DEPARTMENT OF NATURAL RESOURCES

Pollination Guide

For Minnesota Native Plant Species and Native Plant Communities

Contents

Introduction

The Minnesota Pollination Guide (PG) provides data and information on the reproduction and pollination characteristics of native plant species. It is compiled from existing literature, biological collections, and subject matter experts. It presents information relative to 1) individual plant species and 2) the native plant communities (NPC) in which native plants occur.

The data provided in this guide are not intended to predict how plants or native plant communities are affected by pollinator change but are intended to provide information on the reliance of plants on pollinators for reproduction. The PG was designed to help provide clarity to questions such as:

- I am interested in plant conservation, what are the pollinators or pollination ecology of my plants of interest?
- I am interested in integrated plant-pollinator conservation and management, what do we know about pollination ecology in Minnesota?
- I am interested in plant community conservation, to what degree does my NPC of interest involve or rely upon insect pollination?
- I am interested in pollinators, what plants and NPCs interact with my insect pollinator of interest?
- I am interested in pollination, what plants have the pollination attributes of interest?

While the PG provides data for all native Minnesota plant species where it is known, it does not claim or intend to compile data for all insect pollinators. The Minnesota Statewide Bee survey (2014-2023) has contributed to the establishment of a state list of native bee species and expanded upon our understanding of the distributions of many bee species, providing a baseline for conservation actions involving bees in the state. To learn more about these efforts, visit the Minnesota DNR's Native Bees of Minnesota page. However, there is still much we don't know about the insect diversity in Minnesota.

Background

Pollination is the biological process of transferring pollen from the anther to a stigma of a plant, leading to fertilization and seed production. Many plants benefit from assistance from a “pollinator” to ensure successful seed production. This resource refers only to bees, butterflies, and moths as animal pollinators since they are the primary pollinators in Minnesota though birds, bats, and other animals may be successful pollinators in other regions.

Pollination is usually an unintended consequence of animal activity on a flower. Pollen grains attach themselves to the body of an animal as they are collecting or eating pollen or sipping nectar. When the animal visits another flower, pollen falls off onto the stigma and can result in reproduction. This process can also occur in some plants abiotically, without the involvement of another organism, by wind or water. Rather than being mediated by an animal (biotic), the movement of pollen is mediated by wind or water, delivering it to the stigma of a flower.

Reproduction can occur through cross-breeding (cross-pollination) or inbreeding (self-pollination) though cross-pollination is beneficial in that it can increase a plants' diversity and adaptability to changing environments by creating genetic variation. Some plants have developed mechanisms to alter their breeding strategies depending on external conditions, when, for example, cross-pollination is not available. This may allow for less reliance on pollinators and enables seed production in any condition. In this resource, we refer to these strategies as “compatibility”.

Data Collection

The Pollination Guide is based on data collected through searches of scientific literature, biological collections, and existing plant trait databases to capture information on plant attributes related to pollination mechanisms (e.g., TRY Plant Trait Database; Flora of North America; Minnesota Wildflowers; Pladias; Crop Gene Bank). This effort provided the vast majority of information on at least nine attributes of native Minnesota plants. Gaps in data from these sources for traits like longevity, clonality, and pollinator requirements were filled through expert opinion where possible. The remaining data gaps are due to scientific unknowns about some plant species. For instance, ~40% (879) of the 2212 native, vascular plants in Minnesota have a compatibility or breeding system that appears unknown to published science. These unknowns contribute to uncertainty in our final products and shed light on focus areas for future research.

The plant species considered in this guide including their taxonomy and nomenclature are derived from MNTaxa, the Minnesota Department of Natural Resources (MNDNR) list of vascular plant species in Minnesota. Plant varieties and subspecies that are not listed in 2023 as endangered, threatened, or special concern species in Minnesota were excluded from the list since we assume those plants have the same or comparable life histories at the species-level.

Plant Species Traits

We have compiled attributes of each vascular plant species for the following reproductive traits: longevity, clonality, compatibility, principal pollen vector, buzz pollination, flower structure, corolla length, and pollinator requirements. These traits reflect ecological and evolutionary processes of plants that involve pollinators for sexual reproduction, pollen movement, population growth, species persistence, and generating plant species genetic diversity.

Two additional attributes, origin (native vs. non-native) and rarity status are included as a means of filtering plant species that may have conservation value. Origin status was determined using data from MNTaxa, NatureServe Explorer, and species-level maps from The Biota of North America Program and Flora of North

America. State conservation status or rank data were collected from MNDNR Plant checklist (2013) and Rare Species Guide (2022).

Lastly, we developed a ranking system, referred to as the pollination index in the PG, that is a relative measure of how reliant each plant species is on pollinators. The pollination index was created with the intention of being used to suggest conservation or management priorities but should only be used as a comparison to itself for species listed in the PG.

Trait Details

All plant traits used in this PG are explained in detail below.

Longevity

The longevity of each plant species describes the growth of a plant in Minnesota. Perennial plants regrow every spring for more than three years while annual plants live for a single growing season and then die off. Biennial and short-term perennial plants fall somewhere in the middle, usually regrowing for two years.

Clonality

Clonal plants can reproduce asexually by means of vegetative offspring that remain attached to the parent, at least until they establish (Dong, Yu & Alpert, 2014). We describe clonality as either being “present”, “absent”, or “weakly” present (Table 1). The clonality of ~17 species (<1%) in Minnesota is unknown due to lack of information.

Table 1. Clonality values (present, absent, weakly clonal, and unknown) and the percent of the total plant species in each category.

Clonality Value	% plant species
Present	59
Absent	37
Weakly	4
Unknown	< 1

Compatibility

Plants exhibit various strategies to achieve reproduction via cross-breeding or inbreeding and everything in between. Table 2 provides terms used to define the reproductive compatibility traits of Minnesota plants. These terms are not necessarily mutually exclusive as some plant species use more than one known compatibility system.

For many plant species, compatibility is unknown or highly uncertain. Due to lack of information, compatibility attributes for 879 (~40%) of the 2212 plants analyzed are unknown. For a handful of other plants, the degree to which a strategy is used or present is uncertain, leading to terms like “sometimes dioecious”, for example.

Table 2. Compatibility abbreviation, definition, and the percent of the total plant species in each category.

Compatibility Abbreviation	Definition	% plant species
A	Apomixis: Asexual reproductive system in which plants produce seed genetically identical to maternal parent by various mechanisms without fertilization (Barrett, 2019)	2
CH	Chasmogamous: Open flowers capable of open pollination (Molano-Flores, 2004)	1
CL	Cleistogamous: Automatic self-pollination breeding system that uses non-opening, self-pollinating flowers (Culley & Klooster, 2007)	2
D	Dioecious: Sexual polymorphism with populations comprising female and male plants (Barrett, 2019)	4
Di	Dichogamous: Maturation of male and female flower parts occurs at different times, preventing self-fertilization (Osborn & Schneider, 1988)	< 1
GD	Gynodioecious: Sexual polymorphism with populations comprising hermaphrodite and female plants (Barrett, 2019)	< 1
Ge	Geitonogamy: A type of self-pollination by which a flower is pollinated by pollen from another flower on the same plant	< 1
GM	Gynomonoecious: Both hermaphrodite and female flowers on an individual plant (Molano-Flores, 2004)	< 1
H	Heterostylous: Style and stamen lengths vary among individuals within a population	< 1
Herkogamy	Herkogamy: Spatial separation of anthers and stigmas within flowers to reduce self-fertilization	< 1
Pa	Protandrous: Maturation of male reproductive organs before female	< 1
PD	Polygamodioecious: Bearing bisexual and male flowers on some plants, and bisexual and female flowers on others	< 1
Pg	Protogynous: Maturation of female reproductive organs before male	< 1
SC	Self-compatible: Ability of hermaphrodite plants to set abundant seed from self-pollination (Barrett, 2019)	31
SC/si	Mostly self-compatible but self-incompatibility found occasionally (Molano-Flores, 2004)	< 1
SI	Self-incompatible: Physiological mechanism limiting seed set from self-pollination in fertile hermaphrodite plants (Barrett, 2019)	15
SI/SC	Self-incompatible/self-compatible: Both self-incompatibility and self-compatibility systems found	< 1
SI/sc	Mostly self-incompatible but self-compatibility found occasionally (Molano-Flores, 2004)	2
UNK	Unknown compatibility system	40

Principal Pollen Vector

Principal pollen vector describes the primary dispersal mechanism that moves pollen for each plant species. Flowering plants transport pollen using insects, wind, water, or some combination of the three. Ferns and lycophytes are listed under this category with the understanding that they do not produce pollen but rather spores that are transported via wind and water.

Table 3. Principal pollen vector and the percent of the total plant species in each category.

Principal Pollen Vector	%
Insects	64
Primarily insect pollinated but may be sometime pollinated by wind or water	< 1
Water	1
Primarily water pollinated but may be sometime pollinated by insects or wind	< 1
Wind	30
Primarily wind pollinated but may be sometime pollinated by insects or water	4
Sterile (fern)	< 1

Buzz Pollination

Buzz pollination, also known as sonication, is a technique used by some larger bodied bees. A bee will grab onto the flower and rapidly move their flight muscles, causing the flower and anthers to vibrate and release pollen, incidentally fertilizing the plant. ~30 vascular plants in Minnesota require buzz pollination to some degree. Most of these plants require sonication for pollination but around eight plants, primarily *Vaccinium*, have been found to use but not require this technique for pollination.

Flower Structure

Definitions from Minnesota Wildflowers.

Table 4. Flower structure (open, irregular, indistinct, bell, tube, and none), and the definition and percent of the total plant species in each category.

Flower Structure	Definition	%
open	Flower is at the end of a stalk, generally flat with open access	34
irregular	Flower is not generally round, or its petal-like parts are dissimilar in size or shape	10
indistinct	Flower has no discernable petal-like parts	36
bell	Flowers have fused petals and hang downward; any lobes are similar in size and shape	5
tube	(Or funnel-shaped) have fused petals but flowers are proportionately longer and narrower than bell types; lobes on tubular flowers are often dissimilar in size or shape	10
none	No flower present; fern or lycophyte	5

Corolla Length

The petals of a flower are collectively known as the corolla. The corolla generally encircles the reproductive organs of a flower and may be fused, creating a tube or bell shape, or unfused and open. Many wind-pollinated plants lack petals entirely and longer, narrower, or complex corollas may impact the type of pollination or pollinator required for a plant. ~12% of flowering plants have corolla lengths that were not found in literature and are left blank within the guide.

Pollinator Requirements

Pollinator requirements encompass aspects of a flower that might restrict what insects may visit and successfully pollinate a plant. These include flower structure, flower restriction, corolla length, and required specializations like “buzz pollination” (Table 5).

Table 5. Pollinator requirement (generalist, somewhat specific insect, very specific insect, early spring insect, buzz pollination, and facultative buzz pollination), and the definition and percent of the total plant species in each category.

Pollinator Requirements	Definition	%
Generalist	Does not require specific body sized insect or pollination apparatus; flower with no corolla, or corolla very short (less than 3mm); flower wind or water pollinated; ferns and lycophytes	76
Somewhat specific insect	Not just any insect can pollinate; requires specific body sized insect; flower is somewhat restricted; larger "tube" flowers	13
Very specific insect	Requires very specialized insect pollinator; flowers with very long corollas	1
Early spring insect	Early spring flowers (plants listed by Minnesota Wildflowers to bloom by the second week of May or trees blooming before June) that are insect pollinated	9
Buzz pollination	Requires vibrations caused by bees visiting flowers for successful pollination	< 1
Facultative buzz pollination	Buzz pollination (sonication) present but not required	< 1

Pollination Index

We developed a ranking system, referred to as the pollination index, that is a relative measure of how reliant each plant species is on pollinators. Higher reliance indicates a plant is more dependent on insect pollinators to sustain a population through means of natural reproduction.

Through discussions with plant and insect experts, four pollination traits or trait groupings were decided upon as indicators for a plant’s reliance on pollinators. These were given a score between 0 and 3 to better assess and analyze how they collectively impact plant dependency on pollinators for reproduction: principal pollen vector, compatibility, longevity and clonality, and a handful of traits describing “pollinator specialization”. Traits considered under pollinator specialization are aspects of a flower that might restrict what insects may visit and successfully pollinate including flower structure, flower restriction, corolla length, and required specializations like “buzz pollination”. Traits with an unknown value (e.g. unknown compatibility) received a neutral score of 2.

We acknowledge that the pollination index is not a flawless product, but it effectively reflects the diverse ways plants depend on pollinators in a manner that feels intuitive. Numerous iterations of this index were created to

determine the most comprehensive and sound version. All versions of this index, trait scoring, and the thoughts and processes involved in each iteration, are captured in Appendix A. Version 6 is used in our final products and is further described here.

The pollination index was determined by summing the score for: principal pollen vector score (Table A8), compatibility score (Table A9), longevity and clonality score (Table A22), and pollinator specialization score (A12). Those plants pollinated exclusively by wind or water, regardless of their other traits, received an index value of zero. This provides a pollination index range of 0, 3-11. To create a continuous scale, three points were subtracted from all non-zero indices. Plants with a higher index value are considered to have a greater reliance on insect pollinators for reproduction. An index was determined for 2212 plant species in Minnesota with possible values ranging from: 0-8 (Table 6).

Table 6. Pollination index and the definition of each range.

Pollination Index	Definition
0	Exclusively wind or water pollinated
1-3	Least reliant on insect pollinators
4-6	More reliant on insect pollinators
7-8	Most reliant on insect pollinators

Origin

The origin status is listed for all plants within the PG and are defined from MNDNR Plant checklist (2013) as follows: N = native to the state of MN; I = Introduced; U = Native Status Undetermined.

Rarity Status

Definitions from the Minnesota DNR Rare Species Guide. State conservation status or rank data were collected from MNDNR Plant checklist (2013) and Rare Species Guide (2022).

Table 7. Species rarity status (state endangered, state threatened, state special concern, federally endangered, federally threatened, and federal candidate), and the definition for each category.

Rarity Status	Definition
State endangered	A species is considered endangered if the species is threatened with extinction throughout all or a significant portion of its range within Minnesota
State threatened	A species is considered threatened if the species is likely to become endangered within the foreseeable future throughout all or a significant portion of its range within Minnesota
State special concern	A species is considered a species of special concern if, although the species is not endangered or threatened, it is extremely uncommon in Minnesota, or has unique or highly specific habitat requirements and deserves careful monitoring of its status. Species on the periphery of their range that are not listed as threatened may be included in this category along with those species that were once threatened or endangered but now have increasing or protected, stable populations
Federally endangered	A species is considered endangered if the species is in danger of extinction throughout all or a significant portion of its range
Federally threatened	A species is considered threatened if the species is likely to become endangered within the foreseeable future throughout all or a significant portion of its range
Federal candidate	A species proposed for addition to the Federally endangered and threatened species list

Outcomes/Products

Plant Species Pollination Guide

The data collected through this project has contributed to tools used throughout the state. The PG supplied plant attributes as well as specialist pollinator attributes to plant selection tools for The Minnesota Board of Water & Soil Resources (BWSR) and Metro Blooms. All attributes described within the plant species traits section will live in MNTaxa. This tool is used to organize data and currently provides a handful of attributes including species origin, physiognomy, and state distribution.

Native Plant Community Pollination Guide

Different native plant species self-organize into recognizable groups that repeat across the landscape and persist through time, herein referred to native plant communities (NPCs). The NPC PG is designed as a pollination companion to the DNR Field Guide to Native Plant Communities of Minnesota. The NPC PG is based on the NPC Class Fact Sheets and adds to them the pollination attributes for each of the plant species listed for the NPC Class. This provides a view on how the pollination traits of individual plant species compare within each NPC.

The NPC Class Pollination Fact Sheets present information on a plant species frequency and cover within the NPC, compatibility, longevity, clonality, principal pollen vector, pollinator requirements, and pollination index.

Within an NPC, some plant species are grouped due to uncertainty or difficulty in identification (e.g., *Rubus*, *Viola*) in the underlying plant data that supports the NPC classification. In some circumstances within these groups, traits vary by species and therefore are listed as “varies” in the companion guide.

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Literature cited:

Barrett S. C. H. (2019). A most complex marriage arrangement: recent advances on heterostyly and unresolved questions. The New Phytologist, 224(3), 1051–1067. https://doi.org/10.1111/nph.16026

Clough, Y., Ekroos, J., Báldi, A., Batáry, P., Bommarco, R., Gross, N., Holzschuh, A., Hopfenmüller, S., Knop, E., Kuussaari, M., Lindborg, R., Marini, L., Öckinger, E., Potts, S. G., Pöyry, J., Roberts, S. P., Steffan-Dewenter, I., & Smith, H. G. (2014). Density of insect-pollinated grassland plants decreases with increasing surrounding land-use intensity. Ecology Letters, 17(9), 1168–1177. https://doi.org/10.1111/ele.12325

Crop Genebank Knowledge Base. Information on breeding systems for some common tropical and sub-tropical forages. https://cropgenebank.sgrp.cgiar.org/images/file/forage_legumes/breeding%20systems%20table.pdf. Accessed December 22, 2022.

Culley, T. M., & Klooster, M. R. (2007). The Cleistogamous Breeding System: A Review of Its Frequency, Evolution, and Ecology in Angiosperms. Botanical Review, 73(1), 1–30. http://www.jstor.org/stable/27571184

Dong, M., Fei-Hai Yu, & Peter Alpert (2014) Ecological consequences of plant clonality, Annals of Botany, Volume 114, Issue 2, August 2014, Page 367, https://doi.org/10.1093/aob/mcu137

Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico [Online]. 25+ vols. New York and Oxford. Vol. 1, 1993; vol. 2, 1993; vol. 3, 1997; vol. 4, 2003; vol. 5, 2005; vol. 6, 2015; vol. 7, 2010; vol. 8, 2009; vol. 9, 2014; vol. 10, 2021; vol. 11, 2023, vol. 12, 2016; vol. 13, 2024; vol. 14, 2023; vol. 17, 2019; vol. 19, 2006; vol. 20, 2006; vol. 21, 2006; vol. 22, 2000; vol. 23, 2002; vol. 24, 2007; vol. 25, 2003; vol. 26, 2002; vol. 27, 2007; vol. 28, 2014. http://beta.floranorthamerica.org. Accessed October-December, 2022.

Minnesota Wildflowers. [internet]. https://www.minnesotawildflowers.info. Accessed October, 2022

Molano-Flores, Brenda. (2004). Breeding systems of plants used for prairie restorations: A review. Transactions of the Illinois State Academy of Science. 97.

Osborn, J. M., & Schneider, E. L. (1988). Morphological Studies of the Nymphaeaceae Sensu Lato. XVI. The Floral Biology of Brasenia Schreberi. Annals of the Missouri Botanical Garden, 75(3), 778–794. https://doi.org/10.2307/2399366

Pladias – Database of the Czech Flora and Vegetation [internet]. Species profiles available from: https://pladias.cz/en/taxon/. Accessed November, 2022.

TRY plant trait database – enhanced coverage and open access. Global Change Biology. 26: 119 – 188. https://doi.org/10.1111/gcb.14904.

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Appendix A – Pollination Index

Numerous iterations of the pollination index were created to determine the most comprehensive and sound version. All versions of this index, trait scoring, and the thoughts and processes involved in each iteration, are captured in Appendix A. Version 6 is used in our final products.

Version 1

This version of the pollination index is calculated by a sum of the five plant traits or trait groupings: principal pollen vector score (Table A8), compatibility score (Table A9), longevity score (Table A10), clonality score (Table A11), pollination specialization score (Table A12). Scoring for each trait is laid out in the following tables. The index has a range of 0, 4-14, where all wind and water pollinated plants receive an automatic index of 0 (Table A13).

Table A8. Pollination index version 1 principal pollen vector score (0, 1, 2) and the definition of each category.

Principal pollen vector score	Definition
0	wind, water, unknown
1	insects + wind or water
2	insects

Table A9. Pollination index version 1 compatibility score (1, 2, 3) and the definition of each category.

Compatibility Score	Definition
1	± SC, SC, A, CL, Ge, CL in MN, CL only, unknown, blanks
2	SI/SC, SI/sc, SC/si, CL/CH, CL flowers present, sometimes D
3	± SI, SI, CH, D, PD, H, GD, Di, Distylous, Pg, Pa, PD, Gynoecious, GM, CL flowers absent, facultative xenogamy, reverse herkogamous, xenogamous, herkogamy

Table A10. Pollination index version 1 longevity score (1, 2, 3) and the definition of each category.

Longevity Score	Definition
1	Perennial
2	Biennial, short-lived perennial, etc.
3	Annual

Table A11. Pollination index version 1 clonality score (1, 2, 3) and the definition of each category.

Clonality Score	Definition
1	Present, unknown
2	Weakly
3	Absent

Table A12. Pollination index version 1 pollinator specialization score (1, 2, 3) and the definition of each category.

Pollinator Specialization Score	Definition
1	Generalist - does not require specific body size or pollination apparatus; no corolla, or corolla very short (less than 3mm)
2	Somewhat specialized - not just any insect can pollinate; requires specific body sized insect; flower is somewhat restricted; buzz pollination present but not required; larger "tube" flowers; early spring flowers that are insect pollinated
3	Very specialized - requires very specialized pollinator; requires buzz pollination, flowers with very long corollas

Table A13. Pollination index version 1 and the definition of each range.

Pollination Index	Definition
0	Exclusively wind or water pollinated
4-7	Least reliant on insect pollinators
8-11	More reliant on insect pollinators
12-14	Most reliant on insect pollinators

Version 2

Version 2 of the pollination index takes the same scoring and methods as version 1, but subtracts 4 from all non-zero indices to create a continuous range from 0-10 (Table A14). It was determined that version 1 and version 2 put too much weight in clonality and longevity individually and that they may be better captured under a single score (Table A22). These two traits are complementary of one another in that if a species is long-lived, then it can survive into the next year AND if a species is clonal, then it is more likely to survive into the next year because some ramets die and others don't (but this should be accounted for with long-lived variable).

Table A14. Pollination index version 2 and the definition of each range.

Pollination Index	Definition
0	Exclusively wind or water pollinated
1-3	Least reliant on insect pollinators
4-7	More reliant on insect pollinators
8-10	Most reliant on insect pollinators

Version 3

This version of the index created a pollination index with a range from 0-4 on 0.5 increments (Table A19). It uses the principal pollen vector score (Table A15) multiplied by the compatibility score (Table A16) to achieve a "reliance score". If the reliance score is equal to zero, the overall score is zero. However, if the reliance score is greater than zero, the overall score is equal to the (reliance score * weight) plus the longevity score (Table A17) and pollination specialization score (Table A18). The weight is set to 2, making the reliance score relatively more important than longevity and specialization. Throughout the process, we attempted to adjust or put weights on longevity and specialization, but did not feel comfortable making scientific assumptions.

This index places more weight on the compatibility and principal pollen vector, and less on other plant traits. It also does not consider clonality which we feel is worth considering in some manner in the pollination index.

Table A15. Pollination index version 3 principal pollen vector score (0, 0.5, 1) and the definition of each category.

Principal pollen vector score	Definition
0	wind, water
0.5	insects + wind or water, unknown
1	insects

Table A16. Pollination index version 3 compatibility score (0, 0.5, 1) and the definition of each category.

Compatibility Score	Definition
0	± SC, SC, A, CL, Ge, CL in MN, CL only
0.5	SI/SC, SI/sc, SC/si, CL/CH, CL flowers present, sometimes D, unknown, blanks
1	± SI, SI, CH, D, PD, H, GD, Di, Distylous, Pg, Pa, PD, Gynoecious, GM, CL flowers absent, facultative xenogamy, reverse herkogamous, xenogamous, herkogamy

Table A17. Pollination index version 3 longevity score (0, 0.5, 1) and the definition of each category.

Longevity Score	Definition
0	Perennial
0.5	Biennial, short-lived perennial
1	Annual

Table A18. Pollination index version 3 pollinator specialization score (0, 0.5, 1) and the definition of each category.

Pollinator Specialization Score	Definition
0	Generalist - does not require specific body size or pollination apparatus; no corolla, or corolla very short (less than 3mm)
0.5	Somewhat specialized - not just any insect can pollinate; requires specific body sized insect; flower is somewhat restricted; buzz pollination present but not required; larger "tube" flowers; early spring flowers that are insect pollinated
1	Specialized - requires very specialized pollinator; requires buzz pollination, flowers with very long corollas

Table A19. Pollination index version 3 and the definition of each range.

Pollination Index	Definition
0	Exclusively wind or water pollinated or entirely self-compatible
0.5-1.5	Least reliant on insect pollinators
2-3	More reliant on insect pollinators
3.5-4	Most reliant on insect pollinators

Version 4

Version 4 follows the same logic as version 3 but includes clonality (Table A20) in the equation for overall score. This results in a range from 0-5 on 0.5 increments (Table A21).

Like version 3, this index places more weight on the compatibility and principal pollen vector, and less on other plant traits. It was determined that we cannot reliably or confidently make assumptions that one trait is more important towards overall pollination than another and that versions 3 and 4 took PG data beyond our comfortability. Both versions 3 and 4 fail to consider insect pollinated plants that are self-compatible, and missed plants that rely on insects for greater fitness, like many Orchidaceae species.

Table A20. Pollination index version 4 clonality score (0, 0.5, 1) and the definition of each category

Clonality Score	Definition
0	Present
0.5	Weakly clonal or unknown
1	Absent

Table A21. Pollination index version 4 and the definition of each range.

Pollination Index	Definition
0	Exclusively wind or water pollinated or entirely self-compatible
0.5-2	Least reliant on insect pollinators
2.5-4	More reliant on insect pollinators
4.5-5	Most reliant on insect pollinators

Version 5

This version takes the sum of four plant traits or trait groupings: principal pollen vector score (Table 8), compatibility score (Table A9), longevity and clonality score (Table A22), and pollination specialization score (Table A12). The index values have a range of 0, 3-11, where all wind and water pollinated plants receive an automatic index of 0 (Table A16).

Table A22. Pollination index version 5 longevity and clonality score (1, 2, 3) and the definition of each category.

Longevity + Clonality Score	Definition
1	Perennial and clonal, weakly clonal, or unknown clonality
2	Perennial and non-clonal
3	Annual, biennial, short-lived perennial or other intermediate longevity

Table A23. Pollination index version 5 and the definition of each range.

Pollination Index	Definition
0	Exclusively wind or water pollinated
3-5	Least reliant on insect pollinators
6-8	More reliant on insect pollinators
9-11	Most reliant on insect pollinators

Version 6

Version 6 was based on a similar attempt to version 5 to apply a pollination index to plants based on the relative ability of plants to self-pollinate (Clough, 2014). This is the version we used in our final product. This version uses the same scoring and process as version 5, but subtracts three from all non-zero indices, creating a continuous range from 0-8 (Table 6). This was the version that appealed to most of the plant and insect experts that worked on this project and seemed to capture the diversity in reliance of plants on pollinators in the most instinctual way. The results resonated with the experts and was an attempt to equally weight the various plant attributes rather than providing a greater weight on one or another.