation initiatives. Establishing long-term monitoring programs and advancing research into red mulberry ecology and genetics will further inform adaptive management strategies. Ultimately, the sustained collaboration, innovation, and dedication of all stakeholders are paramount to ensuring the continued existence of this ecologically and culturally significant species in Canada.

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