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REVIEW

# Towards a better understanding of the relationships between pollinators, human well-being, and medicine plants in the Great Lakes Region of Eastern North America

Shelby D. Gibson[1] | Sheila R. Colla[2]

[1]Department of Biology, 102 Life Sciences Building, York University, Toronto, Ontario, Canada

[2]Faculty of Environmental and Urban Change, Health, Nursing, and Environmental Sciences Building, York University, Toronto, Ontario, Canada

**Correspondence**
Shelby D. Gibson, Department of Biology, 102 Life Sciences Building, York University, 4700 Keele Street, Toronto, Ontario M3J 1P3, Canada.
Email: shelbydgibson@gmail.com

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**Societal Impact Statement**

A diversity of values is needed to maximize the effectiveness of conservation planning, including policies and programs. The results of the United Nations Biodiversity Conference (COP 15) in Montreal, Canada, highlight the importance of a shift towards recognizing multiple ways of knowing in ecology and conservation. This review aims to provide a baseline of what is known about culturally significant plants in the Great Lakes Region of Eastern North America. The results of this research provide insight into the ways in which ecology has been conducted in the past and the importance of changing the way ecology is conducted in the future.

**Summary**

Biocultural conservation theory allows for an examination of complex problems using systems thinking and conserving biological and cultural diversity together. In the Great Lakes Region of Eastern North America, wild medicine plants are an important part of what Anishinaabe people understand as *Mini bimaadizi*, or the good life, and of *aki miijim*, or traditional food systems. Given the various threats facing wild plant populations and continued global change, this review aims to investigate what is known about the pollination and breeding systems of culturally significant plants in the Great Lakes Region. The overall goal is to determine what proportion of these plants have had basic ecological studies done and the degree to which culturally significant plants in this region rely on insect pollination. A systematic review of the literature was conducted on breeding systems and pollination of culturally significant plants. Half of all the culturally significant plants included lacked specific information related to reproduction. Most plants that have been studied relied on outcrossing, and the most commonly reported pollinators were in the Apidae family. With the complex interactions between plants and pollinators and many insect pollinators experiencing population declines, it is important to determine the dependence of culturally significant plants on animal pollination. These findings will be relevant to conservation planning and policy in the future.

**KEYWORDS**
*aki miijim*, biocultural conservation, breeding system, culturally significant plants, ecological-interactions, *Mini bimaadizi*, plant reproduction, pollination

## 1 | INTRODUCTION

Biocultural approaches to conservation are embedded within social-ecological systems and are focused on reducing declines in both biological and cultural diversity (Berkes et al., 2016; Gavin et al., 2015; Hill et al., 2019; Pretty et al., 2009; Winter et al., 2020). Conservation planning is ineffective when it fails to consider the social system in which it operates (Artelle et al., 2019; Ban et al., 2013; Pretty et al., 2009). The standard (colonial) approach to solving ecological problems in a silo limits our capacity to benefit from diverse people, knowledge systems, and solutions (Artelle et al., 2019; Hill et al., 2019; Smith, 2012; Trisos et al., 2021). The Anishnaabe people of the Great Lakes Region in Northeastern North America have a cultural connection to the land (Brokenleg & Tornes, 2013; Densmore, 2005). *Mino bimaadizi* (Ojibwemowin) (Densmore, 2005) or *Mino bimaadiziwin* (Anishinaabemowin) (Simpson, 2011), which describes "the good life," refers to a state of cultural and spiritual well-being. Plants are considered sacred and are strong components of maintaining *Mino bimaadizi* (Brokenleg & Tornes, 2013; Densmore, 2005). Anishinaabe people have traditionally collected plants for many reasons, including for use as medicine (Brokenleg & Tornes, 2013; Densmore, 2005). Globally, there is a trend of species declines that is occurring simultaneously with losses in Indigenous language and cultural practices (Artelle et al., 2019; Ens et al., 2016). Plant populations are threatened by land use changes, and the traditional knowledge associated with the plant is lost because of a lack of documentation and inter-generational knowledge transmission (Motaleb, 2010). Ongoing settler-colonial violence, including genocidal land management practices (Brokenleg & Tornes, 2013), has had a severe impact on Anishinaabe people, who are undergoing a loss of culture and traditions such as plant knowledge, language, and stories. Indigenous people in North America have used plant management techniques for millennia that rely on a reciprocal, caretaking relationship with the land (Turner et al., 2013). This includes the tending of plant resource sites between human generations (Turner et al., 2013). Biological research on plants has primarily focused on plants used for major crops and commodities (Padulosi et al., 2004). This has resulted in a lack of research on other plants, including basic ecological studies, mapping of distributions, breeding systems (pollination and seed dispersal), taxonomy, and phylogenetics (Kearns et al., 1998; Padulosi et al., 2004). A recent review of at-risk plants in Ontario found that many plants lacked any basic information related to pollination requirements, pollinator needs, and recovery recommendations (MacPhail et al., 2018). The basic aspects of any plant's reproduction are necessary for conservation planning (MacPhail et al., 2018; Wani et al., 2022).

Of all flowering plants, 87.5% are estimated to be animal-pollinated (308,009 species of angiosperms) (Ollerton et al., 2011). Approximately 80% of all wild flowering plants directly require insect pollination for fruit and seed set (Harder & Barrett, 1996; Kearns et al., 1998; Potts et al., 2010, 2016). Self-compatible plants that reproduce through autogamous self-pollination have a particular set of characteristics, such as low herkogamy (anther-stigma distance) and low dichogamy (temporal separation of mature anthers and stigmas) (Thomann et al., 2013). Self-compatible plants must sometimes employ a mixed mating system using cross-pollination to avoid inbreeding depressions (Ollerton et al., 2011; Thomann et al., 2013). Other plants are unable to self-fertilize or require a pollinator to move pollen from the anther to the stigma within a flower (Ollerton et al., 2011). Plants requiring insect pollination often have a set of characteristics, including a large floral display, high scent intensity, large rewards (nectar and pollen), and a large corolla size (Thomann et al., 2013).

Bees are important pollinators of wild plant species (Ollerton et al., 2011; Potts et al., 2010, 2016; Raven et al., 1999). Across many parts of the globe, wild pollinator diversity and abundance are in decline (Colla et al., 2012; Potts et al., 2010; Rodger et al., 2021; Tylianakis, 2013; Zattara & Aizen, 2021). The main factors affecting global pollinator declines identified are habitat loss and fragmentation, agriculture (pesticides and GMOs), pathogens, invasive alien species, pollinator management, and climate change (Brown & Paxton, 2009; Dicks et al., 2021; Potts et al., 2010, 2016). The reproductive success of wild flowering plants is at risk due to pollinator declines (Aslan et al., 2013; Biesmeijer et al., 2006; Bond, 1994; Rodger et al., 2021; Scheper et al., 2014; Thomann et al., 2013). Globally, 75% of crop plants rely on pollination by animals, in particular, bees (Klein et al., 2007). A global review of crop pollination found that wild bees pollinated crops more effectively than honey bees (Garibaldi et al., 2012). In general, honey bees are not able to replace the pollination services provided by wild bees (Garibaldi et al., 2012; Tylianakis, 2013). While this is more well studied in food crop systems, it also occurs in wild plants (Page & Williams, 2022).

Human health and well-being are influenced by pollination services (Kearns et al., 1998; Potts et al., 2016; Stout & Dicks, 2022). The Assessment Report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) on Pollinators, Pollination, and Food Production found that pollinator declines could impact human well-being through loss of wild plant diversity and yield and cultural practices and traditions surrounding plant and pollinator species (Dicks et al., 2021; IPBES, 2016; Potts et al., 2016). This highlights the importance of research and knowledge sharing that consider social and ecological systems together.

According to the World Health Organization (WHO), nearly 80% of the world's population relies on traditional medicines, particularly plants, as their main method of health care (World Health Organization et al., 1993). The surge of interest in using plants as medicine in recent decades (Westfall & Glickman, 2004) has been operating under the assumption that these plants will be available in perpetuity (World Health Organization et al., 1993). This assumption ignores the threats wild medicinal plant populations are currently facing, including increasing overharvest, climate change, and habitat loss (Erland et al., 2022; Mooney & McGraw, 2007; World Health Organization et al., 1993). Based on these factors, the WHO, International Union for the Conservation of Nature (IUCN), and World Wildlife Fund (WWF) convened a meeting in Chiang Mai, Thailand, on March 21–27, 1988, to develop a plan to address the security of medicinal plant populations (World Health Organization et al., 1993). Out of this meeting came "The Chiang Mai Declaration – Saving Lives by Saving Plants," which called upon the United Nations, its agencies, and Member States to work towards medicinal plant conservation.

There is an increasing demand for medicinal plants in North America (Erland et al., 2022; Smith et al., 2020; Westfall & Glickman, 2004). In some cases, a plant may experience a significant population decline due to human overharvesting, such as the case with American ginseng (*Panax quinquefolius*) (Erland et al., 2022; Mooney & McGraw, 2007). One conservation strategy that includes introducing cultivated seeds into wild populations can potentially decrease the genetic integrity of the plant population (Grubbs & Case, 2004; Mooney & McGraw, 2007). Breeding system studies must be conducted to further understand the impacts of various conservation strategies and management plans, especially regarding medicinal plants for which demand is rising (Erland et al., 2022; Grubbs & Case, 2004; Mooney & McGraw, 2007). High-quality seed is a requirement for the production of a reliable, healthy stand of a particular plant (Pooni et al., 1997). Farming a plant for seed stock often requires pollinator supplementation. In order to properly support development of a healthy supply of seed stock, the reproductive biology of the plant must be well understood (Cane, 2006). The strongest threats to wild medicinal plant populations in Canada are habitat loss, invasive species, overharvesting, and climate change (Erland et al., 2022; Karst, 2010; Uprety et al., 2012).

Parties to the Convention on Biological Diversity (CBD) set the 20 "Aichi biodiversity targets" as a conservation framework spanning 2011–2020 (Artelle et al., 2019). The targets have largely been unmet, with continued declines in biodiversity globally (Artelle et al., 2019). At the recent UN Biodiversity Conferences in Montreal, Canada, world leaders agreed on a plan to halt biodiversity decline (Convention on Biological Diversity (CBD), 2022). The new action plan acknowledges the rights of Indigenous peoples and their importance as stewards of nature (CBD, 2022). In the 2030 Action Targets, there is a goal to protect medicines for sustainable harvesting by Indigenous peoples, ensuring Indigenous knowledge informs relevant conservation decision-making, and that Indigenous people have equitable access to participate in decision-making related to biodiversity on their lands based on relevant rights and treaties (CBD, 2022).

This paper aims to determine to what extent culturally significant plant breeding systems have been studied and to what extent culturally significant plants rely on pollination by wild bees in the Great Lakes Region of Eastern/Central North America.

## 2 | MATERIALS AND METHODS

The colonial history of ecology means that the research questions and who can answer them are based on power dynamics, and using a decolonizing framework for the future means having marginalized groups set the research agenda (Trisos et al., 2021; Tuhiwai Smith, 2012). Tuhiwai Smith (2012) outlines two methods for advancing the Indigenous research agenda, which are using a community-based approach and through Indigenous studies departments in the institution. Trisos et al. (2021) highlight five steps for decolonizing ecology, which include: decolonizing your mind, knowing your histories, decolonizing access, decolonizing expertise, and practicing ethical ecology in inclusive teams. This study is part of the Finding Flowers project at York University in Toronto, Ontario, Canada. Finding Flowers is an interdisciplinary project that integrates art, ecology, and education using a biocultural lens to study native plant and pollinator conservation. The Finding Flowers project is co-led by Anishinaabe artist Lisa Myers and native bee ecologist Dr. Sheila Colla. Determining a baseline of what is available in the scientific literature on native plant reproduction is a key component of conducting future research on native plant-pollinator relationships. The authors of this paper are non-Indigenous settlers living in Ontario, Canada, who are grateful to the original inhabitants of Turtle Island for their stewardship of these lands for millennia and who are committed to learn how to responsibly contribute to the care of this land.

This review was conducted to determine what is known about plant breeding systems in the Great Lakes Region and focuses on Anishinaabe medicine plants. A plant list of 215 species was compiled. The focal plant list was compiled using the following studies: Davidson-Hunt et al., 2005; Genuisz, 2015; Meeker et al., 1993; Smith, 1932. This paper focuses on plant–pollinator interactions, so only angiosperms are included. Further, herbaceous plants are the most commonly utilized in the region (Uprety et al., 2012), and therefore we excluded all other plants (e.g., woody-stemmed shrubs, vines).

In order to investigate what is known about the breeding and pollination systems of the selected plants, we used the Scopus and Web of Science databases. Two databases were used in an effort to ensure the search returned all relevant papers. The following search terms were used on both Scopus and Web of Science: ("scientific name" OR "common name" AND "breeding system" OR "pollinat*"). The term breeding system is used here because it is a general term that refers to the sexual or asexual characteristics of a population as well as the level of inbreeding or outcrossing (Neal & Anderson, 2005). The search was conducted in September 2022. As each term was searched, the results underwent preliminary refinement based on the title and abstract (e.g., where pollination referred to the release of pollen into the air with relevance to allergies and not to the act of pollination between plants, the paper was not retained). All relevant articles were downloaded to Mendeley. Papers were included if the title and/or abstract with references to the plant species and also to reproduction OR pollinators. A total of 322 papers were excluded from Scopus and 392 papers were excluded from Web of Science because they did not meet the inclusion criteria. Plants with over 50 results in either search (Scopus or Web of Science) were excluded in order to maintain focus on the lesser studied species. The plant species removed for having over 50 studies included *Brassica rapa*, *Cucurbita maxima*, *Impatiens capensis*, and *Silene latifolia*. Every downloaded article was read, and some were removed based on irrelevance after reading. A total of 525 articles were retained for further analysis.

All retained papers were skimmed for data on breeding systems and pollinator/insect visitors. Data regarding breeding systems and known or recorded pollinators or floral visitors were recorded. Breeding system information was collected into seven categories: apomixis (asexual reproduction), parthenocarpy (fruit without fertilization), anemophily (wind pollination), biparental inbreeding (pollen from genetically related plants), autogamy (self-fertilization within flowers), geitonogamy (self-fertilization within plants), and xenogamy (outbreeding—pollen from another plant). Pollinator information was collected into 23 categories: Coleoptera, Diptera, Hymenoptera, Hymenoptera–Solitary bees, Hymenoptera–Bees, Hymenoptera–Other, Hymenoptera–Andrenidae, Hymenoptera–Apidae, Hymenoptera–Colletidae, Hymenoptera–Halictidae, Hymenoptera–Mellitidae, Hymenoptera–Megachilidae, Hymenoptera–Strenotrinidae, Lepidoptera, Orthoptera, Odonata, Homoptera, Hemiptera, Collembola, Psocoptera, Neuroptera, Thysanoptera, and Mecoptera. Insect visitors were recorded in order except for Hymenopterans, which were recorded in family were possible. In some cases, a study was removed because of its experimental nature, which compromised the results of the floral visitors as being representative of what occurs naturally. For example, a study on *Achillea millefolium* found beetles and flies pollinating control plants (Hambäck, 2016). When a floral volatile experiment was conducted, floral volatile oil from *Cirsium arvense* was sprayed on *A. millefolium*, the host of pollinators changed drastically to one not recorded on the control flowers. The pollinators, then, are not representative of what pollinates the plant in a natural setting, and this information was not extracted and retained as part of this study. General comments on pollinators such as "we saw bees (personal observations)" were included in our analyses in the appropriate categories.

## 3 | RESULTS

Breeding systems of 108 (50%) plants from the plant list have not been studied, while 107 (50%) plants have been studied. Of the 107 plants studied, self-compatibility was recorded in 57 (52%) plant species, while self-incompatibility was recorded in 36 (34%) plant species. Of the plants studied (107), the most commonly recorded breeding system was xenogamy, with 85 (79%) plant species using this system (Figure 1). Autogamy was recorded in 40 plant species (38%) (Figure 1). From our list (107), 54 plant species (50%) were reported

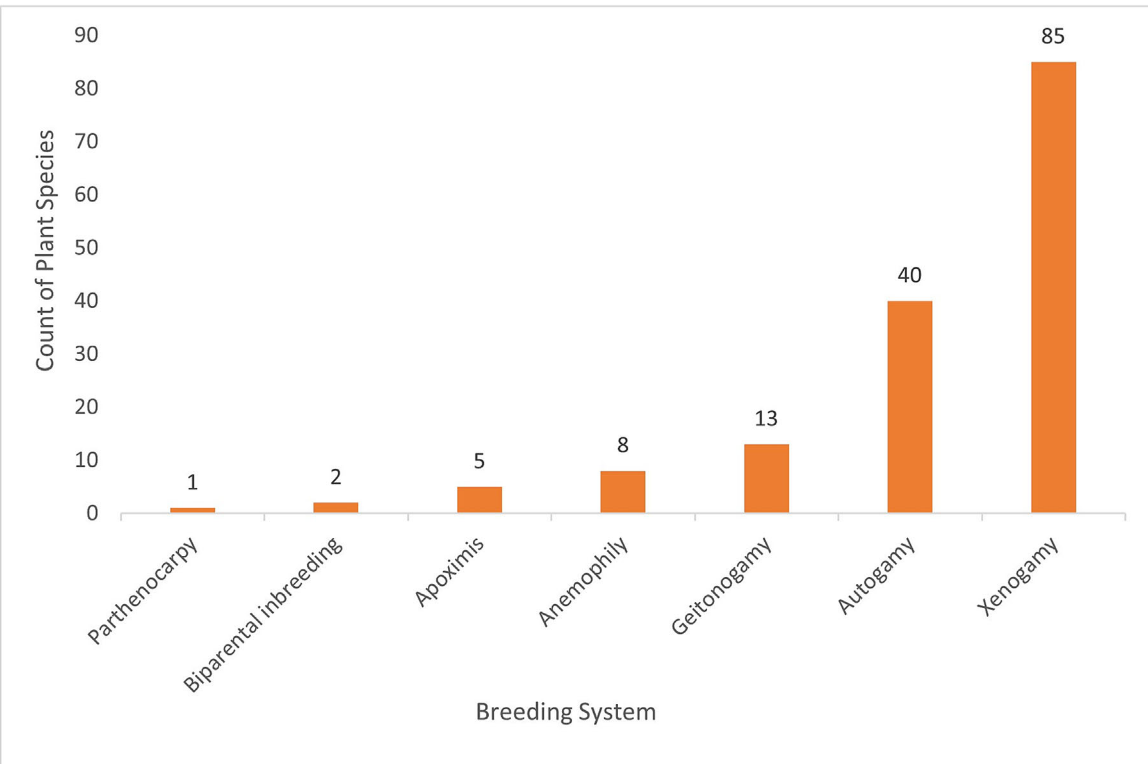


**FIGURE 1** The most common breeding systems apomixis (asexual reproduction), parthenocarpy (fruit without fertilization), anemophily (wind pollination), biparental inbreeding (pollen from genetically related plants), autogamy (self-fertilization within flower), geitonogamy (self-fertilization within plant), xenogamy (outbreeding—pollen from another plant) recorded during a global systematic literature review in Fall 2022 of 215 culturally significant medicine plants of the Great Lakes Region.

to have one breeding system, while 31 (30%) plant species had two breeding systems, 10 (10%) plant species had three breeding systems, and two (2%) plant species had four breeding systems recorded. Of the 85 plant species recorded as xenogamous, 34 (41%) were also recorded as autogamous. A total of 27 (33%) xenogamous plant species were strictly outcrossing. Of the 40 autogamous plants recorded, 34 (85%) were also xenogamous.

The most commonly recorded visiting insect order was Hymenoptera (Table 1). All Hymenoptera were recorded in one of nine categories: Megachilidae, Colletidae, Halictidae, Adrenidae, Apidae, Other, Bees, Solitary bees, and Hymenoptera (Figure 2). “Other” refers to Hymenopterans other than bees. Bees and solitary bees were recorded when the literature stated visitation by “bees” or “solitary bees” occurred with no further taxonomic identification. The most commonly recorded Hymenopteran visitors were in the Apidae family (Figure 2). The highest number of papers for a single plant species was 19 (*Fragaria virginiana*), with 108 plants returning zero papers. The average number of papers for the 105 plants studied was five.

**TABLE 1** Total number of culturally significant medicinal plant species of the Great Lakes Region visited by each insect order according to a global systematic literature review in Fall 2022.

| Insect order | Total number of plant species |
|---|---|
| Coleoptera | 31 |
| Collembola | 1 |
| Diptera | 59 |
| Hemiptera | 8 |
| Homoptera | 1 |
| Hymenoptera | 213 |
| Lepidoptera | 31 |
| Mecoptera | 1 |
| Neuroptera | 2 |
| Odonata | 1 |
| Orthoptera | 2 |
| Psocoptera | 1 |
| Thysanoptera | 7 |

## 4 | DISCUSSION

Limited scientific information is available about many herbaceous plant breeding systems (Cane, 2006; Culley, 2000; Edens-Meier et al., 2018; Kevan et al., 1993; Lindell, 1998; Palmer et al., 2009; Palumbo et al., 2021). Half of the plants included in this literature review have not yet been studied. These findings highlight the importance of conducting biocultural research that focuses on the social components of the system and includes different ways of knowing. Here, we are including Anishinaabe ways of knowing in order to better understand and inform the conservation of social–ecological systems in the Great Lakes region. *Mini bimaadiziwin* is enhanced by access to *aki miijim*, or Indigenous food systems (Pawlowska-Mainville, 2020). This includes access to important medicinal plants for sustainable harvesting. Therefore, research focusing on further understanding the reproductive biology of these plants helps to elucidate human–plant–pollinator relationships. Continued research focus on agricultural plants perpetuates the understudied state of these culturally significant plant species and plant species of lower economic value.

Even among the plants that have been scientifically studied, there are still knowledge gaps and a need for more research (e.g., Akeroyd & Briggs, 1983; MacPhail et al., 2018); the average number of papers for the plants studied was five. In *C. arvense*, one study concluded that previous determinations of the importance of sexual reproduction in plants were overlooked because of a lack of

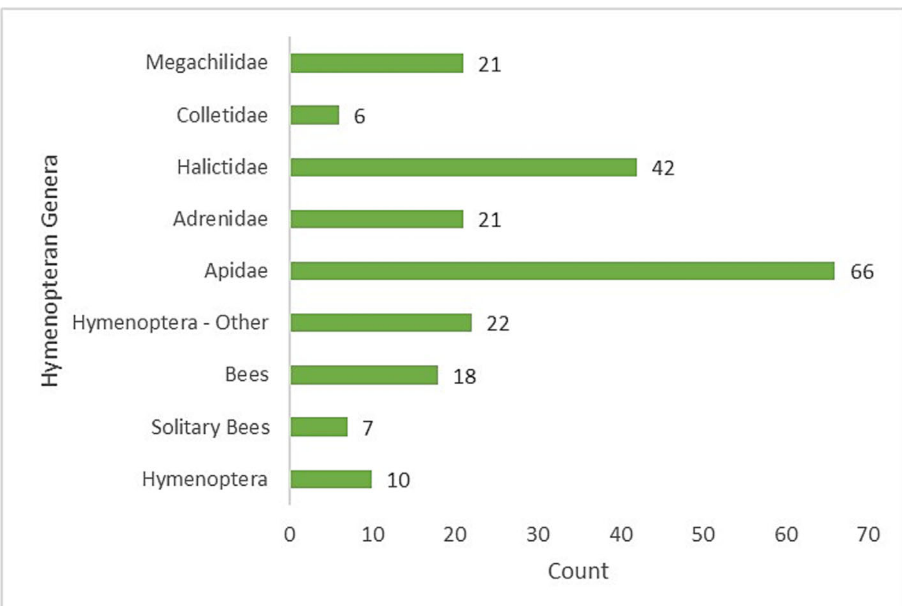


**FIGURE 2** Breakdown of Hymenopteran visitor categories recorded as insect visitors or pollinators of 215 culturally significant medicinal plant species of the Great Lakes Region, examined during a global systematic literature review in Fall 2022.

studies (Heimann & Cussans, 1996). Edens-Meier et al. (2018) refer to findings by Case and Bradford (2009), which indicate that *Cypripedium* species are not well studied in terms of breeding systems because populations are scattered, small, or inaccessible, and that insect visitors are infrequent. Because the *Cypripediums* are unrewarding to pollinators, they have limited insect visitation, which leads to difficulty in understanding their breeding system (Case & Bierbaum, 2013). *Fragaria vesca* (woodland strawberry) is well studied (15 papers) because it is a good model system for better understanding commercial *Fragaria* species (Dong et al., 2022). Particularly, the availability of the plant's draft genome and its short life cycle make it useful as a model system (Dong et al., 2022). This highlights the importance of food plants and their dominance as plants of importance in scientific study. While *F. vesca* is a culturally significant medicine plant, it's reason for being well studied is related to its similarity with other commercial species within the same genus.

Overall, 79% of the plants that have been studied were found to either require or to benefit from outcrossing (xenogamous). This type of breeding system requires a pollinator to move pollen between plants, which highlights the importance of pollinators to the reproduction of culturally significant medicine plants. A total of 32% of the plants that had been studied were found to be self-incompatible. These results are similar to those of Rodger et al. (2021), who found in a global assessment of flowering plants that 33% of species would produce no seeds with the exclusion of pollinators. Similarly, 33% of xenogamous plants were limited to one breeding system—outcrossing. Rodger et al. (2021) concluded that across all flowering plants, there was a 0.60 mean pollinator contribution (PC) to reproduction in flowering plants. These results provide a level of understanding as to the changes that can be expected with pollinator declines (Rodger et al., 2021). While self-compatibility is common, many species benefit from pollination in terms of seed production, and therefore the impact of pollinator declines on wild plant populations could be significant. It has been suggested that plants will evolve in the short term to either higher degrees of autogamy or by increasing their attractiveness to pollinators (Thomann et al., 2013). This short-term evolution, however, will not be available in plant populations with inbreeding depression or a lack of genetic diversity (Rodger et al., 2021). Rodger et al. (2021) found a higher PC in plants with a longer life span, greater stature, and greater pollinator specificity and predicted that pollinator declines would be stronger, causing changes (e.g., decreased abundance) in those plant populations. Highly autogamous plant species will potentially become increasingly abundant. Higher PC in native plants when compared with invasives, which showed greater self-capability, should also be considered (Rodger et al., 2021).

While a mixed mating system appears to be common, there is a large portion of this group of plants that requires a pollination vector. Biesmeijer et al. (2006) found that in Britain and the Netherlands, plants capable of self-pollination had an intermediate effect, plants that require outcrossing by an abiotic factor (e.g., apomixis) were increasing, and plants that were obligate outcrossers requiring insect visitors were in decline. Specifically, a decline was found in bee-pollinated obligately outcrossing plant species. Because Apidae bees were the most commonly recorded insect visitors to the medicinal plants studied here, it would be useful to focus future research efforts on expanding the knowledge base on bee and medicinal plant interactions. Biesmeijer et al. (2006) suggest future research on this group of plants to determine if the plant is in decline due to a loss of pollinators, if the pollinators are in decline due to a loss of their forage plants, or if there is some other causal factor affecting both populations (e.g., habitat alteration, climate change, pesticide use).

The common woodland herb *Maianthemum canadense* is self-incompatible and requires pollination by insects (particularly hoverflies and bees) (Taki et al., 2008). This plant has been found to have a decreased sexual reproductive output due to the loss of insect pollinators where pesticides have been used to treat forest pests (Kevan & Plowright, 1995). Populations of *M. canadense* are able to persist in the short term using clonal reproduction, but eventually the lack of insect pollination causes a decrease in genetic diversity in the population (Taki et al., 2008). Taki et al. (2008) found that maintaining even this common forest herb requires consideration and management in a fragmented landscape (e.g., effort to increase forest cover).

A total of 38% of plants included in this review that had been studied were found to be autogamous, and 85% of those plants were also found to be capable of outcrossing (xenogamy). Having a generalized breeding system can give plants an advantage by increasing plasticity in a new or changing environment (Parker, 1991; Powell et al., 2011; Trapp & Hendrix, 1988). Insects play a major role as pollen vectors during plant breeding of boreal forest herbs (Helenurm & Barrett, 1987). While many plants are automatically autogamous, outcrossing significantly increases plant reproductive success (Helenurm & Barrett, 1987). When studied as an invasive plant outside of its native range, *Cirsium vulgare* was able to set high levels of seed without high insect visitation (Powell et al., 2011). Powell et al. (2011) concluded that due to its generalist insect visitor guild and autonomous self-pollination, *C. vulgare* was capable of invading an area with a small number of propagules. Parker (1991) concluded that the *Amphicarpaea bracteate* mating system (large reliance on self-pollination) is a major factor restricting the plant's evolutionary capacity in relation to protection from plant pathogen attack. The lack of pollen movement between populations restricts the opportunity for recombination of alleles (Parker, 1991). Hog peanut does, however, have plasticity within its mating system, which allows the plant to adjust its reproductive strategy based on environmental conditions (Trapp & Hendrix, 1988). To have the ability to outcross between populations, this requires the management of plant populations of adequate size and within an appropriate distance for access by relevant pollinators (Taki et al., 2008). This is a key feature for avoiding inbreeding depression in plant populations. Having information about a plant's ability and affinity for outcrossing is necessary in order to properly manage plant populations, especially under pressure from human overharvesting. Linking human medicinal and traditional harvesting and needs with the plant's breeding system means better understanding (a) how the human uses of the plant will affect the plant population and

(b) how to properly manage the plant to ensure its continued presence on the landscape for human uses.

Obligately outcrossing animal-pollinated flowering plants have been found to be in decline when the animals that pollinate them are also declining (Biesmeijer et al., 2006). The level of threat of pollinator declines to the success of wild flowering plants depends on the contribution of pollinators to seed production in the plant (Rodger et al., 2021). It is unclear to what extent self-compatibility and insect pollination contribute to reproductive success for many plants globally (Rodger et al., 2021). Studies quantifying seed production of plants with pollinators excluded and those with pollinators present are required in order to quantify pollinator contribution to the plant's reproductive success (Rodger et al., 2021). When assessing the risk of extinction due to pollination or dispersal, four key attributes are examined. (1) The plant species' dependence on pollination; (2) Whether pollination was dependent on one pollinator species; (3) spatial movement requirements; and (4) the degree of dependence on seeds for survival (Löfgren, 2002). This suggests that when a plant species depends on generalist visitors for pollination services, it is better able to adapt and avoid difficulties due to isolation (Löfgren, 2002). Some plant species may be capable of adaptation within their breeding systems, which allows for survival under the threat of pollinator declines (Thomann et al., 2013). Bee declines are also highest for species with a dependence on declining plant species (Scheper et al., 2014). This suggests there is an interdependence between declines in wild pollinators and wild plant species (Potts et al., 2016). It has been hypothesized that under the pressure of pollinator declines, plants will evolve in one of two ways: (1) evolution towards higher automous selfing, or (2) reinforcement of characteristics that support the plant-pollinator relationship (Thomann et al., 2013). Declines of wild pollinators can affect the reproduction of wild plant species through reductions in fruit or seed set (Potts et al., 2016). The extent to which wild plant reproduction is impacted will vary based on redundancy within the plant-pollinator network (Potts et al., 2016). Burkle et al. (2013) measured changes in plant-pollinator interactions over 120 years at revisited sites in Illinois and found that the herbaceous perennial plant species *Claytonia virginica* experienced a 75% reduction in pollinator species between the 1970s and 2009/2010. Burkle et al. (2013) also found that declines in bee species were associated with specialists, parasites, cavity-nesters, and species with weak historic interactions.

Researchers have examined the degree of cultural significance for each plant in previous studies (e.g., Petelka et al., 2022). Future research may investigate the degree of cultural significance of each plant and combine that with our research findings to further elucidate research priorities for medicine plants in the Great Lakes Region. Our results show that there is little information available in the published scientific literature about these culturally and ecologically important plant species. Thus, there is an urgent need to construct new methods of conservation by incorporating different ways of knowing into planning. These findings will be useful in determining future research priorities regarding medicine plants in the Great Lakes Region.

## AUTHOR CONTRIBUTIONS

Shelby D. Gibson and Sheila R. Colla planned and designed the research. Shelby D. Gibson conducted the systematic review and data analysis. Shelby D. Gibson wrote the manuscript. Sheila R. Colla edited and revised the manuscript. Sheila R. Colla provided supervision.

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## CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in Mendeley Data at doi: 10.17632/mfc2dv3bpb.1.

## ORCID

*Shelby D. Gibson* https://orcid.org/0000-0003-0210-5001
*Sheila R. Colla* https://orcid.org/0000-0002-9621-8607

## REFERENCES

Akeroyd, J. R., & Briggs, D. (1983). Genecological studies of *Rumex crispus* L. II. Variation in plants grown from wild-collected seed. *New Phytologist*, *94*(2), 325–343.

Artelle, K. A., Zurba, M., Bhattacharrya, J., Chan, D. E., Brown, K., Housty, J., & Moola, F. (2019). Supporting resurgent indigenous-led governance: A nascent mechanism for just and effective conservation. *Biological Conservation*, *240*(October), 108284. https://doi.org/10.1016/j.biocon.2019.108284

Aslan, C. E., Zavaleta, E. S., Tershy, B., & Croll, D. (2013). Mutualism disruption threatens global plant biodiversity: A systematic review. *PLoS ONE*, *8*(6), e66993. https://doi.org/10.1371/journal.pone.0066993

Ban, N. C., Mills, M., Tam, J., Hicks, C. C., Klain, S., Stoeckl, N., Bottrill, M. C., Levine, J., Pressey, R. L., Satterfield, T., & Chan, K. M. A. (2013). A social-ecological approach to conservation planning: Embedding social considerations. *Frontiers in Ecology and the Environment*, *11*(4), 194–202. https://doi.org/10.1890/110205

Berkes, F., Arce-Ibarra, M., Armitage, D., Charles, A., Loucks, L., Makino, M., Satria, A., Seixas, C., Abraham, J., & Berdej, S. (2016). *Analysis of social-ecological systems for community conservation* (Vol. 45). Community Conservation Research Network.

Biesmeijer, J. C., Roberts, S. P. M., Reemer, M., Ohlemüller, R., Edwards, M., Peeters, T., Schaffers, A. P., Potts, S. G., Kleukers, R., Thomas, C. D., Settele, J., & Kunin, W. E. (2006). Parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands. *Science*, *313*(5785), 351–354. https://doi.org/10.1126/science.1127863

Bond, W. J. (1994). Assessing the risk of plant extinction due to pollinator and disperser failure. In J. H. Lawton & R. M. May (Eds.), *Extinction rates* (pp. 131–146). Oxford University Press.

Brokenleg, I., & Tornes, E. (2013). *Walking toward the sacred: Out Great Lakes tobacco story*. Great Lakes Inter-Tribal Epidemiology Center.

Brown, M. J. F., & Paxton, R. J. (2009). The conservation of bees: A global perspective. *Apidologie*, *40*(3), 410–416. https://doi.org/10.1051/apido/2009019

Burkle, L. A., Marlin, J. C., & Knight, T. M. (2013). *Plant-pollinator interactions over 120 years: Loss of species, co-occurrence, and function* (Vol. 32). Biology Faculty Publications & Presentations. https://openscholarship.wustl.edu/bio_facpubs/32

Cane, J. (2006). An evaluation of pollination mechanisms for purple prairie–clover, dalea purpurea (Fabaceae: Amorpheae). *American Midlast Naturalist*, *156*, 193–197.

Case, M. A., & Bierbaum, T. J. (2013). Pollinator-mediated mating restriction between sympatric varieties of yellow lady's slipper orchids (Cypripedium parviflorum Salisb.). *Plant Systematics and Evolution*, *299*(9), 1721–1735. https://doi.org/10.1007/s00606-013-0828-4

Case, M. A., & Bradford, Z. R. (2009). Enhancing the trap of lady's slippers: A new technique for discovering pollinators yields new data from *Cypripedium parviflorum* (Orchidaceae). *Botanical Journal of the Linnean Society*, *160*(1), 1–10. https://doi.org/10.1111/j.1095-8339.2009.00962.x

Colla, S. R., Gadallah, F., Richardson, L., Wagner, D., & Gall, L. (2012). Assessing declines of North American bumble bees (*Bombus* spp.) using museum specimens. *Biodiversity and Conservation*, *21*(14), 3585–3595. https://doi.org/10.1007/s10531-012-0383-2

Convention on Biological Diversity (CBD). (2022). "Nations Adopt Four Goals, 23 Targets for 2030 in Landmark UN Biodiversity Agreement". https://prod.drupal.www.infra.cbd.int/sites/default/files/2022-12/221219-CBD-PressRelease-COP15-Final_0.pdf. Accessed Feb 24, 2023.

Culley, T. M. (2000). Inbreeding depression and floral type fitness differences in *Viola canadensis* (Violaceae), a species with chasmogamous and cleistogamous flowers, (Cl). *Canadian Journal of Botany*, *78*, 1420–1429. https://doi.org/10.1139/b00-115

Davidson-Hunt, I. J., Jack, P., Mandamin, E., & Wapioke, B. (2005). Iskatewizaagegan (Shoal Lake) plant knowledge: An Anishinaabe (ojibway) ethnobotany of Northwestern Ontario. *Journal of Ethnobiology*, *25*(2), 189–227. https://doi.org/10.2993/0278-0771(2005)25[189:islpka]2.0.co;2

Densmore, F. (2005). *Strength of the earth: The classic guide to Ojibwe uses of native plants*. The Minnesota Historical Society Press. ISBN 0-87351-562-5.

Dicks, L. V., Breeze, T. D., Ngo, H. T., Senapathi, D., An, J., Aizen, M. A., Basu, P., Buchori, D., Galetto, L., Garibaldi, L., Gemmill-Herren, B., Howlett, B., Imperatriz-Fonseca, V., Johnson, S., Kovács-Hostyánszki, A., Kwon, Y. J., Lattorff, M., Lungharwo, T., Seymour, C., Vanbergen, A., & Potts, S. G. (2021). A global-scale expert assessment of drivers and risks associated with pollinator decline. *Nature Ecology and Evolution*, *5*(10), 1453–1461. https://doi.org/10.1038/s41559-021-01534-9

Dong, Y., Song, M., Liu, X., Tian, R., Zhang, L., & Gan, L. (2022). Effects of exogenous KT and BA on fruit quality in strawberry (*Fragaria vesca*). *Journal of Horticultural Science and Biotechnology*, *97*(2), 236–243. https://doi.org/10.1080/14620316.2021.1979428

Edens-Meier, R., Arduser, M., Camilo, G. R., & Bernhardt, P. (2018). Comparative pollination ecology between two populations and two varieties of *Cypripedium parviflorum* (Orchidaceae) in Missouri, United States of America—Does size matter? *Botanical Journal of the Linnean Society*, *186*(4), 544–559. https://doi.org/10.1093/botlinnean/boy001

Ens, E., Scott, M. L., Rangers, Y. M., Moritz, C., & Pirlz, R. (2016). Putting Indigenous conservation policy into practice delivers biodiversity and cultural benefits. *Biodiversity Conservation*, *25*, 2889–2906.

Erland, L. A. E., Turi, C. E., & Murch, S. J. (2022). Preliminary assessment of the conservation status of medicinal plant species in Canada. *Canadian Journal of Botany*, *100*(2), 247–260. https://doi.org/10.1139/cjb-2021-0090

Garibaldi, L. A., Steffan-dewenter, I., Winfree, R., Aizen, M. A., Bommarco, R., Cunningham, S. A., … Carvalheiro, L. G. (2012). Wild pollinators enhance fruit set of crops regardless of honey bee abundance. *Science*, *339*(May), 1608–1611.

Gavin, M. C., Mccarter, J., Mead, A., Berkes, F., Stepp, J. R., Peterson, D., & Tang, R. (2015). Defining biocultural approaches to conservation. *Trends in Ecology & Evolution*, *30*(3), 140–145. https://doi.org/10.1016/j.tree.2014.12.005

Genuisz, M. S. (2015). *Plants have so much to give us, all we have to do is ask: Anishinaabe botanical teachings*. University of Minnesota Press.

Grubbs, H. J., & Case, M. A. (2004). Allozyme variation in American ginseng (*Panax quinquefolius* L.): Variation, breeding system, and implications for current conservation practice. *Conservation Genetics*, *5*(1), 13–23. https://doi.org/10.1023/B:COGE.0000014064.44592.bc

Hambäck, P. A. (2016). Getting the smell of it—Odour cues structure pollinator networks. *Journal of Animal Ecology*, *85*(2), 315–317. https://doi.org/10.1111/1365-2656.12454

Harder, L. D., & Barrett, S. C. H. (1996). Pollen dispersal and mating patterns in animal-pollinated plants. In D. G. Lloyd & S. C. H. Barrett (Eds.), *Floral biology: Studies on floral evolution in animal-pollinated plants* (pp. 140–190). Chapman and Hall. https://doi.org/10.1007/978-1-4613-1165-2_6

Heimann, B., & Cussans, G. W. (1996). The importance of seeds and sexual reproduction in the population biology of *Cirsium arvense*—A literature review. *Weed Research*, *36*(6), 493–503. https://doi.org/10.1111/j.1365-3180.1996.tb01678.x

Helenurm, K., & Barrett, S. C. H. (1987). The reproductive biology of boreal forest herbs. II. Phenology of flowering and fruiting. *Canadian Journal of Botany*, *65*(10), 2047–2056. https://doi.org/10.1139/b87-279

Hill, R., Nates-Parra, G., Quezada-Euán, J. J. G., Buchori, D., LeBuhn, G., Maués, M. M., Pert, P. L., Kwapong, P. K., Saeed, S., Breslow, S. J., Carneiro da Cunha, M., Dicks, L. V., Galetto, L., Gikungu, M., Howlett, B. G., Imperatriz-Fonseca, V. L., O'B. Lyver, P., Martín-López, B., Oteros-Rozas, E., … Roué, M. (2019). Biocultural approaches to pollinator conservation. *Nature Sustainability*, *2*, 214–222. https://doi.org/10.1038/s41893-019-0244-z

IPBES. (2016) The assessment report of the intergovernmental science-policy platform on biodiversity and ecosystem services on pollinators, pollination and food production.

Karst, A. (2010). *Conservation value of the North American boreal forest from an ethnobotanical perspective Canadian boreal initiative*. David Suzuki Foundation and Boreal Songbird Initiative.

Kearns, C. A., Inouye, D. W., & Waser, N. M. (1998). Endangered mutualisms: The conservation of plant-pollinator interactions. *Annual Review of Ecology and Systematics*, *28*, 83–112. https://doi.org/10.1146/annurev.ecolsys.29.1.83

Kevan, P. G., & Plowright, R. C. (1995). Impact of pesticides on forest pollination. In J. A. Armstrong & W. G. H. Ives (Eds.), *Forest insect pests in Canada* (pp. 607–618). Canadian Forest Service.

Kevan, P. G., Tikhmenev, E. A., & Usui, M. (1993). Insects and plants in the pollination ecology of the boreal zone. *Ecological Research*, *8*(3), 247–267. https://doi.org/10.1007/BF02347185

Klein, A. M., Vaissière, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. A., Kremen, C., & Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. *Proceedings of the Royal Society B: Biological Sciences*, *274*(1608), 303–313. https://doi.org/10.1098/rspb.2006.3721

Lindell, T. (1998). Breeding systems and crossing experiments in Anemone patens and in the Anemome pulsatilla group (Ranunculaceae). *Nordic Journal of Botany*, *18*(5), 549–561. https://doi.org/10.1111/j.1756-1051.1998.tb01535.x

Löfgren, A. (2002). Effects of isolation on distribution, fecundity, and survival in the self-incompatible *Achillea millefolium* (L.). *Ecoscience*, *9*(4), 503–508. https://doi.org/10.1080/11956860.2002.11682737

MacPhail, V. J., Ferguson, S., Tompkins, H., & Colla, S. R. (2018). The missing link: A case for increased consideration for plant-pollinator interactions for species at-risk recovery in Ontario. *Journal for Nature Conservation*, *42*(April 2017), 1–6. https://doi.org/10.1016/j.jnc.2018.01.004

Meeker, J. E., Elias, J. E., & Heim, J. A. (1993). *Plants used by the Great Lakes Ojibwa*. Great Lakes Indian Fish and Wildlife Commission. ISBN 0–9665820–1-2.

Mooney, E. H., & McGraw, J. B. (2007). Effects of self-pollination and outcrossing with cultivated plants in small natural populations of American ginseng, *Panax quinquefolius* (Araliaceae). *American Journal of Botany*, *94*(10), 1677–1687. https://doi.org/10.3732/ajb.94.10.1677

Motaleb, M. A. (2010). *Approaches to conservation of medicinal plants and traditional knowledge: A focus on the Chittagong Hill tracts*. IUCN (International Union for Conservation of Nature), Bangladesh Country Office. pp viii+30.

Neal, P. R., & Anderson, G. J. (2005). Are "mating systems" "breeding systems" of inconsistent and confusing terminology in plant reproductive biology? Or is it the other way around? *Plant Systematics and Evolution*, *250*(3–4), 173–185. https://doi.org/10.1007/s00606-004-0229-9

Ollerton, J., Winfree, R., & Tarrant, S. (2011). How many flowering plants are pollinated by animals? *Oikos*, *120*(3), 321–326. https://doi.org/10.1111/j.1600-0706.2010.18644.x

Padulosi, S., Leaman, D., & Quek, P. (2004). Challenges and opportunities in enhancing the conservation and use of medicinal and aromatic plants. *Journal of Herbs, Spices & Medicinal Plants*, *9*(4), 243–267. https://doi.org/10.1300/j044v09n04_01

Page, M. L., & Williams, N. M. (2022). Honey bee introductions displace native bees and decrease pollination of a native wildflower. *Ecology*, *104*(2), e3939. https://doi.org/10.1002/ecy.3939. Epub ahead of print. PMID: 36457280.

Palmer, I. E., Ranney, T. G., Lynch, N. P., & Bir, R. E. (2009). Crossability, cytogenetics, and reproductive pathways in Rudbeckia subgenus Rudbeckia. *Horts*, *44*(1), 44–48. https://doi.org/10.21273/HORTSCI.44.1.44

Palumbo, F., Vannozzi, A., & Barcaccia, G. (2021). Impact of genomic and transcriptomic resources on apiaceae crop breeding strategies. *International Journal of Molecular Sciences*, *22*(18), 9713. https://doi.org/10.3390/ijms22189713

Parker, M. A. (1991). Nonadaptive evolution of disease resistance in an annual legume. *Evolution*, *45*(5), 1209–1217.

Pawlowska-Mainville, A. (2020). Aki Miijim (land food) and the sovereignty of the asatiwisipe anishinaabeg boreal forest food system. In P. Settee, & S. Shukla (Eds.), *Chapter four in indigenous food systems: Concepts, cases, and conversations*. CSP Books Inc.

Petelka, J., Bonari, G., Saumel, I., Plagg, B., & Zerbe, S. (2022). Conservation with local people: Medicinal plants as cultural keystone species in the Southern Alps. *Ecology and Society*, *27*(4), 14.

Pooni, H. S., Foster, R., & Zhao, B. (1997). Impact of pollination time, seed size, position and maturity on quantitative variation in *Nicotiana rustica*. *Journal of Agricultural Science*, *128*(2), 181–188. https://doi.org/10.1017/S0021859696004042

Potts, S. G., Biesmeijer, J. C., Kremen, C., Neumann, P., Schweiger, O., & Kunin, W. E. (2010). Global pollinator declines: Trends, impacts and drivers. *Trends in Ecology & Evolution*, *25*(6), 345–353. https://doi.org/10.1016/j.tree.2010.01.007

Potts, S. G., Imperatriz–Fonseca, V., Ngo, H. T., Aizen, M. A., Biesmeijer, J. C., Breeze, T. D., Dicks, L. V., Garibaldi, L. A., Hill, R., Settele, J., & Vanbergen, A. J. (2016). Safeguarding pollinators and their values to human well–being. *Nature*, *540*(7632), 220–229.

Powell, K. I., Krakos, K. N., & Knight, T. M. (2011). Comparing the reproductive success and pollination biology of an invasive plant to its rare and common native congeners: A case study in the genus *Cirsium* (Asteraceae). *Biological Invasions*, *13*(4), 905–917. https://doi.org/10.1007/s10530-010-9878-5

Pretty, J., Adams, B., Berkes, F., de Athayde, S. F., Dudley, N., Hunn, E., Maffi, L., Milton, K., Rapport, D., Robbins, P., Sterling, E., Stolton, S., Tsing, A., Vintinner, E., & Pilgrim, S. (2009). The intersections of biological diversity and cultural diversity: Towards integration. *Conservation and Society*, *7*(2), 100–112.

Raven, P. H., Evert, R. F., & Eichhorn, S. E. (1999). *Biology of plants*. W. H. Freeman and Company. ISBN 1–57259–611-2.

Rodger, J. G., Bennett, J. M., Razanajatovo, M., Knight, T. M., van Kleunen, M., Ashman, T.-L., Steets, J. A., Hui, C., Arceo-Gómez, G., Burd, M., Burkle, L. A., Burns, J. H., Durka, W., Freitas, L., Kemp, J. E., Li, J., Pauw, A., Vamosi, J. C., Wolowski, M., … Ellis, A. G. (2021). Widespread vulnerability of flowering plant seed production to pollinator declines. *Science Advances*, *7*(42), eabd3524. https://doi.org/10.1126/sciadv.abd3524

Scheper, J., Reemer, M., van Kats, R., Ozinga, W. A., van der Linden, G. T. J., Schaminée, J. H. J., Siepel, H., & Kleijn, D. (2014). Museum specimens reveal loss of pollen host plants as key factor driving wild bee decline in the Netherlands. *Proc. Natl Acad. Sci. USA*, *111*, 17552–17557. https://doi.org/10.1073/pnas.1412973111

Simpson, L. B. (2011). *Dancing on our turtle's back: Stories of Nishnaabeg re–creation, resurgence, and a new emergence*. ARP Books.

Smith, H. H. (1932). Ethnobotany of the Ojibwe Indians. *Bulletin of the Public Museum of the City of Milwaukee*, *4*(3), 327–525. Aetna Press Inc. Milwaukee, Wis.

Smith, L. T. (2012). *Decolonizing methodologies* (2nd ed.). Zed Books.

Smith, T., May, G., Eckl, V., & Reynolds, C. M. (2020). US sales of herbal supplements increase by 8.6% in 2019. *HerbalGram*, *127*, 54–69.

Stout, J. C., & Dicks, L. V. (2022). From science to society: Implementing effective strategies to improve wild pollinator health. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *377*(1853), 20210165. https://doi.org/10.1098/rstb.2021.0165

Taki, H., Kevan, P. G., & Yamaura, Y. (2008). Effects of forest cover on fruit set in the woodland herb, *Maianthemum canadense* (Liliaceae). *Canadian Field-Naturalist*, *122*(3), 234–238. https://doi.org/10.22621/cfn.v122i3.605

Thomann, M., Imbert, E., Devaux, C., & Cheptou, P. O. (2013). Flowering plants under global pollinator decline. *Trends in Plant Science*, *18*(7), 353–359. https://doi.org/10.1016/j.tplants.2013.04.002

Trapp, E. J., & Hendrix, S. D. (1988). Consequences of a mixed reproductive system in the hog peanut, *Amphicarpaea bracteata*, (Fabaceae). *Oecologia*, *75*(2), 285–290. https://doi.org/10.1007/BF00378611

Trisos, C. H., Auerbach, J., & Katti, M. (2021). Decoloniality and anti-oppressive practices for a more ethical ecology. *Nature Ecology and Evolution*, *5*(9), 1205–1212. https://doi.org/10.1038/s41559-021-01460-w

Tuhiwai Smith, L. (2012). *Decolonizing methodologies: Research and indigenous peoples*. Zed Books Ltd. ISBN 9781780324227.

Turner, N. J., Deur, D., & Lepofsky, D. (2013). Plant management systems of British Columbia's first peoples. *BC Studies*, *179*, 107–133. https://doi.org/10.14288/bcs.v0i179.184112

Tylianakis, J. M. (2013). The global plight of pollinators. *Science*, *340*(6127), 1532–1533. https://doi.org/10.1126/science.1235464

Uprety, Y., Asselin, H., Dhakal, A., & Julien, N. (2012). Traditional use of medicinal plants in the boreal forest of Canada: Review and perspectives. *Journal of Ethnobiology and Ethnomedicine*, *8*(1), 7. https://doi.org/10.1186/1746-4269-8-7

Wani, I. A., Verma, S., Ahmad, P., El-Serehy, H. A., & Hashim, M. J. (2022). Reproductive biology of *Rheum webbianum* Royle, a vulnerable medicinal herb from alpines of North-Western Himalaya. *Frontiers in Plant Science*, *13*(February), 1–19. https://doi.org/10.3389/fpls.2022.699645

Westfall, R. E., & Glickman, B. W. (2004). Conservation of Indigenous medicinal plants in Canada. *Proceedings of the Species at Risk 2004 Pathways to Recovery Conference*, 1–8.

Winter, K. B., Ticktin, T., & Quazi, S. A. (2020). Biocultural restoration in Hawaii also achieves core conservation goals. *Ecology and Society*, *25*(1), art26. https://doi.org/10.5751/ES-11388-250126

World Health Organization, International Union for Conservation of Nature and Natural Resources, & World Wide Fund for Nature. (1993). *Guidelines on the conservation of medicinal plants*. International Union for Conservation of Nature and Natural Resources. https://apps.who.int/iris/handle/10665/41651

Zattara, E. E., & Aizen, M. A. (2021). Worldwide occurrence records suggest a global decline in bee species richness. *One Earth*, *4*(1), 114–123. https://doi.org/10.1016/j.oneear.2020.12.005

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