Developing biogeographically based population introduction protocols for at-risk Willamette Valley plant species:

Agrostis howellii (Howell's bentgrass)
Aster curtus (white-topped aster),
Aster vialis (wayside aster),
Delphinium leucophaeum (hot rock larkspur),
Delphinium pavonaceaum (peacock larkspur),
Erigeron decumbens var. *decumbens* (Willamette daisy),
Horkelia congesta ssp. *congesta* (shaggy horkelia),
Lomatium bradshawii (Bradshaw's desert parsley),
Lupinus sulphureus ssp. *kincaidii* (Kincaid's lupine),
Montia howellii (Howell's montia),
Sidalcea spp. (Willamette Valley checkermallows)

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The following species are presented in alphabetical order: *Agrostis howellii* (Howell's bentgrass), *Aster curtus* (white-topped aster), *Aster vialis* (wayside aster), *Delphinium leucophaeum* (hot rock larkspur), *Delphinium pavonaceaum* (peacock larkspur), *Erigeron decumbens* var. *decumbens* (Willamette daisy), *Horkelia congesta* ssp. *congesta* (shaggy horkelia), *Lomatium bradshawii* (Bradshaw's desert parsley), *Lupinus sulphureus* ssp. *kincaidii* (Kincaid's lupine), *Montia howellii* (Howell's montia), *Sidalcea* sp. (Willamette Valley checkermallows). Each species' section consists of segments covering Conservation Status, Range and Habitat, Species Description, Seed Production, Seed Germination, Vegetative Reproduction, Breeding System, Hybridization, Cultivation, Transplanting and Introduction Attempts, Population Monitoring, and Land Use Threats and other Limitations, followed by a final segment outlining a specific Population Introduction/Augmentation Strategy.

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Developing biogeographically based population introduction protocols for at-risk Willamette Valley plant species:

Willamette Valley checkermallows

Sidalcea nelsoniana

Sidalcea campestris

Sidalcea cusickii

Willamette Valley checkermallows:
Sidalcea nelsoniana
Sidalcea campestris
Sidalcea cusickii

Conservation status

Primarily associated with the undeveloped remnants of prairies, wetlands, and edges of woodlands and riparian areas, *Sidalcea nelsoniana* (Figure 34), *S. campestris* (Figure 35), and *S. cusickii* (Figure 36) have all dwindled to an alarming paucity of mostly small, fragmented populations. Because these three members of the mallow family (Malvaceae) are very similar with regard to their ecology, life history, anthropogenic threats, and conservation needs, they are treated together in this chapter.

Figure 34. *Sidalcea nelsoniana*. (Photo by Steven Gisler.)

Figure 35. *Sidalcea campestris*. (Photo by Steven Gisler.)

Sidalcea nelsoniana is the rarest of this group of Willamette Valley checkermallows, and has been listed as threatened by the U.S. Fish and Wildlife Service and the State of Oregon. It is on the Oregon Natural Heritage Program List 1 (threatened or endangered throughout its range), and has a Natural Heritage Network Rank of G2/S2 (imperiled throughout its range/imperiled in Oregon) (ONHP 2001).

Figure 36. *Sidalcea cusickii*. (Photo by Steven Gisler.)

Remaining somewhat more common than its state- and federally-listed relative, *Sidalcea campestris* is listed as a Candidate species by the State of Oregon, but lacks federal conservation status. The species is on the Oregon Natural Heritage Program List 4 (of conservation concern but not currently threatened or endangered) and has a Natural Heritage Network Rank of G4/S4 (not rare, apparently secure throughout its range and in Oregon). Although *S. campestris* has been nearly extirpated from its former distribution in the central and northern Willamette Valley (Kemp et al. 1978, Jimmy Kagan, Oregon Natural Heritage Program, Portland, Oregon, personal communication, Gisler unpublished), there are still enough populations persisting in the southern half of its range (especially Lane, Linn, Benton, Polk, and southern Marion counties), such that the species does not yet meet state and federal requirements for listing as threatened or endangered. However, such an unfortunate meeting will likely take place soon if southern *S. campestris* populations continue to follow the fate of those to the north, with populations yielding to development, successional encroachment by trees and shrubs, and roadside maintenance activities.

Sidalcea cusickii currently has no designated federal or state conservation status, though it shares the same Oregon Natural Heritage Program and Natural Heritage Network ranks as *S. campestris*. Like the other Willamette Valley checkermallows, *S. cusickii* is primarily restricted to small, undeveloped native prairie remnants along roadsides in the southern Willamette Valley and interior valleys of the Rogue and Umpqua Rivers and their tributaries. Despite the lack of state and federal conservation status, *S. cusickii* is a very rare species occupying exceedingly vulnerable habitats. Relative to its two aforementioned congeners, the status of *S. cusickii* has been very poorly documented and this species has markedly fewer representative specimens in the OSU herbarium.

Together, the Willamette Valley checkermallows face overwhelming threats posed by widespread habitat loss to agricultural and urban development, and population displacement caused by invasive weeds and successional encroachment by trees and shrubs (Kemp et al. 1978, Siddall 1979, Scofield and Sawtelle 1985, ONRC 1986, Robinson and Parenti 1990, U.S. Fish and Wildlife Service 1993, 1998, ODA 1995, Gisler unpublished). Additional threats include pre-dispersal seed predation by weevils (U.S. Fish and Wildlife Service 1993, 1998, Gisler and Meinke 1997, 1998), and the potential threats of inbreeding depression and interspecific hybridization (Gisler 2003).

Because *Sidalcea campestris* and *S. cusickii* lack state and federal threatened and endangered species designations, there are no legal mechanisms in place for their mandated protection, regardless of the land ownership of their extant occurrences. In contrast, *S. nelsoniana* is legally protected on public lands by virtue of its formal listing as threatened, though many populations still lack protection on private lands, and most publicly owned populations continue to be threatened by lack of habitat management and other limitations that transcend land ownership boundaries (U.S. Fish and Wildlife Service 1993, 1998, Gisler and Meinke 1995).

The two overriding factors favoring the persistence and eventual recovery of Willamette Valley checkermallows are the occurrence of several large "stronghold" populations on public lands, and the very promising cultivation and re-introduction potential exhibited by all three species. *Sidalcea* recovery will ultimately hinge on the rapid implementation of large-scale habitat management and population re-introduction and enhancement projects, such as those outlined in U.S. Fish and Wildlife Service (1998), before additional extant populations experience further declines or extirpation.

Range and habitat

Collectively, the three checkermallow species treated in this chapter span the majority of western Oregon's interior valleys, ranging from Jackson County in the south to the Puget Trough of Washington in the north.

Sidalcea nelsoniana, the rarest and most thoroughly documented of the checkermallows, is currently known from approximately 65 sites, distributed from southern Benton County, Oregon, northward through the central and western Willamette Valley, to Cowlitz and Lewis Counties, Washington (City of McMinnville 1997, U.S. Fish and Wildlife Service 1998, ONHP 2002). Additionally, this species occurs in several higher elevation Coast Range meadows that flank the western Willamette Valley in Yamhill, Washington, and Tillamook Counties, Oregon. Known populations range in elevation from 145-1,960 ft.

Although *Sidalcea campestris* and *S. cusickii* are by no means common within their respective geographic ranges, to date their populations have proven too numerous and poorly documented to reliably quantify and track in a database. Both species are limited to Oregon, and the majority of remaining populations, albeit fairly numerous (relative to some other western Oregon endemics), are extremely small, containing fewer than a hundred individuals (Gisler unpublished). The range of *Sidalcea campestris* essentially overlaps the Willamette Valley and Coast Range distribution of *S. nelsoniana*, though it is not known to extend across the Columbia River into Washington. *Sidalcea campestris* also extends beyond the range of *S. nelsoniana* into Lane County to the south, and across the Willamette Valley into the foothills of the Western Cascades.

Sidalcea cusickii has the most southerly range of the species group, extending from Jackson, Coos, and Douglas Counties in southern Oregon, northward to the southern end of Linn and Benton Counties. Interestingly, the northernmost extent of *S. cusickii*'s distribution in Benton County precisely coincides with the southernmost extent of *S. nelsoniana*'s distribution, rendering the two species narrowly parapatric, but non-overlapping (Gisler 2003).

Habitats occupied by these three Willamette Valley checkermallow species are very similar, consisting of grasslands (wet and dry prairie), wetlands, and edges of woodlands and riparian areas, frequently existing as small habitat remnants located along roadsides (Figures 37 and 38). OSU herbarium specimen labels variously describe these habitats as: "dry prairies," "grassy fencerows," "moist, open ground and thickets," "overgrown drainage ditches," "roadside ditch with tall grasses," "wet, grassy openings along right-of-ways," "lightly wooded ash swales," and "moist flats with adobe soil." Although these species tend to occupy sites that are relatively undisturbed, such as parks and wildlife refuges and the undeveloped margins of fields and roads, all three species nevertheless appear capable of colonizing (or at least persisting within) some disturbed sites (City of McMinnville 1986, Halse and Glad 1986, Glad et al. 1994). It is uncertain, however, to what degree seedling recruitment occurs in weedy sites, and how long populations can persist under such conditions after mature plants with large, established root systems die.

Of the three species, *Sidalcea nelsoniana* tends to occupy the wettest habitats, with *S. cusickii* and *S. campestris* usually preferring slightly drier (but still seasonally wet), more upland habitats (Gisler unpublished). However, there are numerous exceptions to this generalization, and *S. campestris* co-occurs with both species (independently) in several locations, reflecting the breadth and overlap of habitat tolerances in the group (Gisler 2003).

Glad et al. (1994) reported 111 species associated with *Sidalcea nelsoniana*, about half of which were non-native. Some of the species most commonly associated with *S. nelsoniana* and the other two Willamette Valley checkermallows include: *Achillea millefolium*, *Agrostis tenuis*, *Alopecuris pratensis*, *Arrhenatherum elatius*, *Brodiaea hyacinthina*, *Carex* spp., *Cirsium* spp., *Chrysanthemum leucanthemum*, *Crataegus* spp., *Dactylis glomerata*, *Daucus carota*, *Deschampsia caespitosa*, *Equisetum arvense*, *Festuca arundinaceae*, *Fragaria virginiana*, *Fraxinus latifolia*, *Galium aparine*, *Geum macrophyllum*, *Heracleum lanatum*, *Holcus lanatus*, *Hordeum brachyantherum*, *Hypericum perforatum*, *Hypochaeris radicata*, *Juncus* spp., *Lotus corniculatus*, *Lupinus polyphyllus*, *Madia sativa*, *Parentucellia viscosa*, *Phalaris arundinaceae*, *Prunella vulagris*, *Pteridium aquilinum*, *Quercus garryana*, *Rubus* spp., *Rosa* spp., *Spiraea* douglasii, *Symphoricarpos albus*, *Vicia* spp., (Kemp et al. 1978, Siddall 1979, Halse and Glad 1986, U.S. Fish and Wildlife Service 1993, 1998, Gisler and Meinke 1995, ONHP 2002, OSU herbarium specimen label information).

Figure 37. Roadside prairie remnant occupied by *Sidalcea campestris* (linear band of white flowers along fencerow) near Lebanon in Linn County, Oregon. (Photo by Steven Gisler.)

Figure 38. *Sidalcea nelsoniana* (pink flowers) occupying a narrow strip of undeveloped prairie habitat between a county road and a grass seed field south of Philomath in Benton County, Oregon. (Photo by Steven Gisler.)

As indicated by the preceding paragraph, Willamette Valley checkermallow species are frequently associated with various trees, especially *Fraxinus latifolia* and *Quercus garryana*. These trees frequently occur as small woodlands, with checkermallows typically occupying small clearings and edges with fairly open canopies. Although *Sidalcea* species are sometimes found under closed canopies, they frequently become etiolated under such conditions and it is uncertain how long they can persist in the shade. It is likewise unknown if these shaded plants colonized habitats that were originally wooded, or if they pre-date canopy closure and simply persist in areas that have become overgrown by trees and shrubs through successional encroachment of previously open habitat. Such encroachment is considered a primary threat to the species (see "Conservation status," above).

Soils found in habitats occupied by Willamette Valley *Sidalcea* species are variable, ranging from gravelly, well drained loams, to poorly drained, hydric clay soils (City of McMinnville 1986, Glad et al. 1994). Generally, all three species are found in soils that become saturated during the rainy season, with *Sidalcea nelsoniana* frequently becoming inundated for several weeks or longer. *Sidalcea campestris* and *S. cusickii* also grow in areas of standing water at some sites, though in general their habitats remain slightly drier throughout the year than those occupied by *S. nelsoniana* (Gisler unpublished).

Species description

Willamette Valley checkermallows are herbaceous perennials arising from stout, often somewhat rhizomatous and laterally spreading rootstocks that can form multiple crowns. All three species produce numerous, erect inflorescences ranging from 5 to 15 decimeters in height. Basal leaves are palmately lobed, with upper leaves and stem leaves becoming deeply divided. Stem and leaf pubescence traits vary between species, with *S. cusickii* typically having essentially glabrous stems and upper leaf surfaces, *S. campestris* typically having forked (or long simple and forked) stem hairs and densely hairy upper leaf surfaces, and *S. nelsoniana* usually exhibiting sparse, short simple stem and upper leaf surface hairs. All three species produce fruits that are 7-9 seeded schizocarps, with single-seeded, beaked carpels that form a ring, like the segments of an orange. Carpels separate at maturity and simply fall from the parent plant. Flowers vary considerably in size within species due to sexual dimorphism, with the larger flowers formed on hermaphroditic individuals and smaller flowers formed on female (male-sterile) individuals. Although flower color can vary dramatically within species (Gisler 2003), flower color is *usually* white to very pale pink in *S. campestris* and pink to rose in *S. nelsoniana* and *S. cusickii*. For further descriptive information see Hitchcock and Kruckeberg (1957), Peck (1961) and Halse et al. (1989).

Because of pronounced intraspecific variability, it can be very difficult to delimit Willamette Valley checkermallow species using single morphological traits. Instead, accurate identification often rests on a combination of characters. In general, *S. cusickii* can usually be discerned from its congeners by its glabrous (and typically non-glaucous) stems and leaves, dark pink flowers (though some populations contain white to pale pink flowers), sepals that are frequently widened above the base (and purple-tinged) before they taper to a point, bluntly terminated inflorescences (rather than tapered to a point) when in bud, and by its more southerly geographic distribution (see "Range and habitat," above). *Sidalcea campestris* can usually be recognized by its white flowers (though some populations contain darker pink flowers), stem hairs that are typically long, dense, and forked (or simple and forked together), and basal leaves that are often more deeply dissected than those of the other congeners. *Sidalcea nelsoniana* typically has glaucous stems, pink flowers (though sometimes very pale pink to white in some populations in the southern portion of its range), sparse and short-simple stem and upper leaf pubescence, and a distribution entirely north of southern Benton County. *Sidalcea nelsoniana* and *S. cusickii* are the two most difficult species to distinguish from one another, though fortunately they are not known to overlap in the wild (Gisler unpublished).

Besides the checkermallows treated in this chapter, there is one other *Sidalcea* species occurring in the Willamette Valley, *S. virgata* (Figure 39). This species can be distinguished from its congeners by its more decumbent and rhizomatous habit, stellate stem pubescence, shorter flowering stems, sparser inflorescences, longer sepals that are rolled along the margins, and an earlier phenology (flowering is usually completed by early June, when the other congeners are just starting to flower) (Gisler 2003 and unpublished).

Figure 39. *Sidalcea virgata*, another species of checkermallow that occurs in the Willamette Valley. (Photo by Steven Gisler.)

Seed production

With their large floral displays and multi-carpeled fruits, Willamette Valley checkermallow species are prolific seed produces. Gisler and Meinke (1998) surveyed seed production in 20 *Sidalcea nelsoniana* populations and estimated mean seed production at 5.18 seeds per fruit (which equated to about 65 percent of available ovules). This rate was essentially equivalent to seed set levels achieved through controlled crosses using large pollen loads in the greenhouse, which yielded a mean 5.26 seeds per fruit, suggesting that individuals in the wild are neither pollen nor resource limited in terms of seed production. Analysis showed that rates of ovule conversion to filled seeds did not differ significantly between the 20 study populations, though rates of seed loss to pre-dispersal predation by weevils (ranging from 0-100 percent seed loss) did exhibit significant differences between populations.

A later study (Gisler and Meinke 2001a) showed that seed losses to pre-dispersal predators can be significantly reduced through the use of a synthetic pyrethroid insecticide applied early in the flowering season. If insecticides are utilized to reduce seed predation, then total plant seed yields can be directly estimated by multiplying seed average set rates by the number of fruits (because deductions need not be made to account for seed losses to pre-dispersal predation). Typical *Sidalcea* plants produce 30-100 or more fruits per multi-racemed inflorescence, with individuals frequently producing 10-30 or more inflorescences. As such, a typical checkermallow individual could be expected to produce as many as 1,500-15,000 seeds per year in the absence of seed predation or other reproductive constraints (i.e., herbivory, severe drought conditions, or disease). Thus, a population containing a mere 50 individuals could ostensibly produce 750,000 or more seeds in a single season.

One important caveat associated with weevil control practices, however, is that the weevil species (Figure 40) infesting Willamette Valley checkermallows are native, are specific to Pacific Northwest *Sidalcea* species, and host an unidentified species of parasitic wasp (Gisler and Meinke 1998, 2001a). As such, weevil control activities could have unintended and undesirable consequences to the conservation status of these native organisms, which may be equally as rare, or *more* rare, than their host plants.

Figure 40. Adult weevil (*Macrorhoptus Sidalcea*) emerging from a carpel of *Sidalcea nelsoniana*. This weevil species is only known from *S. nelsoniana* and its rare coastal relative, *S. hendersonii*. Weevils dramatically reduce seed survival in some *S. nelsoniana* populations. (Photo by Steven Gisler.)

Levels of seed production in *Sidalcea campestris* and *S. cusickii* are commensurate with those stated above for *S. nelsoniana*, ranging from 60-70 percent of available ovules (Gisler 2003 and unpublished). In the wild, this species pair has an advantage over *S. nelsoniana*, insofar that they both (particularly *S. cusickii*) generally suffer much lower levels of pre-dispersal seed predation by weevils (Gisler and Meinke 1997 and unpublished).

Seed germination

With the exception of germination trails performed on *Sidalcea cusickii* by Guerrant and Raven (1995), which yielded rather low germination rates of 10.4-34.8 percent under a variety of environmental conditions, all other data suggest that seeds of Willamette Valley checkermallows exhibit high levels of viability and germination. The apparent key to seed germination in these species (a key not utilized in the *S. cusickii* trials discussed above) is seed coat scarification. As reported by the City of McMinnville (1986)(also reported in Halse and Mishaga 1988), seed germination in *S. nelsoniana* ranged from 43-100 percent following seed coat penetration with a needle probe, whereas non-scarified seeds exhibited less than 13 percent germination. Seed germination was not significantly affected by light and dark conditions, though it was affected by level of seed maturity; lower seed germination levels were associated with immature seeds that had greenish colored seed coats at the time of collection, whereas higher germination rates were associated with mature seeds with dark brown seed coats.

The efficacy of seed coat scarification on *Sidalcea* germination was also demonstrated by Gisler (2003), who scarified seed coats with 120 grit sandpaper and reported 97 percent seed germination in *S. cusickii*, 73 percent germination in *S. campestris*, and 90 percent germination in *S. nelsoniana.* Seed germination in all three species occurred in a single flush, within 2 weeks of imbibition. This rapid pace of seed germination helps mitigate the potentially adverse impacts of mold growth, which commonly accompanies *Sidalcea* seeds after they become wet and might otherwise become problematic for more slowly germinating seeds (Gisler unpublished). Mold growth was also noted as a potential problem by the City of McMinnville (1986), but was minimized by rinsing seeds in a dilute bleach solution.

Seed scarification, accompanied by cold stratification, also yielded high germination rates during a large-scale *Sidalcea nelsoniana* cultivation project performed by Lynda Boyer (Heritage Seedlings Inc., Salem, Oregon, personal communication). According to Boyer, nearly 100 percent germination was achieved by treading and "doing the twist" on seeds, and then mixing the scarified seeds with pre-moistened vermiculite inside sealed plastic bags and cold stratifying the mixture at 1°C for 11 weeks. This seed/vermiculite mixture was then sown into soil-filled flats, lightly covered with a "light dusting of soil," and germination typically occurred within 7 days of sowing.

Vegetative reproduction

Willamette Valley *Sidalcea* species are all apparently capable of some degree of vegetative expansion via rhizomes and/or laterally spreading root systems that form multiple crowns bearing distinct clusters of flowering stems (Figure 41)(City of McMinnville 1986, U.S. Fish and Wildlife Service 1993, 1998, Glad et al. 1994, Gisler and Meinke 1998, Guerrant 1998). This tendency for rhizomatous/lateral growth has resulted in substantial confusion regarding development of appropriate monitoring methodologies and the identification of "genetic individuals" in *Sidalcea nelsoniana* (Guerrant 1998). Traditionally, this complication has been dealt with by assigning all clusters of stems within an occupied square meter of habitat as an individual (City of McMinnville 1986, Glad et al. 1994, U.S. Fish and Wildlife Service 1993, 1998), though in most cases stem clusters that appear distinct are probably indicative of physiologically (if not genetically) distinct individuals (City of McMinnville 1986).

Figure 41. Spreading rhizomes of *Sidalcea nelsoniana*, shown from the Oregon Coast Range, where the species tends to have a more rhizomatous habit than in the Willamette Valley portion of its range. (Photo by Steven Gisler.)

For the most part, the three *Sidalcea* species treated in this manual tend not to actively form new shoots *per se* through rhizomatous growth. According to the City of McMinnville (1986), "*Sidalcea nelsoniana* rhizomes are more likely to reproduce vegetatively through breaking, with the broken-off part being moved away from the parent plant, than they are by sending out long rhizomes that give rise to new plants." The only Willamette Valley checkermallow species that demonstrates a strong tendency for developing new sprouts via long, spreading rhizomes is *S. virgata* (Gisler unpublished). It is currently unknown to what extent population maintenance in Willamette Valley checkermallows is dependent upon asexual expansion versus sexual reproduction.

One conservation benefit offered by the clonal nature of these *Sidalcea* species is that they readily lend themselves to the rapid increase of propagated through divisions. In greenhouses at OSU, the authors were able to obtain flowering individuals of all three species from divisions within two months of planting. These divisions, in turn, grew rapidly and soon lent themselves to repeated divisions, thus yielded additional propagated stock. Similarly, divisions have been successfully utilized to increase *Sidalcea* stock for on-site wetland and prairie restoration purposes by Ted Gahr (Gahr Farm, McMinneville, Oregon, personal communication) in Yamhill County. As will be discussed later, however, the use of divisions in propagation and re-introduction work should be undertaken with some restraint in order to discourage low genetic variability and skewed sex ratios in introduced or augmented populations. Instead, propagation via clonal divisions should be undertaken in concert with cultivation from seeds, the latter encouraged by high seed set and germination rates (see “Seed production” and “Seed germination,” above).

Breeding system

The genus *Sidalcea* is characterized by a gynodioecious breeding system, whereby individuals can either be hermaphroditic (bearing exclusively perfect flowers with both male and female sex organs) or female (bearing exclusively male-sterile flowers). Because female flowers produce no pollen, they require insect-mediated outcrossed pollen in order to produce seeds. Although hermaphroditic flowers produce pollen, within-flower self-fertilization (auto-autogamy) is discouraged by protandry, whereby pollen dehisces 2-3 days prior to stigma emergence and receptivity. However, Willamette Valley species of *Sidalcea* are self-compatible, and self-fertilization can still occur (and probably occurs quite frequently) in hermaphroditic plants through pollen transfer between flowers of the same individual (i.e., geitonogamy) (Gisler and Meinke

1998, Gisler 2003). It is currently unknown to what extent progeny from female individuals might exhibit increased fitness over those from hermaphrodites, through greater heterozygosity (due to mandatory outcrossing). Likewise, it is unknown if progeny from females might also experience higher quality and fitness if maternal individuals allocate resources to seed production that are saved through production of smaller flowers and lack of pollen production.

Although female individuals require co-occurring hermaphroditic individuals in order to receive pollen and produce seeds, there is no evidence that female-biased population structures lead to reduced seed set caused by pollen limitation (Gisler and Meinke 1998). However, lone female individuals lacking hermaphroditic pollen sources will not produce seeds, as these species show no evidence of apomixis, or seed production in the absence of fertilization (Gisler 2003). This means that population introduction projects should include a mixture of female and hermaphroditic individuals, to ensure seed production. However, this mixture may be weighted towards female individuals without apparent undue consequences to seed yields. Most *Sidalcea nelsoniana* populations in the Willamette Valley have female-dominated sex ratios, whereas females in Coast Range populations are usually outnumbered by hermaphroditic individuals (Gisler and Meinke 1995).

Willamette Valley checkermallows produce showy floral displays and attract an impressive abundance and diversity of insect visitors. Gisler (2003) inventoried pollinators at over 25 populations of each checkermallow species in the Willamette Valley and identified over 17 species of bees, 3 species of wasps, 9 species of flies, 6 species of beetles, and 5 species of lepidopterans. Three species of bumblebees (*Bombus californicus*, *B. sitkensis*, and *B. vosnesenskii*) were the most common and active pollinators of the checkermallows, though solitary bees in the families Anthophoridae, Halictidae, and Megachilidae were also significant visitors. One interesting finding was the occurrence of *Diadasia nigrofrons* (Anthophoridae)(Figure 42) on all three *Sidalcea* species. This native bee is a specialist on *Sidalcea* in the Willamette Valley, so its status is intimately tied to the occurrence and survival of its sole host/forage species. In contrast, given the role of Willamette Valley checkermallows as “cornucopia” species, attracting large and diverse assemblages of bees, there is little reliance of *Sidalcea* species to one particular taxon or group of pollinators, and thus little vulnerability to pollinator limitations.

Figure 42. *Diadasia nigrofrons*, a native bee specializing on species of *Sidalcea* for nectar and pollen forage in the Willamette Valley. (Photo by Steven Gisler.)

Gisler (2003) also noted that insect visitors will, if given the opportunity, transfer pollen indiscriminately between *Sidalcea* species, leading to interspecific pollen flow and the possibility for interspecific hybridization (see “Hybridization,” below).

Hybridization

Because of their frequent co-occurrence in the wild, and the appearance of morphologically intermediate *Sidalcea* individuals and populations, there has long been speculation about the occurrence of hybridization between Willamette Valley checkermallow species. The risk of hybridization in this species group would seem to be high, given risk factors identified by Gisler (2003) that are believed to promote interspecific hybridization, including: demonstrated sexual compatibility between other members of the genus (i.e., Hitchcock and Kruckeberg 1957), sympatry of potential interspecific mating partners, human-mediated dispersal of Willamette Valley checkermallow species (through horticultural, agricultural, and restoration practices), ubiquity of disturbances that promote habitat homogenization and the creation of novel microsites for hybrid colonization, outcrossing mating systems, and the ability to spread vegetatively (thus promoting hybrid establishment, even if they prove sexually sterile).

Based upon investigations of pre- and post-mating reproductive isolating mechanisms, interspecific crossing experiments, and chromosome counts, Gisler (2003) showed that *Sidalcea campestris* is largely reproductively isolated from its Willamette Valley congeners by genetic/chromosomal incompatibilities (it is a hexaploid, whereas *S. nelsoniana* and *S. cusickii* are both diploid). However, although hybridization involving *S. campestris* is therefore unlikely in the wild, it is not entirely impossible, as evidenced by a few tetraploid hybrids were successfully created through artificial crosses in the greenhouse. *Sidalcea nelsoniana* and *S. cusickii* have a very strong potential for hybridization, insofar that they share many pollinators, overlap in flowering time, and are completely sexually interfertile in the greenhouse, yielding fertile diploid hybrids. The one important obstacle to hybridization in this species pair is geographical separation; as mentioned earlier, the respective geographic ranges of these two species are currently separated by about 3 km in southern Benton County, near the southern boundary of Finley National Wildlife Refuge. This separation appears to preclude the potential for interspecific pollen flow and hybridization between *S. nelsoniana* and *S. cusickii*.

According to Gisler (2003), all three *Sidalcea* species treated in this manual share pollinators and geographic distributions with a fourth Willamette Valley checkermallow species, *S. virgata*. Hybridization is discouraged with *S. virgata*, however, by its flowering time, which begins much earlier than the other local checkermallows and generally comes to an end just as the remaining checkermallow species are beginning to flower. Moreover, the tetraploid nature of *S. virgata* serves as another obstacle to hybridization with its diploid and hexaploid relatives. Crosses between these species yielded only occasional hybrids, and these were sterile. Nevertheless, because of their strongly clonal nature, sterile hybrids could still become established and pose a potential threat to parental species. Likewise, fertility could potentially be regained in these sterile hybrids through backcrossing and/or chromosome doubling events. Polyploidy within *S. virgata*, yielding both diploid and tetraploid cytotypes, may further influence the likelihood of hybridization if seasonal timing barriers are disrupted through random climatic events or human interference.

The main lesson from the findings by Gisler (2003) appears to be that current pre- and post-mating attributes serve to discourage hybridization among the Willamette Valley checkermallows, but great care should be taken to prevent anthropogenic dispersal of these taxa beyond their current distributions, lest hybridization potentially ensue. Likewise, *Sidalcea* species should not be grown close together for cultivation purposes, as this could promote the kind of artificially enhanced interspecific pollination events that can overcome crossing barriers and lead to hybrid formation. This danger is especially pronounced between *S. cusickii* and *S. nelsoniana*, which are fully interfertile.

Cultivation

Willamette Valley checkermallow species lend themselves to successful cultivation in the greenhouse and outdoor beds. The authors have obtained large, multi-stemmed, flowering *Sidalcea* individuals (of all three species) as rapidly as within 2 months of planting using divisions, and within 3 months using seeds, when they are supplied with ample light, warm temperatures, irrigation, and fertilization (Gisler unpublished). The authors observed no evidence that *Sidalcea* requires unique soil mixtures, symbionts, or other specialized conditions for vigorous growth under cultivation, though it was noted that these species are highly susceptible to white flies, and to a lesser extent to other greenhouse pests, including aphids and spider mites. Despite these pests, *Sidalcea* survival was extremely high under cultivation, with the major source of mortality (usually less than 5 percent) attributable to damping-off fungal infections that killed young seedlings within the first two weeks after emergence (Gisler unpublished).

Other reports of successful *Sidalcea* cultivation have come from the City of McMinnville (1986), who cultivated 1,370 seedlings and noted that although plants grew faster and larger in a warmer (22°C day/18°C night) greenhouse room than in a cooler (18°C day/16°C night) greenhouse room, those from the cooler greenhouse experienced fewer setbacks (i.e. basal leaf die-back) upon placement in outdoor cold frames. Large-scale cultivation of *S. nelsoniana* was also reported by L. Boyer (personal communication), who mixed seeds with pre-moistened vermiculite and cold stratified (at 1°C) the mixture inside sealed plastic bags for 11 weeks. This seed/vermiculite mixture was then sown into flats filled with a planting medium consisting of bark, compost, peat, perlite, and Philip's pre-mix (crabmeal, 3 kinds of lime, micronutrients, Actino-iron, and a wetting agent). Following establishment in flats, seedlings were transplanted into 5 inch x 2 3/8 inch pots, and later moved into large, outdoor beds. Boyer reported very high (nearly 100 percent) rates of seedling establishment, yielding fast-growing, "healthy and happy" plants. These cultivated individuals will be used to augment *Sidalcea nelsoniana* populations located at Baskett Slough National Wildlife Refuge (Jock Beall, Finley National Wildlife Refuge, Corvallis, Oregon, personal communication).

Cultivation of Willamette Valley checkermallows can also be successfully undertaken using large-scale "farming" techniques. One private grower, Peter Kenagy (Kenagy Family Farms near Albany, Oregon), is performing a grow-out of *Sidalcea campestris* and *S. cusickii* for purposes of supplying seeds for restoration on BLM and other public lands near Eugene. Here, thousands of seeds of both species were fall seeded using a seed drill (drilled to half an inch deep or less), into ground that was pre-fumigated to reduce competitive pressure from weeds. Although seeds were sown without any form of pre-treatment, such as scarification or stratification, excellent rates of germination and establishment were reported. Likewise, plant survival and fecundity was very high, despite the lack of any supplemental irrigation or fertilization (Peter Kenagy, Kenagy Family Farms, Albany, Oregon, personal communication).

In summary, Willamette Valley checkermallows are very easy to grow, and can be successfully cultivated under a variety of indoor and outdoor conditions. The ease of cultivation may be one reason why these species are available in local nurseries, have already been used in numerous habitat and population restoration projects, and are present in private gardens throughout the Willamette Valley (Gisler unpublished).

Transplanting and introduction attempts

Although Willamette Valley checkermallows have no doubt been transplanted for horticultural/gardening purposes for many years, the earliest documented efforts to transplant these *Sidalcea*s for conservation-related purposes was reported by the City of McMinnville (1986). Here, to investigate the transplant potential of *Sidalcea nelsoniana*, six rhizomes from the Oregon Coast Range were transplanted to a new site in 1985, yielding "vigorous plants." Based upon this initial success, 200 rhizomes were excavated and transplanted to several new locations in 1986. After 11 years, survival of the transplanted rhizomes was reported as 87 percent (City of McMinnville 1997), though subsequently some plants were apparently lost due to inundation caused by beaver dams (Guerrant 1998).

Transplanting of *Sidalcea nelsoniana* has also been undertaken at Finley National Wildlife Refuge. Here, *S. nelsoniana* rhizomes were excavated from two sites occurring on water retention dikes slated for potentially destructive management activities, and were transplanted into more secure locations. One target location was a wet swale already occupied by *S. nelsoniana*, and another site was a former agricultural field undergoing restoration to native prairie. At one of the rhizome source sites, *S. nelsoniana* was excavated by hand, using shovels, whereas the other source site utilized a mini excavator to remove rhizomes and their surrounding sod layer. Transplanted rhizomes were watered several times during the first year to aid establishment, and survival of transplants has been "very high," with 23 of 24 still alive at one target site (J. Beall, personal communication). Interestingly, excavation of *S. nelsoniana* rhizomes with shovels apparently did not result in *complete* rhizome removal from one source site at the Refuge, as new plants were later observed re-sprouting from their former locations over subsequent years, essentially resulting in a doubling of the total number of individuals from the site.

In addition to transplanting checkermallows from one "natural" site to another, they can also be introduced from cultivation into the wild. Such methods were performed for *Sidalcea nelsoniana* by the City of McMinnville, whereby 1,370 cultivated seedlings were introduced into six new sites (City of McMinnville 1986). Eleven years after transplanting, 58 percent of introduced seedlings from 1986 survived (City of McMinnville 1997). Transplanting cultivated plugs into the wild was also reported by Gisler and Meinke (2001b). Here, 300 *Sidalcea nelsoniana* were cultivated in gallon size pots to a large, flowering size in the greenhouse, and then introduced into three sites in Yamhill County near McMinnville (Figure 43). Despite unusually droughty conditions, which severely limited soil moisture availability at the introduction sites, survival after one growing season was 100 percent at two sites, and 93 percent at the third site (this lower survival was probably due to intensive competition with dense growths of invasive weeds). Most introduced plants flowered during their first year at all three sites, and some seedling recruitment was observed during the second year (Kathy Pendergrass, U.S. Fish and Wildlife Service, Portland, Oregon, personal communication). Additional *S. nelsoniana* introductions also took place at a fourth site, located at a city park in Corvallis. Here, 125 of 130 introduced individuals survived and flowered after two years, and some new seedlings have been observed at this introduction site as well (Gisler unpublished).

Although introduction of *Sidalcea* species is probably most effectively and successfully performed using cultivated plugs, they can also be introduced using seeds. Clark et al. (2001) reported seeding of *Sidalcea campestris* at the Danebo Wetland in Eugene, Oregon. Here, 150 seeds were sown, with 0.3 percent establishment in burned plots and 1.9 percent establishment in the unburned plots. In a previous study (Clark and Wilson 2000), establishment of *S. campestris* from seed was similar, with 1.7 percent in the burned plots and 2.1 percent in unburned plots. Clark et al. (2001) also reported sowing of *S. cusickii* seeds. For this species, 120 seeds were sown, with 3.3 percent establishment in burned plots and 4.3 percent germination in unburned plots.

Figure 43. *Sidalcea nelsoniana* introduction project in Yamhill County. Plugs were planted into 10 meter x 10 meter grids, with plugs spaced 1 meter apart, to facilitate recognition and relocation of individuals over time. (Photo by Steve Gisler.)

Population monitoring

The most intensive and consistent population monitoring for *Sidalcea* has been carried out at the Walker Flat population of *S. nelsoniana*, located in the Coast Range of western Yamhill County, Oregon. Portions of this population have been monitored annually since the mid 1980's, including areas owned by the City of McMinnville and adjacent areas owned by the Salem District BLM. Because this population is so large, monitoring has typically consisted of various approaches to either detect relative changes in *S. nelsoniana* frequency within random sampling plots (Guerrant 1998), or estimate overall population size based upon random, stratified sampling within fixed grids (City of McMinnville 1997).

Although such statistically intensive sampling procedures are probably necessary to identify demographic changes in large populations like Walker Flat, most *Sidalcea* populations are fairly small, generally containing fewer than 100 individuals, and therefore lend themselves to monitoring through simple censusing. Regular censusing has been performed for many *Sidalcea nelsoniana* populations by the City of McMinnville since 1985 (City of McMinnville 1997), providing a general picture of populations trends over time. The primary complication to direct census methods is the tendency for some *Sidalcea* individuals to exhibit vegetative (clonal) spread via rhizomes or laterally spreading root systems (see "Vegetative reproduction," above). This complication has traditionally been dealt with by considering all flowering stems within 1 square meter as a single individual, unless both female and hermaphroditic plants are present, in which case both sexes are counted as separate individuals (since individuals are either exclusively female or hermaphroditic) (City of McMinnville 1997). However, for the most part even closely spaced individuals can be recognized by the spatial distinctness of their clustered stems, a trend supported by rhizome excavations performed by the City of McMinnville (1986).

Given the aforementioned monitoring difficulties inherent among closely spaced individuals, population introductions should probably be performed in such a way that introduced plugs can be discerned and re-located over time. Therefore, if space and other environmental constraints of introduction sites allow, plugs should be widely spaced (at least one meter apart) when planted into the ground. Although such widely spaced individuals may eventually grow closer together over time, this spacing will at least initially offer several years of relatively easy monitoring to measure survival rates and transplant performance. Such measures were taken during introductions of *Sidalcea nelsoniana* in Yamhill County by the Oregon Department of Agriculture, in cooperation with the Natural Resource Conservation Service and U.S. Fish and Wildlife (Gisler and Meinke 2001b). Here, transplants were introduced into three different sites within 100 meter square grids, with each square meter occupied by a single transplanted plug (Figure 43, above). The spacing of plugs not only facilitated recognition of individuals, but the regular placement of transplants within the grid also made it easier to re-locate and track individuals using meter tapes and x-y coordinates.

Land use threats and other limitations

As briefly discussed in "Conservation status," above, Willamette Valley checkermallow species uniformly face serious threats posed by urban and agricultural development, ecological succession that results in shrub and tree encroachment of open prairie habitats, and competition with invasive weeds (Kemp et al. 1978, Siddall 1979, Scofield and Sawtelle 1985, ONRC 1986, Robinson and Parenti 1990, U.S. Fish and Wildlife Service 1993, 1998, ODA 1995, Gisler unpublished). Additional threats include pre-dispersal seed predation by weevils (U.S. Fish and Wildlife Service 1993, 1998, Gisler and Meinke 1997, 1998), and the potential threats of inbreeding depression, due to small population sizes and habitat fragmentation, and interspecific hybridization (Gisler 2003).

Fortunately, although many checkermallow populations face uncertain long-term fates, especially those on private lands that are not regulated by state and federal endangered plant laws, there are several *Sidalcea nelsoniana* and other congener populations that occur on public and other protected lands. For instance, large *S. nelsoniana* and *S. campestris* populations occur within National Wildlife Refuges, Oregon Department of Fish and Wildlife Areas, several city and county parks, and Oregon Department of Transportation lands. Both *S. campestris* and *S. cusickii* also have large populations on lands owned by the West Eugene Wetlands Program, The Nature Conservancy, and the Eugene District BLM. Therefore, while population losses on private lands still constitute one of the most pressing threats to these species, their occurrence on public lands simultaneously offers great optimism for their conservation and recovery. However, these conservation goals will hinge on actual implementation of habitat management and population enhancement projects. Without such real implementation, the threats that transcend land ownership (i.e., invasive weeds, successional encroachment, seed predation, hybridization, deer herbivory, etc.) may still pose irreversible threats to even these publicly protected populations.

Population introduction/augmentation strategy

Based upon the biogeographical data compiled and described above for the Willamette Valley checkermallows, there are no significant ecological, life history, or administrative obstacles to the successful implementation of population introduction and augmentation projects for these rare species. Many of the known extant *Sidalcea* populations occur on public ownerships so, pending interagency cooperation and funding availability, sites should be available for collection of seeds for use in off-site cultivation, and locations should also be available for population augmentation and introduction purposes. The primary environmental constraint to these much-needed conservation projects is the proliferation of invasive weeds, which already poses a serious threat to the majority of existing populations. However, non-weedy sites still remain in many "natural" areas within these species' current ranges, so high quality sites should still be available for introduction projects.

Willamette Valley *Sidalcea* species produce ample supplies of seeds (despite pre-dispersal seed predation), and seeds exhibit high levels of germination following seed coat scarification (see "Seed germination," above). Following germination, seedlings exhibit no specialized growth or symbiont requirements, and it is possible to cultivate the species to a reproductively mature stage within as little as three months in the greenhouse (see "Cultivation," above). Willamette Valley *Sidalcea* species can also be very successfully propagated by rhizome cuttings, such that propagation stock can be repeatedly divided (in the greenhouse or even in the wild) to increase the quantity of stock for population enhancement and introduction projects.

Although sowing seeds directly into field plots has not proven an effective means of establishing new checkermallow populations, cultivated plugs and rhizomes have repeatedly demonstrated very high levels of survival and establishment when placed in the field, even when placed into marginal-appearing habitats. This trend suggests that the large-scale population introduction and enhancement projects needed for recovery should both feasible and successful.

One factor that should be considered a potential complication to Willamette Valley *Sidalcea* introduction projects is interspecific hybridization. Evidence suggests that *S. nelsoniana* and *S. cusickii* are completely interfertile and are only reproductively isolated by the current geographic separation of their respective ranges (their ranges are parapatric, meeting in southern Benton County, Oregon) (Gisler 2003). Although crossing barriers exist that discourage hybridization between the other checkermallow species (i.e., *S. campestris* and *S. virgata*) in the Willamette Valley, these barriers could potentially be disrupted by anthropogenic dispersal events. As such, to avoid problems associated with hybridization, population introduction target sites should be carefully selected in areas located strictly within each species' current range and habitat type, and inventories should be performed to ensure the absence of other congeners within project target areas. Likewise, *Sidalcea* species should not be cultivated closely together for population introduction and enhancement projects, to minimize opportunities for interspecific gene flow and hybridization.

Based upon this information, the following step-down procedures are recommended for Willamette Valley checkermallow population introductions:

1. <u>Select population introduction/enhancement target sites</u>. Several primary factors should be considered when selecting target sites for *Sidalcea* population introduction and enhancement projects. First, target sites should obviously contain suitable *Sidalcea* habitat, which can range from wetlands and riparian areas to dry uplands and edges of coniferous forests. To assist in identification of suitable habitat, extant *Sidalcea* populations in the vicinity of target sites should be visited to obtain familiarity with potential species' adaptations to various local environmental parameters. In general, however, Willamette Valley *Sidalcea* species appear to have fairly broad ecological tolerances and have proven capable of becoming established in a variety of introduction sites. As such, although efforts should definitely be made to select the highest quality introduction sites possible, limitations posed by seemingly marginal habitat should not necessarily negate introduction attempts.

Given the history of *Sidalcea* habitat destruction on private lands, and the ubiquitous threat posed by invasive species, inventories for suitable population introduction and augmentation sites should be focused strictly to publicly owned (or otherwise secure) lands that appear safe from imminent weed and successional encroachment problems. Selection and use of sites should be coordinated with pertinent public landowners to ensure administrative protection and management of populations following introductions.

2. Collect *Sidalcea* seeds for off-site cultivation of introduction stock. Source material for off-site cultivation of Willamette Valley checkermallow species should be collected from the extant population(s) located nearest to population introduction target sites to minimize undesirable mixing of gene pools, reduce hybridization potential, and maximize conveyance of potential local adaptations (if such intraspecific variability and adaptations exist).

   Based upon previous reproductive studies, Willamette Valley checkermallows can generally be expected to produce 4-7 seeds per fruit (usually 65-70 percent of available ovules). As individual plants can produce 30-100 or more fruits per inflorescence, and 10-30 or more inflorescences per plant, total reproductive output can potentially exceed 10,000 or more seeds per plant. The primary limitation to seed production in these species, which can dramatically reduce seed yields to very low levels, is pre-dispersal seed predation by weevils (see "Seed production," above). Although *Sidalcea cusickii* and *S. campestris* suffer fewer predation losses, seed mortality often exceeds 80 percent in *S. nelsoniana*, and can even reach 100 percent in some populations (whereas some populations suffer little or no losses at all).

   Given high levels of seed production reported for these species, and high levels of seed germinability, a single collecting year should be adequate to supply enough viable seeds for most cultivation projects, unless source populations are extremely small or seed losses to pre-dispersal predation are high. In the latter case, insecticide applications may be considered as a tool for temporarily reducing seed losses to predation, as described in Gisler and Meinke (2001a).

3. Cultivation. Willamette Valley checkermallow species lend themselves to successful and rapid cultivation in greenhouses, outdoor garden settings, and even in agricultural fields, using both seeds and rhizome cuttings. Seed germination typically exceeds 75 percent in all species following seed coat scarification. Care must be taken to collect fully ripe seeds with brown seed coats, otherwise germination of immature seeds (with greenish seed coats) will be low. Once *Sidalcea* seedlings are obtained, they can reach reproductive maturity and large size within three months in the greenhouse, or more time may be needed (up to two years) if seedlings are started and maintained outdoors. Rhizome cuttings tend to grow even more quickly than seedlings, and can reach reproductive maturity within two months in the greenhouse. Once large plants are obtained, they can be easily divided into numerous smaller divisions and used to further enhance the quantity of stock under propagation. However, to maintain genetic diversity and productive sex ratios in introduced populations, such clonal propagation techniques should be undertaken with some restraint and/or augmented with individuals derived from sexual reproduction (i.e., seeds).

   Due to the high potential for hybridization among Willamette Valley checkermallows (despite the occurrence of certain ecological and genetic crossing barriers), *Sidalcea* species should not be cultivated closely together, to minimize opportunities for interspecific pollen flow.

4. Introduce cultivated plugs into the target site(s). Willamette Valley checkermallow introductions should be performed after the arrival of fall rains, so that soils are moist at the time of planting and plugs have ample opportunity for root system development prior to summer drying. However, later season planting (even during unusually dry years) has resulted in very high transplant survival rates, a testimony to the resiliency of these species. Multiple introduction efforts

have been undertaken for *Sidalcea nelsoniana*, with uniformly high rates of survival (ranging from 85-100 percent) over several years of monitoring following introduction. Anecdotal reports and personal observation of *S. campestris* and *S. cusickii* in garden and restoration settings suggest that the other Willamette Valley checkermallow species likewise perform well when introduced as plugs.

Due to the aforementioned concerns about hybridization in Willamette Valley checkermallows, care should be taken to introduce Sidalceas into sites not already occupied by other congeners, and target sites should only be located within the current ranges of the respective species. This concern is especially pronounced for the interfertile species pair of *S. nelsoniana* and *S. cusickii*. To maintain reproductive isolation of these species, *S. nelsoniana* should not be introduced south of Finley National Wildlife Refuge in southern Benton County, and *S. cusicki*i should not be introduced north of the same area.

Given potential monitoring complications related to clonal growth of introduced plugs, the design of introduction projects should keep monitoring objectives in mind and endeavor to space plugs such that they can be relocated and discerned over time, in order to evaluate project success.

5. Monitor introduced populations. Introduced *Sidalcea* plugs should be monitored annually to evaluate project success. Monitoring efforts could either entail simple methods of population censusing of reproductive and non-reproductive plants, or more intensive methods could be employed to track the fates and reproductive performance of individuals over time. In larger populations, it may be necessary to replace direct censuses with statistical sampling procedures, as described by the City of McMinnville (1997) and Guerrant (1998).

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