Chenopodium rubrum var. *rubrum*

Red Goosefoot

Chenopodiaceae

Chenopodium rubrum var. *rubrum* by Peter M. Dziuk, 2012

Chenopodium rubrum var. *rubrum* Rare Plant Profile

New Jersey Department of Environmental Protection
State Parks, Forests & Historic Sites
State Forest Fire Service & Forestry
Office of Natural Lands Management
New Jersey Natural Heritage Program

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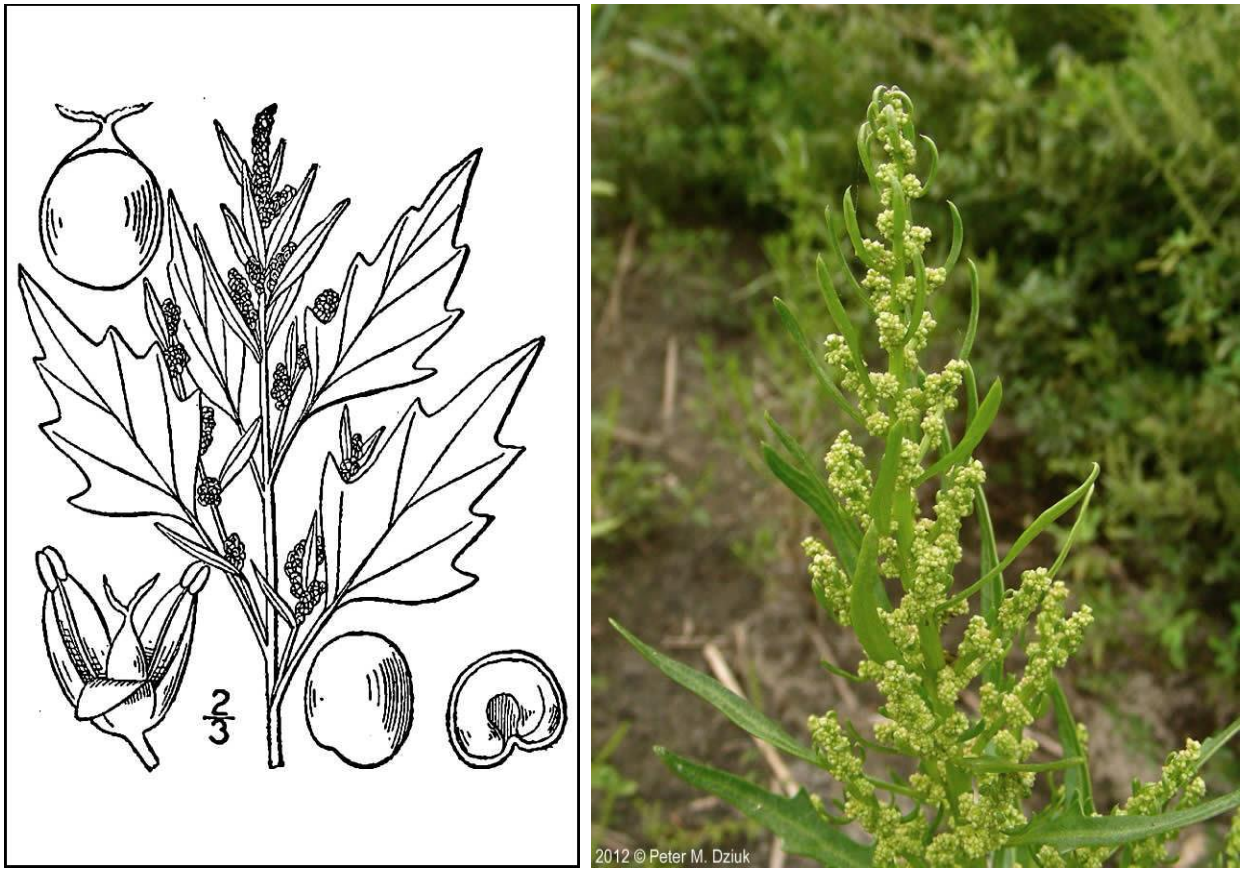
Life History

Chenopodium rubrum var. *rubrum* (Red Goosefoot) is a fleshy annual herb that has traditionally been placed in the Chenopodiaceae. Some taxonomists now include the goosefoot family in the Amaranthaceae (APG III 2009, Kartesz 2015) but others remain unconvinced that the merge is justified (Clements and Mosyakin 2020, Weakley et al. 2022). Red Goosefoot plants are usually shallowly rooted, relying on a well-developed system of lateral roots for support (Williams 1969). The stems of *C. rubrum* var. *rubrum* range from 1–8 dm in height: They are erect and smooth with ascending branches. The leaves are green on both sides and they are not aromatic. The larger ones can be up to 9 cm long and 6 cm wide with deeply lobed margins, wedge-shaped bases, and pointed tips while the smaller ones are typically narrow and nearly entire. The terminal and lateral inflorescences consist of dense flower clusters in leafy spikes. The flowers have an inconspicuous green to red perianth of 3-4 parts that are fused at the base. The terminal flowers on *C. rubrum* var. *rubrum* plants are bisexual, with 2 stigmas and 2–3 stamens, but lateral flowers may be pistillate (or occasionally staminate according to Williams, 1969). The fruits are single-seeded, thin-walled, and somewhat inflated and the seeds are flattened. Seed orientation may be vertical or horizontal. (See Britton and Brown 1913, Fernald 1950, Bassett and Crompton 1982, Gleason and Cronquist 1991, Tiner 2009, Fuentes-Bazan et al. 2012, Iamonico 2014, Clements and Mosyakin 2020).



Left: Britton and Brown 1913, courtesy USDA NRCS 2023a. Right: Peter M. Dziuk, 2012.

The patterns of growth and development in *Chenopodium rubrum* var. *rubrum* vary in response to environmental conditions. Larger plants sometimes shed their lower leaves late in the growing season (Rayner 1978). Plant characteristics such as leaf length, lobe size, and number of branches depend on available resources, particularly light (Williams 1969, Rayner 1978). Some variations in form may be governed by latitude (Tsuchiya and Ishiguri 1983), and the light exposure history of maternal plants is also thought to influence germination and development in the offspring (Mitrović et al. 2010).

Under normal circumstances flowering is initiated late in the summer as the days begin to shorten. A number of studies have examined the potential role of various chemical messengers in the process (eg. Macháčková et al. 1993, Mitrović et al. 2003). Reiter et al. (2015) found that melatonin levels in *Chenopodium rubrum* var. *rubrum* rise at night and may be a means for detection of the longer nights that trigger blooming. *C. rubrum* var. *rubrum* typically flowers and fruits between August and October (Hough 1983, Clements and Mosyakin 2020, Weakley et al. 2022) but blooming may occasionally begin earlier and the fruiting period can extend into November (Tiner 2009, Les 2017). Germination can occur throughout the growing season so plants that begin to develop early in the season have time to make a large investment in vegetative growth and may become quite large while plants from late germinating seeds are smaller at flowering time (Salisbury 1970, Rayner 1978, Van der Sman et al. 1988). Both seedlings and mature plants are killed by frost (Williams 1969).

The *C. rubrum* var. *rubrum* plants that develop earlier in the season produce smaller and more numerous seeds but those that establish later invest less energy in root development or vegetative growth and produce larger seeds (Cook 1975, Josefusová et al. 1985, Van der Sman 1993). A single population of Red Goosefoot is likely to produce both small and large seeds (Salisbury 1970). Late developing plants are capable of rapid maturation. The seedlings are responsive to light cycles even at the cotyledonary stage and require only six suitable photoperiods to induce flowering (Mitrović et al. 2010). Salisbury (1970) described a colony of tiny *C. rubrum* var. *rubrum* plants on a shoreline in Great Britain, many with just cotyledons and two leaves present and estimated ages of 2–3 weeks, that were already bearing fruit. Such flexibility allows *C. rubrum* var. *rubrum* to rapidly complete its life cycle in unpredictable environments and restock the seed bank for the next germination opportunity that may arise (Blom and Voesenek 1996).

The other variety of *Chenopodium rubrum*, var. *humile*, is native to the western United States and Canada but occasionally establishes as an adventive in parts of the northeast, including New Jersey (NatureServe 2023, USDA NRCS 2023b). *C. rubrum* var. *humile* is more likely to have whitish stems that are prostrate or spreading, leaves that are shallowly lobed or entire, and relatively larger seeds (Tiner 2009, Mosyakin 2013). Although Wahl (1954) noted that the characteristics of the varieties could sometimes overlap he believed that the differences were generally consistent enough to justify species-level separation, and a number of current sources do recognize *C. humile* as a distinct species (eg. Tiner 2009, NatureServe 2023, USDA NRCS 2023b). Some hybrids between *Chenopodium rubrum* and *C. glaucum* have been reported: The plants are similar to *C. rubrum* but can be distinguished by their smaller, mealy leaves (Clements and Mosyakin 2020).

Pollinator Dynamics

Chenopodium rubrum var. *rubrum* plants typically bloom over a period of several weeks. The inconspicuous, odorless flowers are mainly pollinated by wind, although some insect-mediated pollination may also occur (Williams 1969, Zomlefer 1994). Self-pollination is possible in *C. rubrum* var. *rubrum* but there are mechanisms in place to promote cross-fertilization. The bisexual flowers are protogynous, having stigmas that are receptive when the flowers initially open but shrivel by the time the anthers release their pollen (Williams 1969), and when pistillate flowers are present they generally appear after the bisexual flowers have matured (Les 2017).

Seed Dispersal and Establishment

The seeds of *Chenopodium rubrum* var. *rubrum* typically range from 0.6–0.8 mm in diameter (Clements and Mosyakin 2020) although, as previously noted, their size is influenced by the germination dates of the parent plants. Each flower is single-seeded but individual plants can produce numerous propagules. Count-based approximations of fertility by Salisbury (1970) suggested that an average Red Goosefoot plant produced around 176,000 seeds in a year, with two particularly vigorous plants generating an estimated 327,000+ and 586,000+ seeds apiece. At the other end of the spectrum, small plants that developed late in the season produced about 5–22 seeds each.

Williams (1969) indicated that seedlings of *Chenopodium rubrum* var. *rubrum* often occur in patches because the propagules have no special mechanism for dispersal. While it is likely that many of the seeds are gravity-dispersed, some may also be transported to new locations by birds. Rayner (1978) observed that Red Goosefoot was attractive to ducks, and viability rates of 6–21% have been reported for *C. rubrum* seeds that have passed through the digestive tracts of waterfowl (Mueller and van der Valk 2002, Les 2017). Mueller and van der Valk (2002) further noted that ducks can consume thousands of goosefoot seeds in a single meal and subsequently transport them for distances of up to 1400 kilometers, although 20–30 km is more typical. Human-mediated dispersal is also relatively common for *C. rubrum* var. *rubrum*: The plants have been found along railway corridors and in topsoils that have been removed from one site for use at another (Hodkinson and Thompson 1997, Les 2017).

Chenopodium rubrum var. *rubrum* is often abundant in the seed bank of communities where the species occurs (Rayner 1978, Smith and Kadlec 1983, Poiani 1987). Seed longevities up to and exceeding 50 years have been reported (Williams 1969, Bakker et al. 1996) although germination rates appear to decline with age (Mitrović et al. 2005). The authors of the latter study also found that older seeds were more likely to produce smaller plants with fewer flowers.

Germination of *C. rubrum* var. *rubrum* usually occurs during a period of warm to hot, dry weather when water levels have been drawn down (Ter Heerdt et al. 2017). The seeds may sprout any time during the growing season when conditions are favorable although the majority of seedlings appear during the spring (Williams 1969). Salisbury (1970) found no difference in seed viability based on size although the larger seeds showed a slight tendency to germinate earlier. Germination of *C. rubrum* var. *rubrum* is greatest at or near the soil surface because the

seeds are sensitive to both light availability and temperature fluctuations (Williams 1969, Salisbury 1970, Thompson and Grime 1983). Germination rates are also enhanced by a period of stratification (Galatino and van der Valk 1986).

Developmental observations of *Chenopodium rubrum* var. *rubrum* indicate that when a seed germinates a protruding radicle (initial root) 2 mm in length is detectable by the third day (Dučić et al. 2003). After about a week a small shoot with cotyledons and a terminal bud is present (Josefusová et al. 1985). The cotyledons of *C. rubrum* var. *rubrum* are four times as long as they are wide, while the first true leaves are shallowly lobed, light green with reddish margins, and shining (Williams 1969). Williams indicated that Red Goosefoot was non-mycorrhizal and no mycorrhizae were found in specimens examined by Harley and Harley (1987).

Habitat

Chenopodium rubrum var. *rubrum* is a halophytic (salt-tolerant) species, which gives it access to habitats where many other plants are unable to grow. One morphological adaptation resulting from the harsh environment is leaf succulence, which is caused by the retention of water in cells with high concentrations of electrolytes. As soil salinity levels increase, Red Goosefoot plants develop fewer and smaller stomata, which may remain partially closed to further reduce water loss (Warne 1985). Svenson (1927) discussed the peculiar distribution of *C. rubrum* and other halophytes in North America, noting that they were mainly restricted to coastal areas or salt springs in the east, fairly uncommon in the central states, and relatively abundant in saline and alkaline soils in the west. Soil pH values ranging from 7.0–8.0 were recorded at sites where *C. rubrum* var. *rubrum* was growing in Manitoba (Rayner 1978).

Chenopodium rubrum var. *rubrum* is often characterized as a pioneer species because it colonizes mudflats and other recently exposed substrate (Shay 1984, Galinato and van der Valk 1986, Spencer 1994). The species has also been known to appear after fires (Les 2017) or in disturbed areas (Iamonico 2014, Weakley et al. 2022). *C. rubrum* var. *rubrum* is a poor competitor and is likely to disappear as other species become established, at least until the next disturbance opens up the habitat (Rayner 1978, Spencer 1994, Kenkel 1995).

The sites utilized by *Chenopodium rubrum* var. *rubrum* are generally open, ranging from full sunlight to partial shade (Les 2017, Clements and Mosyakin 2020). In New Jersey the species is usually associated with salt marshes or saline meadows (Hough 1983). The two extant populations in the state are situated in zones where *Spartina patens* is dominant (NJNHP 2022). Harshberger (1909) noted that *C. rubrum* var. *rubrum* was found in parts of the marsh that were only flooded to a depth of about 5 cm or less during high tide. Breden et al. (2001) indicated that the species could also occur in interdunal swale communities that support a *Spartina patens*—*Eleocharis parvula* Herbaceous Vegetation Association. The association is rare (S1S2) in the state.

In eastern Massachusetts, *Chenopodium rubrum* var. *rubrum* was once considered a characteristic plant of the middle beach zone, which is located between the spring tide line and the summer storm tide line (Roberts 1915). Examples of western habitats include alkaline

shorelines (Rayner 1978) and brackish, semi-permanent wetlands (Poiani 1987). Dodd and Coupland (1996) described seven halophytic vegetation communities in Saskatchewan and *C. rubrum* was documented in all of them. Habitats in Europe are similar to those in North America (Salisbury 1970, Lubińska-Mielińska et al. 2023) although the species has sometimes become weedy in farmland or waste places (Williams 1969, Iamonico 2014).

Wetland Indicator Status

The U. S. Army Corps of Engineers divided the country into a number of regions for use with the National Wetlands Plant List and portions of New Jersey fall into three different regions (Figure 1). *Chenopodium rubrum* has more than one wetland indicator status within the state. In the Northcentral and Northeast region it is an obligate wetland species, meaning that it almost always occurs in wetlands. In other parts of New Jersey it is a facultative wetland species, meaning that it usually occurs in wetlands but may occur in nonwetlands (U. S. Army Corps of Engineers 2020).

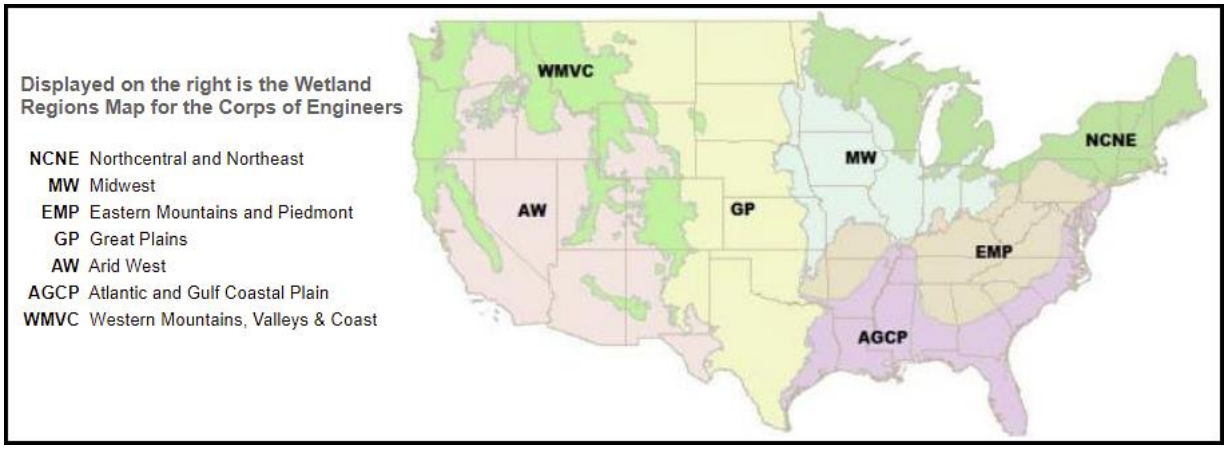


Figure 1. Mainland U. S. wetland regions, adapted from U. S. Army Corps of Engineers (2020).

USDA Plants Code (USDA, NRCS 2023b)

CHRU

The USDA code does not reflect a variety of *Chenopodium rubrum* because *C. rubrum* var. *humile* is treated as a distinct species (*C. humile*).

Coefficient of Conservancy (Walz et al. 2020)

CoC = 9. Criteria for a value of 9 to 10: Native with a narrow range of ecological tolerances, high fidelity to particular habitat conditions, and sensitive to anthropogenic disturbance (Faber-Langendoen 2018).

Distribution and Range

Chenopodium rubrum var. *rubrum* can be found throughout the northern hemisphere including much of Asia, Europe, and North America, where its southern extent reaches central Mexico (POWO 2023). The map in Figure 2 depicts the extent of Red Goosefoot in the United States and Canada.

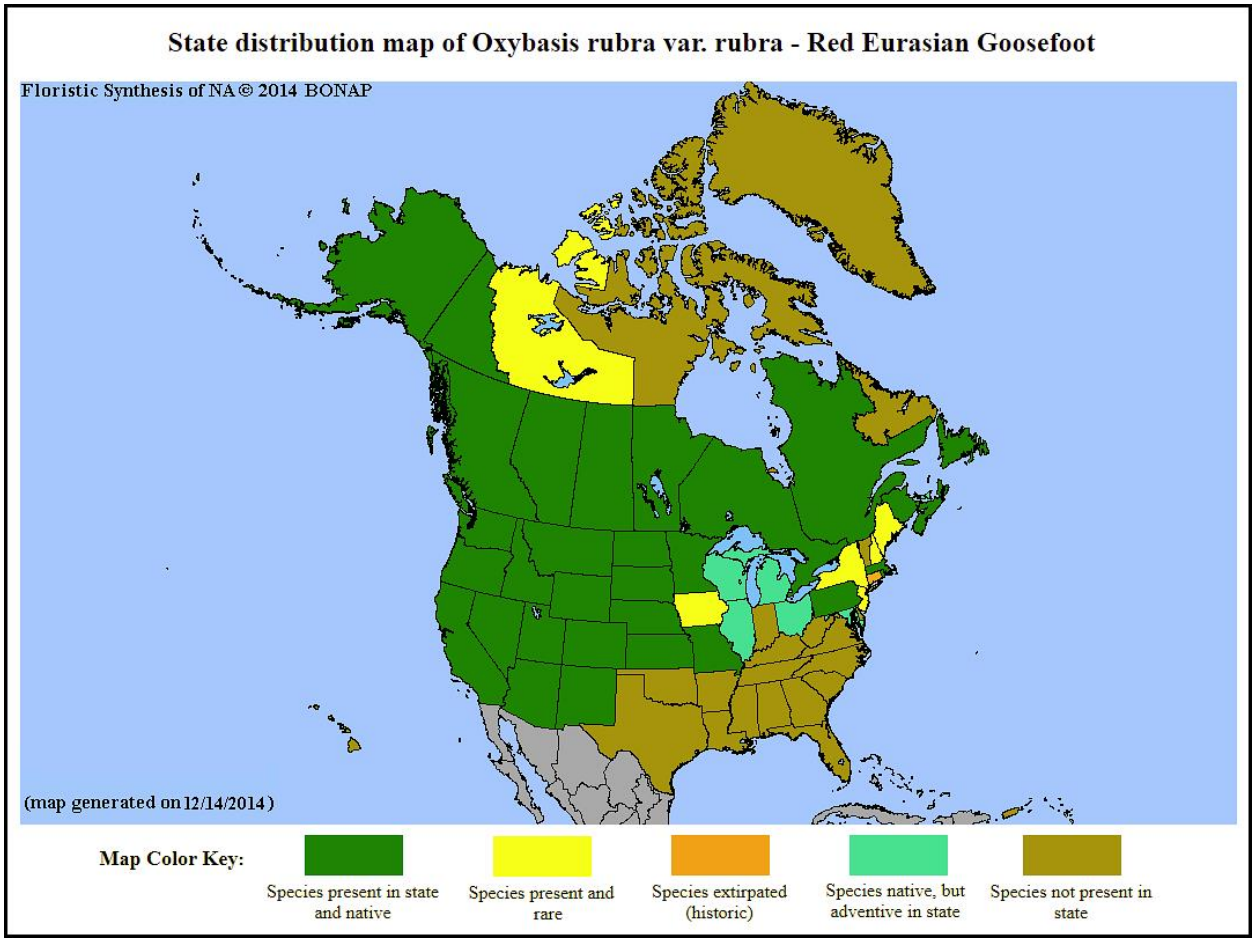


Figure 2. Distribution of C. rubrum var. rubrum in the United States and Canada, adapted from BONAP (Kartesz 2015).

The USDA PLANTS Database (2023b) shows records of *Chenopodium rubrum* var. *rubrum* in six New Jersey counties: Atlantic, Camden, Cape May, Hudson, Middlesex, and Monmouth (Figure 3 below). There is also a record from Burlington County (NJNHP 2022). The data include historic observations and do not reflect the current distribution of the species.

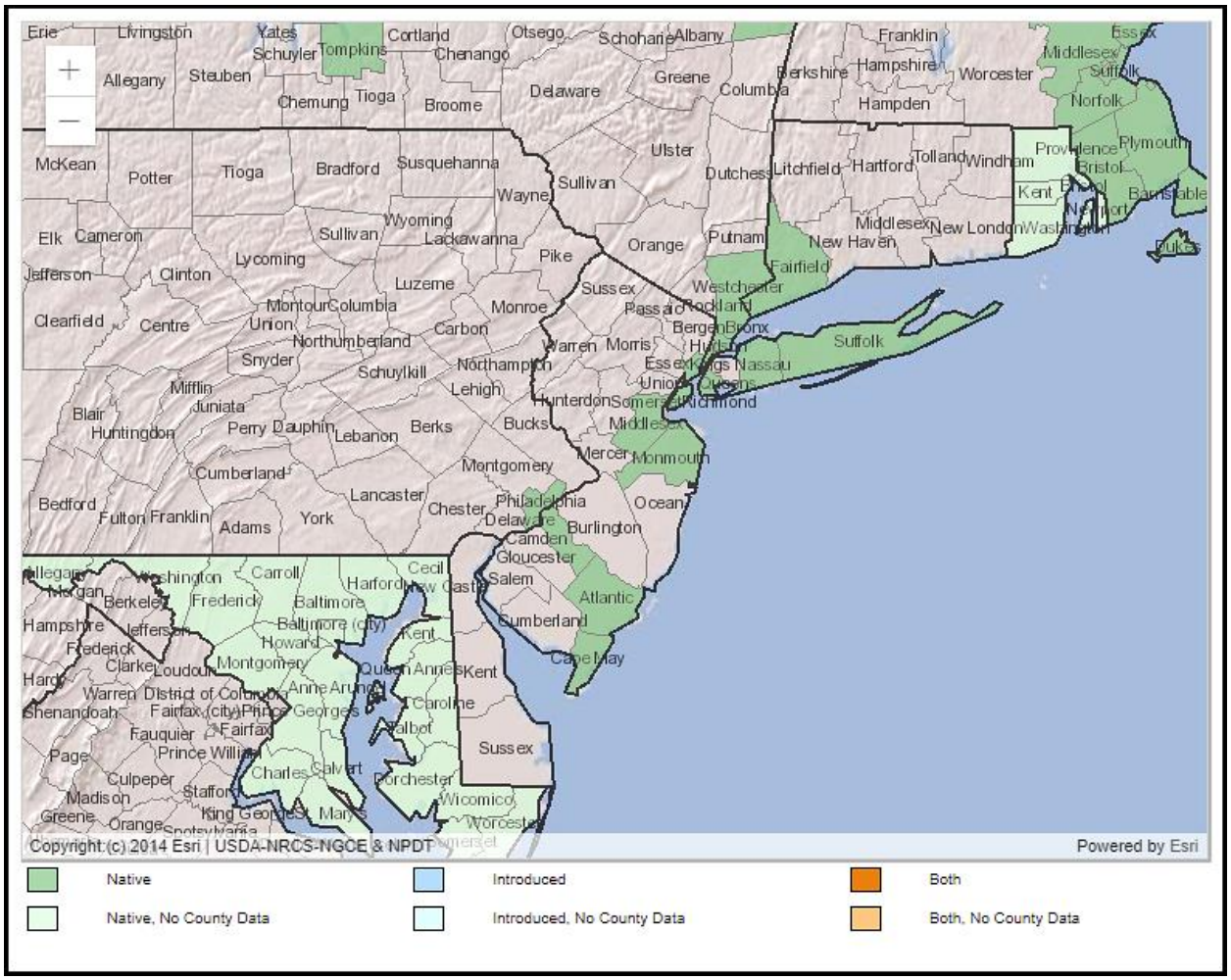


Figure 3. County records of C. rubrum var. rubrum in New Jersey and vicinity (USDA NRCS 2023b).

Conservation Status

Chenopodium rubrum var. *rubrum* is considered globally secure. The G5 rank means the species has a very low risk of extinction or collapse due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats (NatureServe 2023). The map below (Figure 4) illustrates the conservation status of Red Goosefoot in the United States and Canada. The species is vulnerable (moderate risk of extinction) in two provinces and one state, imperiled (high risk of extinction) in three provinces and one state, critically imperiled (very high risk of extinction) in one province and two states, and possibly extirpated in Connecticut, Iowa, and Maine. In much of its range, *C. rubrum* var. *rubrum* is apparently secure or unranked. It is not accepted as native in Illinois or Michigan.

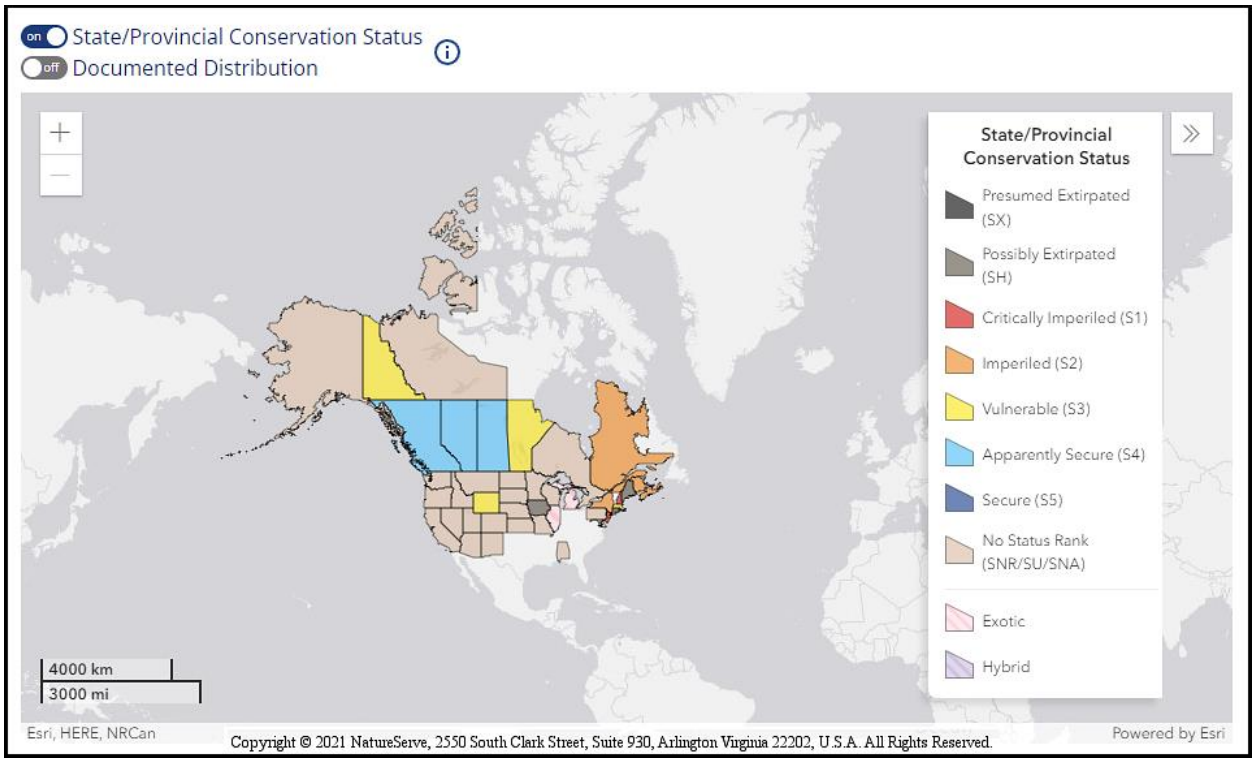


Figure 4. Conservation status of C. rubrum var. rubrum in the United States and Canada (NatureServe 2023).

New Jersey is one of the states where *Chenopodium rubrum* var. *rubrum* is critically imperiled. The S1 rank signifies five or fewer occurrences in the state. A species with an S1 rank is typically either restricted to specialized habitats, geographically limited to a small area of the state, or significantly reduced in number from its previous status. *C. rubrum* var. *rubrum* is also listed as an endangered species (E) in New Jersey, meaning that without intervention it has a high likelihood of extinction in the state. Although the presence of endangered flora may restrict development in certain communities such as wetlands or coastal habitats, being listed does not currently provide broad statewide protection for the plants. Additional regional status codes assigned to Red Goosefoot signify that the species is eligible for protection under the jurisdictions of the Highlands Preservation Area (HL) and the New Jersey Pinelands (LP) (NJNHP 2010).

Early reports of *Chenopodium rubrum* var. *rubrum* in New Jersey generally described it as a rare species of coastal salt marshes only known from Ocean County (Willis 1874, Britton 1889, Stone 1911). However, an 1800s-era specimen in the New York Botanical Garden's Steere Herbarium apparently originated in Hudson County (NJNHP 2022, Mid-Atlantic Herbaria 2023). Other early records in the state were based on either plants that had been introduced in ballast or misidentified specimens (Keller and Brown 1905, Stone 1911, Hough 1983). Despite its lack of abundance, Harshberger (1909) viewed *Chenopodium rubrum* as a characteristic salt marsh species of New Jersey's coast. Red Goosefoot was observed in Atlantic and Middlesex counties between 1930 and 1983 (Hough 1983), although there does not appear to be any documentation of the latter occurrence. *Chenopodium rubrum* var. *rubrum* is currently known from two sites in

the state, and when last seen both populations consisted of less than three dozen plants (NJNHP 2022).

Threats

No immediate threats to New Jersey's two populations of *Chenopodium rubrum* var. *rubrum* have been reported. Although both occurrences were small when last observed, healthy goosefoot plants are capable of producing copious amounts of seed and the habitat at both sites appeared to be of high quality (NJNHP 2022). However, some time has passed since the populations were viewed and there may have been changes to the plant community composition. As previously noted, *C. rubrum* var. *rubrum* is a plant of early successional habitats: It often disappears as other species become established because its growth is inhibited by competition and the seedlings generally do not establish in closed communities (Williams 1969, Rayner 1978).

Chenopodium rubrum var. *rubrum* may have some susceptibility to browsing, as herbivory by both cattle and deer has been observed. The level of threat is likely to depend on the life stage at which the plants are consumed. Loss of plants early in the season could reduce reproduction, but once the seeds have matured it appears that both deer and cattle can disperse viable propagules (Williams 1969, Rayner 1978).

Chenopodium rubrum var. *rubrum* occurrences in New Jersey are highly vulnerable to climate change. As the global climate becomes warmer the state is experiencing higher temperatures, shifting precipitation patterns that increase the frequency and intensity of both droughts and floods, and rising sea levels in coastal areas (Hill et al. 2020). *C. rubrum* var. *rubrum* can withstand high temperatures and it is relatively drought tolerant (Williams 1969, Ter Heerdt et al. 2017). The most direct threat to local *C. rubrum* var. *rubrum* populations is sea level rise, which is projected to have a severe impact on the brackish marshes the species inhabits. Anticipated effects on the communities include elevated salinity levels, more frequent floods, and eventual long-term inundation. Although Red Goosefoot is salt-tolerant, research has demonstrated that the plants can experience reduced growth, chlorosis, or necrosis at high concentrations (Warne 1985). The species is also particularly susceptible to flooding: Reported impacts from studies of plants in waterlogged soils have included reductions in growth and seed production, leaf loss, root decay, and death (Rayner 1978, Van der Sman et al. 1988 and 1993). Because *C. rubrum* var. *rubrum* is a poor competitor that requires open habitat, an additional challenge is likely to result from the further spread of *Phragmites australis* ssp. *australis*—an invasive species which is already well-established along the New Jersey coast and is expected to benefit from climactic changes (Mozdzer and Megonigal 2012). Even in Europe, where *Chenopodium rubrum* var. *rubrum* is sometimes considered weedy, a climate change risk assessment has projected a decline in the species' range (Hyvönen et al. 2012).

Management Summary and Recommendations

Although *Chenopodium rubrum* var. *rubrum* is secure at the global level it is rare in the northeast and has been ranked as a species of conservation concern in most of the Atlantic Coast states and provinces where it has been recorded, including two states where it may no longer be present (Figure 4). The regional scarcity of *C. rubrum* var. *rubrum* increases the importance of protecting New Jersey's remaining populations. Both of the extant occurrences are in need of site visits to reassess the species' status and evaluate threats. Particular attention should be given to changes in the plant communities and opportunities for Red Goosefoot to establish at new locations in the vicinity. *Phragmites* was not cited as a concern for the occurrences in the past (NJNHP 2022) and if that continues to be the case more frequent monitoring could provide an opportunity to prevent its establishment and spread at sites where *C. rubrum* var. *rubrum* is present. However, care should be taken with the use of control measures for invasive plant species because Red Goosefoot is susceptible to growth regulator herbicides (Williams 1969).

Little can be done to stem the rising tides that comprise the primary threat to coastal populations of *Chenopodium rubrum* var. *rubrum*, and the long-term persistence of the species in the state is likely to depend on its capacity to colonize new sites as the coastline changes. While the species may be able to readily establish on fresh disturbances resulting from inland seawater incursions, its ability to disperse to those sites could be hampered by the extensive development that has taken place along New Jersey's shoreline. *C. rubrum* var. *rubrum* may be a species for which it is appropriate to consider assisted distribution, using seeds from extant plants to help the goosefoot become established in a more secure location.

Synonyms

The accepted botanical name of the species is *Chenopodium rubrum* var. *rubrum* L. Orthographic variants, synonyms, and common names are listed below (ITIS 2023, POWO 2023). A recent molecular study suggested that the genus traditionally recognized as *Chenopodium* consisted of six independent lineages so the group which included *C. rubrum* was reassigned to *Oxybasis* (Fuentes-Bazan et al. 2012). Consequently, the name *Oxybasis rubra* var. *rubra* is now coming into popular use (Kartesz 2015, Weakley et al. 2022, POWO 2023).

Botanical Synonyms	**Common Names**
Blitum acuminatum Schur	Red Goosefoot
Blitum maritimum Nutt.	Red Eurasian Goosefoot
Blitum polymorphum C. A. Mey.	Coast Blite
Blitum rubrum var. *hypoleucum* Speg.	Alkali Blite
Botrys succosus (A. Nelson) Lunell	
Chenopodium astracanium Ledeb.	
Chenopodium blitoides Lej.	
Chenopodium glaucum var. *rubrum* Klett & Richt.	
Chenopodium intermedium Mert. & W. D. J. Koch	
Chenopodium macrocarpum var. *elongatum* P. Y. Fu & W. Wang	

Chenopodium macrocarpum var. *microstachyum* P. Y. Fu & W. Wang
Chenopodium macrocarpum var. *rubrum* P. Y. Fu & W. Wang
Chenopodium matthioli Bertol. ex Moq.
Chenopodium patulum Mérat
Chenopodium pygmaeum Menyh.
Chenopodium rubrum var. *blitoides* (Lej.) Wallr.
Chenopodium rubrum var. *blitum* Mert. & W. D. J. Koch
Chenopodium rubrum var. *diffusum* Boenn.
Chenopodium rubrum var. *foliolosum* Wallr.
Chenopodium rubrum var. *glomeratum* Wallr.
Chenopodium rubrum var. *intermedium* (Mert. & W. D. J. Koch) Jauzein
Chenopodium rubrum var. *strictum* Boenn.
Chenopodium rubrum var. *vulgare* Wallr.
Chenopodium rubrum var. *zachae* F. Dvořák
Chenopodium succosum A. Nelson in Bot. Gaz. 34: 361 (1902)
Chenopodium urbicum var. *intermedium* (Mert. & W. D. J. Koch) W. D. J. Koch
Orthospermum acuminatum Schur
Orthospermum crassifolium Schur
Oxybasis rubra var. *intermedia* (Mert. & W. D. J. Koch) B. Bock & J.-M. Tison
Oxybasis rubra var. *rubra* (L.) S. Fuentes, Uotila & Borsch

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