

Castilleja coccinea (L.) Spreng.

Indian Paintbrush

Orobanchaceae



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Castilleja coccinea Rare Plant Profile

New Jersey Department of Environmental Protection
Division of Parks and Forestry
New Jersey Forest Service
Office of Natural Lands Management
New Jersey Natural Heritage Program

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Life History

Castilleja coccinea, scarlet paintbrush, is a showy member of the Orobanchaceae, commonly referred to as the broomrape family (although some sources still place it in the figwort family, Scrophulariaceae). Most members of this family are parasitic or hemiparasitic, utilizing a host plant for all or some nutrient acquisition. *C. coccinea* is a hemiparasitic herbaceous annual or biennial plant of damp, sandy meadows and prairies, usually preferring sites with calcareous soil (Gleason & Cronquist, 1991; New York Natural Heritage Program, 2019). *C. coccinea* produces chlorophyll and is capable of photosynthesis, but requires haustorial connections to a host plant in order to reach full potential, often not surviving past the seedling stage without a host (Shenk & Holsinger, 2001; Malcolm, 1966). *C. coccinea* grows roughly 20-60cm tall with a stem covered in fine, but conspicuous hair. Cauline leaves are highly variable, ranging from entire to cleft with 3-5 lobes (Gleason & Cronquist, 1991). Basal leaves remain entire and form a rosette around the stem (Newcomb, 1977). The “scarlet paintbrushes” are actually bracts, divided into 3-5 scarlet (rarely yellow) tipped lobes, while the actual flower corolla is a far less conspicuous yellow, partially hidden and overshadowed by the brightly colored bracts (New York Natural Heritage Program, 2019). Flower length ranges from 21-27mm, usually slightly longer than the calyx (Gleason & Cronquist, 1991). Individual plants are capable of producing multiple stems and flowers. *C. coccinea* flowers and fruits from May to mid-August and is most easily identifiable during these life stages (New York Natural Heritage Program, 2019).

Hemiparasitic Nature of *C. coccinea*

C. coccinea is what is known as a “green root-parasite” or hemiparasite since it still photosynthesizes, but requires a haustorial connection to host plants in order to mature. Haustorial connections involve initial attachment to the host root, softening of host root tissue, penetration of host root tissue, and finally development and cell differentiation of the parasite within the host root (Malcolm, 1966). The ecological definition of parasitism is that of an interaction where the growth and fitness of the parasite increases and as a result, host fitness and growth is decreased. Furthermore, when the interaction does not occur, host fitness and growth is left unaffected, while fitness and growth of the parasite decreases (Malcolm, 1964). Under that definition, *C. coccinea* is a definite root-parasite. In a host-parasite interaction study, *Kalanchoe daigremontiana* (now *Bryophyllum daigremontianum*), an easily propagated succulent was grown with and without *C. coccinea*. On average, the dry weight of unparasitized plants was more than 2.1 times that of parasitized plants, a clear indicator that *C. coccinea* was having detrimental effects on the host plants (Malcolm, 1964). It has also been demonstrated that *C. coccinea* seedlings will not even mature unless attached to a host plant (Malcolm, 1966).

C. coccinea is a generalist, as it will attach to a wide variety of host species. Malcolm (1962, 1966) performed a haustorial attachment experiment with 17 different host species commonly found in *C. coccinea* habitat in Michigan: *Achillea millefolium*, *Alnus rugosa*, *Antennaria neglecta*, *Chrysanthemum leucanthemum*, *Danthonia spicata*, *Fragaria virginiana*,

Hieracium aurantiacum, *Krigia biflora*, *Lactuca canadensis*, *Lobelia spicata*, *Panicum sphaeroides*, *Populus deltoides*, *Rubus hispidus*, *Rudbeckia hirta*, *Solidago graminifolia*, *Solidago juncea*, and *Solidago rugosa*. Out of the 17 species, all but 3, *Populus deltoides*, *Alnus rugosa*, and *Rubus hispidus*, showed signs of haustorial attachment. An occurrence in Connecticut is associated with these species: *Carex* spp., *Erigeron* sp., *Gallium mollugo*, *Geranium maculatum*, *Lilium* sp., *Lobelia spicata*, *Medicago* sp., *Onoclea sensibilis*, *Phalaris arundinacea*, *Phleum pratense*, *Plantago lanceolata*, *Potentilla simplex*, *Prunella vulgaris*, *Rosa multiflora*, *Rudbeckia hirta*, *Solidago* sp., *Sisyrinchium* sp., and *Trifolium pratense*; however, there is no indication whether or not *C. coccinea* is forming haustorial attachments with any of them (Shenk & Holsinger, 2001). While *C. coccinea* appears to associate with a wide variety of hosts, it is unclear whether or not any of them are being actively parasitized. *C. coccinea* is known to form connections with rocks, pebbles, and other nutritionally useless objects (Malcolm, 1966). Furthermore, not all host species are equal; different host species or number of active hosts can affect how vigorously a parasitic plant will grow (Marvier, 1998).

Pollinator Dynamics

The ruby throated hummingbird (*Archilochus colubris*), a migratory species, is a well reported visitor and probable pollinator of *C. coccinea* (Bertin, 1982). Both the scarlet and the yellow morphs have been shown to attract bumblebees (*Bombus* spp.), sweat bees (Halictidae), and butterflies. However, a study comparing pollination and reproductive rates between the scarlet and yellow morphs noted that while bumble bees and butterflies visited the mostly scarlet populations, none were actually observed pollinating the scarlet individuals and were instead seen on the yellow morphs (Kim et al., 2019). The same study also observed that both the scarlet morph and the yellow morph are fully capable of self-pollinating with little to no change in seed and fruit production compared to cross pollinated groups. For six treatments, animal pollinators were excluded from inflorescences by using nylon mesh bags to cover the flowers. The study showed that pollinator excluded yellow morph *C. coccinea* still produced the same amount of fruit and only 12% lower seed set compared to uncovered scarlet and yellow individuals while the pollinator excluded scarlet morph suffered a 43% decrease in fruit set and a 66% decrease in seed set, which may indicate that yellow morph *C. coccinea* is capable of autogamous selfing (Kim et al., 2019). However, the mechanism was not investigated and more research would need to be done to prove that *C. coccinea* is actually capable of autogamous selfing.

Seed Dispersal

C. coccinea produces hundreds of very small seeds that bear no obvious adaptations for dispersal. However, an anecdotal account by a Connecticut farmer mentioned that a *C. coccinea*

population in his hay meadow would migrate based on the direction that the hay was raked each year and that it had been doing so for many decades (Shenk & Holsinger, 2001).

Habitat

C. coccinea inhabits calcareous fens, damp meadow, prairies, fields, the open edges of swamps and bogs, and rights of way such as powerline cuts, pipeline cuts, and open roadsides (Gleason and Cronquist, 1991; Native Plant Trust, 2019; Walz et al., 2018). *C. coccinea* thrives in mesic, sandy early successional habitat, preferring more alkaline substrates and areas exposed to large amounts of light (Native Plant Trust, 2019). Areas maintained as early successional habitat such as powerline cuts, logging roads, and hay meadows are important habitat in the eastern portion of *C. coccinea*'s range where many abandoned farm fields and meadows have reverted back to forest in the last century (Shenk & Holsinger, 2001; New York Natural Heritage Program, 2019). Calcareous, groundwater fed fens are an important habitat type for *C. coccinea*. These fen habitats are increasingly threatened by development, ditching, and agricultural pollution (Virginia Natural Heritage Program, 2018). Being hemiparasitic, *C. coccinea* is heavily reliant on haustorial connection to host plants for survival.

Wetland Indicator Status

C. coccinea is classified as a facultative (FAC) wetland species (USDA, 2019).

USDA Plants Code

CACO17

“Each symbol is composed of the first two letters of the genus+first two letters of the species+first letter of the terminal infraspecific name+tiebreaking number (if needed)” (USDA, 2019). <https://plants.usda.gov/core/profile?symbol=CACO17>

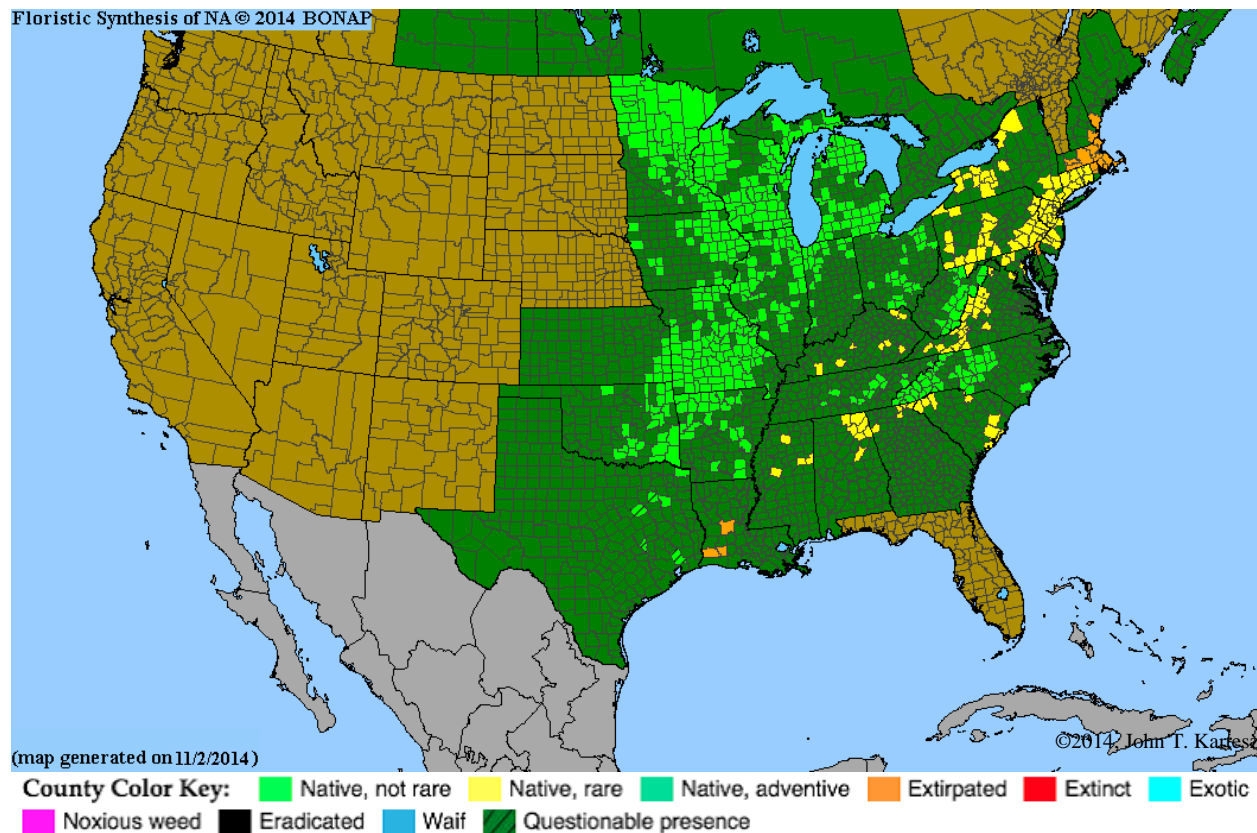
Coefficient of Conservatism (Walz et al. 2018)

CoC=8; Native with a narrow range of ecological tolerances and typically associated with a stable community.

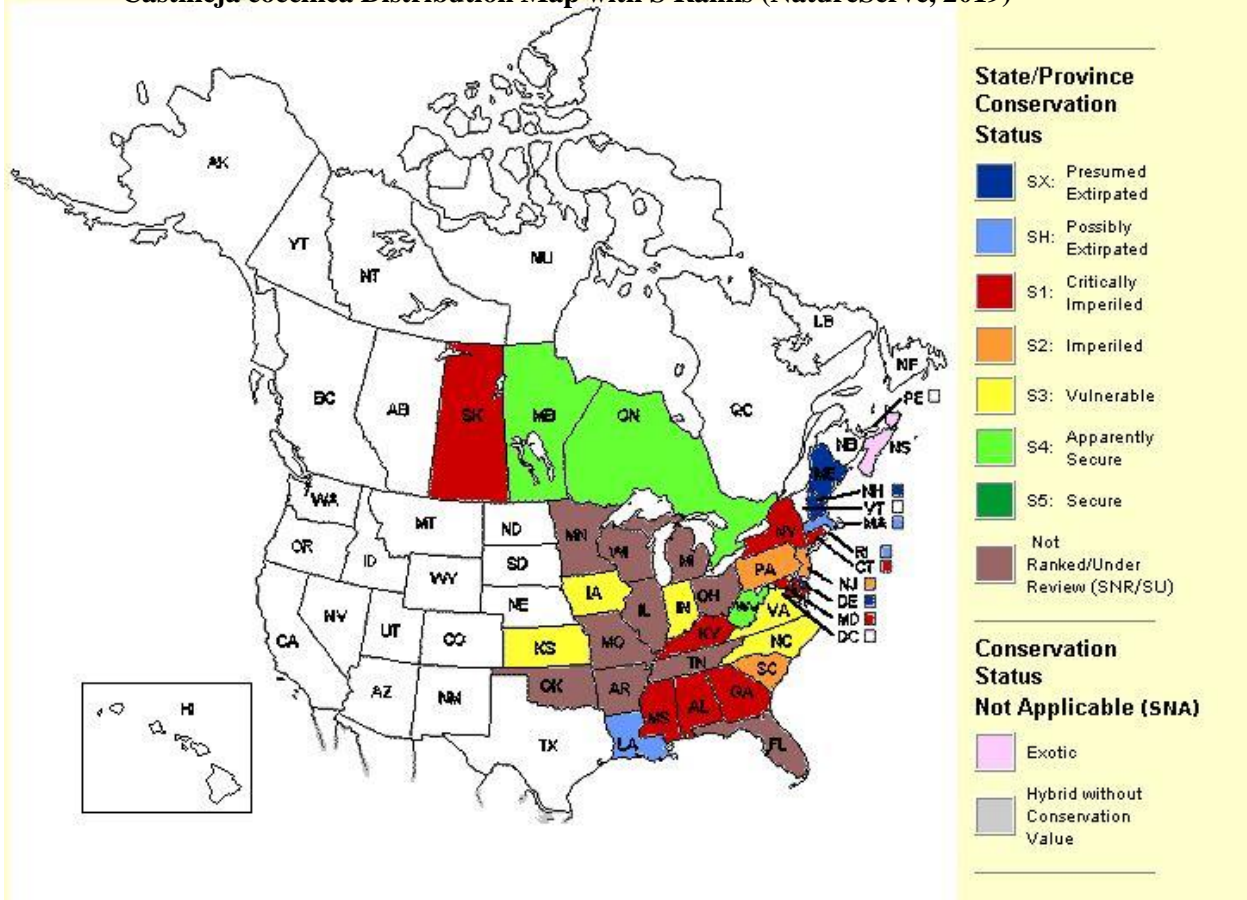
Distribution and Range

C. coccinea is widespread, though regionally rare, throughout Eastern North America, from Maine to Saskatchewan and south to Eastern Texas (USDA, 2019; Kartesz, 2015). While it is widespread, *C. coccinea* is threatened or endangered throughout much of its range. Little data exists on overall population numbers and many states within its range list it as, “Not Ranked/Under Review, SNR/SU” (NatureServe, 2019). Conservation ranking for each state/province within the range is as follows: Alabama (S1), Arkansas (SNR), Connecticut (S1), Delaware (SX), Florida (SNR), Georgia (S1), Illinois (SNR), Indiana (S3), Iowa (S3), Kansas (S3), Kentucky (S1), Louisiana (SH), Maine (SX), Maryland (S1), Massachusetts (SH), Michigan (SNR), Minnesota (SNR), Mississippi (S1), Missouri (SNR), New Hampshire (SX), New Jersey (S2), New York (S1), North Carolina (S3), Ohio (SNR), Oklahoma (SNR), Pennsylvania (S2), Rhode Island (SH), South Carolina (S2), Tennessee (SNR), Texas (SNR), Virginia (S3), West Virginia (S4), Wisconsin (SNR), Manitoba (S4S5), Nova Scotia (SNA), Ontario (S4S5), Saskatchewan (S1) (NatureServe, 2019; Kartesz, 2015).

Castilleja coccinea Geographic Distribution Map (Kartesz, 2015)



Castilleja coccinea Distribution Map with S Ranks (NatureServe, 2019)



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Conservation Status

Status for New Jersey:

Castilleja coccinea (S2) (HL)

Imperiled in New Jersey because of rarity (6 to 20 occurrences). Historically many of these elements may have been more frequent but are now known from very few extant occurrences, primarily because of habitat destruction. Diligent searching may yield additional occurrences. HL indicates protection by the Highlands Water Protection and Planning Act within the jurisdiction of the Highlands Preservation Area (New Jersey Natural Heritage Program, 2019).

Global Status: *Castilleja coccinea* (G5):

Demonstrably secure globally; although it may be quite rare in parts of its range, especially at the periphery.

Threats

The most immediate threats to occurrences both in and out of New Jersey are the succession of woody species, off-road vehicle activity, and human development. These threats are mentioned in multiple EO reports (New Jersey Natural Heritage Program, 2019). In many cases, the woody succession involves invasive species like *Rosa multiflora*, which can rapidly colonize an area, shading and outcompeting native species (New Jersey Natural Heritage Program, 2019; Shenk & Holsinger, 2001). The lack of frequent, low intensity fire may represent a threat to *C. coccinea* as well as its habitat (Rodger, 1998). NatureServe (2019) lists land use conversion, habitat fragmentation, interspecific competition and predation as threats; in addition, *C. coccinea* may have difficulty producing flowers and fruit in the prolonged absence of fire. Off-road vehicles used both recreationally and by loggers can leave deep ruts in the damp substrate, directly harming *C. coccinea* and leading to further degradation of the habitat. The New York Natural Heritage Program (2019) also lists the invasive species, *Cynanchum louiseae*, as a threat to *C. coccinea* habitat. The invasive reed *Phragmites australis* also represents a threat to *C. coccinea* and its habitat (New Jersey Natural Heritage Program, 2019).

Management Summary and Recommendations

C. coccinea thrives in sunny, open habitat. Extant occurrences in New England and New York are maintained by yearly mowing (New York Natural Heritage Program, 2019; Shenk & Holsinger, 2001). A large occurrence in New Jersey was found among a field used for cow grazing with comments in the report suggesting that the grazing activities may be having a positive effect on the robust population (New Jersey Natural Heritage Program, 2019). Management should be directed towards preventing woody succession and invasion by exotic species. In some cases, mowing may be necessary and even beneficial to populations of *C. coccinea*.

Additional Information

Occurrences in New Jersey:

The biotics database shows 49 recorded occurrences of *C. coccinea* in New Jersey. However, a large number of these occurrences have not been seen in many decades and are assumed destroyed by development or encroaching woody succession. Many large population occurrences have not been checked in many years. However, the Biotics database may be incomplete for more common species (S2 and S3) and additional occurrence information may be found in herbaria or other sources.

Research Suggestions:

The Biotics database shows that many populations have not been visited in over a decade; the more robust populations in good habitat should be revisited. It is also possible that there are still more populations waiting to be found throughout damp, early successional habitat in New Jersey.

Synonyms

Castilleja ludoviciana Pennell (USDA, 2019)

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