Cynanchum louiseae, C. rossicum

INTRODUCTORY

Pale swallow-wort

Black swallow-wort

Photos by Leslie J. Mehrhoff, University of Connecticut, Bugwood.org

AUTHORSHIP AND CITATION:
Stone, Katharine R. 2009. Cynanchum louiseae, C. rossicum. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2010, January 13].

FEIS ABBREVIATION:
CYNSPP
CYNLOU
CYNROS

NRCS PLANT CODE [68]:
CYLO11
CYRO8

COMMON NAMES:
black swallow-wort
Louise's swallow-wort
black dog-strangling vine

pale swallow-wort
European swallow-wort
dog-strangling vine

TAXONOMY:
The genus name for swallow-worts is *Cynanchum* L. (Asclepiadaceae). This review summarizes information on the following swallow-wort species [35]:

Cynanchum louiseae Kartesz and Gandhi, black swallow-wort
Cynanchum rossicum (Kleopow) Borhidi., pale swallow-wort

In this review, species are referred to by their common names, and "swallow-worts" refers to both species.

Hybrids: A review states that hybridization has been observed between the swallow-worts but is unlikely to occur in North America [16].

SYNONYMS:
for ***Cynanchum louiseae* Kartesz and Gandhi:**
Vincetoxicum nigrum (L.) Moench [22,24,55]

for ***Cynanchum rossicum* (Kleopow) Borhidi.:**
Vincetoxicum rossicum (Kleopow) Barbar. [55]

LIFE FORM:
Vine-forb

FEDERAL LEGAL STATUS:
No special status

OTHER STATUS:
Information on state-level noxious weed status of plants in the United States is available at Plants Database.

DISTRIBUTION AND OCCURRENCE

SPECIES: Cynanchum louiseae, C. rossicum

- GENERAL DISTRIBUTION
- HABITAT TYPES AND PLANT COMMUNITIES

GENERAL DISTRIBUTION:
Black swallow-wort is native to northern and southwestern Europe, including Portugal, Spain, the Balearic Islands, France, Italy, and The Netherlands [16,43,56]. **Pale swallow-wort** is native to the Ukraine and part of Russia [16,43,56,60]. It has rarely escaped cultivation in Europe, though it is considered invasive in Norway [16].

Both **black** and **pale swallow-wort** were introduced in northeastern North America in the mid- to late 1800s and escaped from cultivated gardens or experimental plantations [12,16,43,52,56,57,60]. Neither species is a favored horticultural plant [43]. Swallow-worts have discontinuous distributions in North America, with populations most concentrated in the northeastern United States and eastern Canadian Provinces. **Pale swallow-wort** is generally more common than **black swallow-wort** [16]. Plants Database provides distributional maps for **black** and **pale swallow-wort**.

Black swallow-wort occurs from southern Ontario and southwestern Quebec south and west to Kansas and Nebraska, east to Maryland, and north to Maine. An isolated population of **black swallow-wort** occurs in southern California [16].

Pale swallow-wort is discontinuously distributed from southern Ontario and southwestern Quebec south and west to Missouri, east to New Jersey, and north to New Hampshire. There is one record of **pale swallow-wort** from Victoria, British Columbia [16].

HABITAT TYPES AND PLANT COMMUNITIES:
Plant community associations of nonnative species are often difficult to describe accurately because detailed survey information is lacking, there are gaps in understanding of nonnative species' ecological characteristics, and nonnative species may still be expanding their North American range. Therefore, **black** and **pale swallow-wort** may occur in plant communities other than those discussed here and listed in the Fire Regime Tables.

Black swallow-wort: In the United States, most information on plant community associations of **black swallow-wort** comes from New York. Near Buffalo, **black swallow-wort** was found along forest edges; overstory trees were red and chinkapin oak (*Quercus rubra*, *Q. muehlenbergii*) with an understory of grasses or smooth sumac (*Rhus glabra*), hawthorn (*Crataegus* spp.), and American bladdernut (*Staphylea trifolia*) thickets [5]. On Long Island, **black swallow-wort** was found on dredged material within what was formerly the oak-American chestnut (*Quercus* spp.-*Castanea dentata*) forest region [18], but with the loss of American chestnut is now considered the central hardwoods-eastern hemlock (*Tsuga canadensis*) forest vegetation zone. This zone is dominated by eastern hemlock and a variety of hardwood species, most prominently oak and hickory (*Carya* spp.) [71]. In southern New York, **black swallow-wort** was listed as an uncommon species in forests dominated by red and chestnut oaks (*Q. prinus*). Hilltops were dominated by a mix of oaks, pignut hickory (*C. glabra*), and pitch pine (*Pinus rigida*), and north-facing coves were dominated by eastern hemlock [4]. In Dutchess County, **black swallow-wort** was found in disturbed sunny areas twining over itself and other weedy plants such as poison-ivy (*Toxicodendron radicans*), cypress-spurge (*Euphorbia cyparissias*), and goldenrod (*Solidago* spp.) [46].

In Canada, a review lists **black swallow-wort** as occurring on various ruderal sites, pastures, hedgerows, gardens, tree plantations, small woodlots and thickets, dry-mesic oak-maple (*Acer* spp.) forests, and eastern whitecedar (*Thuja occidentalis*) forests [16].

Pale swallow-wort: The majority of research on **pale swallow-wort** was conducted in forests and old fields in New York. In forests, **pale swallow-wort** occurred with the following dominant overstory species: eastern redcedar (*Juniperus virginiana*), eastern whitecedar, shagbark hickory (*C. ovata*), sugar maple (*Acer saccharum*), red oak, bitternut hickory (*C. cordiformis*), basswood (*Tilia americana*), eastern hemlock, eastern white pine (*P. strobus*), white ash (*Fraxinus americana*), and other ashes (*Fraxinus* spp.) [15,25,45,56].

In New York, **pale swallow-wort** occurred on old fields that were often occupied by other weedy species; in one old field, 71% of the identified plant species were nonnative. The dominant species in this field were sulphur cinquefoil (*Potentilla recta*), oxeye daisy (*Chrysanthemum leucanthemum*), bird vetch (*Vicia cracca*), goldenrod, fescue (*Festuca* spp.), and timothy (*Phleum pratense*) [3]. Another old field was dominated by bluegrass (*Poa* spp.), fescue, blackberry (*Rubus* spp.), Canada thistle (*Cirsium arvense*), and goldenrod [15].

There are a few plant community descriptions for Canadian sites with **pale swallow-wort**. One review reports **pale swallow-wort** growing in forests dominated by maple, American beech (*Fagus grandifolia*), oak, and ash in Ontario and western Quebec. Near Ottawa, **pale swallow-wort** occurred with dominant overstory tree species such as eastern redcedar, eastern whitecedar, white ash, prickly-ash (*Zanthoxylum americanum*), eastern hop hornbeam (*Ostrya virginiana*), sugar maple, and basswood [16]. Old fields containing **pale swallow-wort** near Ottawa were dominated by a mixture of native and nonnative grasses or dense patches of tall goldenrod (*S. altissima*) [19].

BOTANICAL AND ECOLOGICAL CHARACTERISTICS

SPECIES: Cynanchum louiseae, C. rossicum

GENERAL BOTANICAL CHARACTERISTICS:

Botanical description: This description covers characteristics that may be relevant to fire ecology and is not meant for identification. Keys for identification are available (e.g., [16,24]).

Aboveground description: Swallow-worts are perennial vines with milky sap and are very similar in appearance. Stems may reach a height of 6.5 feet (2 m) and may be erect or twining depending on maturity, density, and the availability of support [12,16,24,32,43,56]. Swallow-worts tend to grow in clusters [16]. They form extensive patches, making identification of individual plants difficult [24,41,42,56].

The leaves of swallow-worts are opposite [12,16,24,32]. **Black swallow-wort** leaves are oblong to ovate, 2 to 5 inches (5-12 cm) long, and 1 to 2.6 inches (2-6.5 cm) wide [16]. **Pale swallow-wort** leaves are ovate to elliptic, 3 to 5 inches (7-12 cm) long, and 2 to 3 inches (5-7 cm) wide [16]. Flower color is the easiest way to differentiate the swallow-wort species; corolla lobes are dark purple in **black swallow-wort** and pale purple to maroon in **pale swallow-wort** [12,16,41,42,46,60]. Swallow-wort flowers are borne on loose, axillary cymes [12,16,24]. The fruits are small, slender follicles, 2 to 3 inches (4-7 cm) long, which contain many seeds [8,16,32]. The fruits are often borne in pairs and split open lengthwise to release seeds [43].

Seeds: The seeds of swallow-worts have a narrow, membranous, marginal wing and 1-inch-long (2 cm) apical tufts of hairs (**comas**), which aid in wind dispersal [8,16,32]. **Black swallow-wort** seeds are 6.0 to 8.0 mm × 3.0 to 4.7 mm in area; **pale swallow-wort** seeds are 4.0 to 6.5 mm × 2.4 to 3.1 mm [16].

Belowground description: The roots of swallow-worts are described as pale, and both fibrous and "somewhat thick and fleshy" [16]. Roots extend from thick, woody rhizomes [16] or, as described for **pale swallow-wort**, a "stout, almost woody, shoot base" [56].

Black swallow-wort is a clonal, rhizomatous species [16,41,43,46]. In one study, several plants were dug up and examined. The authors found "that what appeared to be several plants were often one, connected by horizontal underground stems" [46]. One review clarifies that the rhizomes are short and "not creeping" [16]. The roots and rhizomes of **black swallow-wort** grow to a depth of about 20 inches (50 cm) [46].

Though listed as a rhizomatous vine in an early historical record [56], 2 authors examined samples of **pale swallow-wort** plants and were always able to separate closely associated individuals without finding a vegetative connection. They concluded that rhizomes were not present [12,56]. However, one review asserts that **pale swallow-wort** has short rhizomes similar to those of **black swallow-wort** [16]. There are perennating buds on the root crowns [16,45,51,70] and shoot bases or lower stem nodes [16,56] of **pale swallow-wort**. One author observed that most **pale swallow-wort** roots occurred within the top 6 inches (15 cm) of soil (DiTommaso, personal observation cited in [15]), while an Element Stewardship Abstract stated that the root crown was generally more than 0.4 inch (1 cm) below the soil surface [43].

Stand size and/or population structure: Swallow-worts may form large, monospecific stands of clumped plants [15,41,42,43]. In central New York, some monospecific stands of **pale swallow-wort** exceed 2 acres (1 ha) [44]. Another New York site was a 14.1-acre (5.7 ha) old field dominated by **pale swallow-wort** for at least 5 years [60].

Black swallow-wort populations in New York grew with each clump a minimum of 13 feet (4 m) away from the next nearest clump [46].

Swallow-worts often grow in dense stands [15,41,42,43]. In central New York, a **pale swallow-wort** stand had 178 mature shoots/m² [25]. At 3 study sites in central New York, mean densities of **pale swallow-wort** varied from high density (117 mature shoots/m²) in a mature, mixed-hardwood forest to low (15 shoots/m²) and high (130 shoots/m²) densities in 2 old fields [15]. In 2 old fields in northern New York, density of stems >4 inches (10 cm) tall was approximately 98 stems/m², and the seedling density was approximately 1,003/m² [3]. In an open powerline right-of-way, Sheeley [56] found mean density of mature **pale swallow-wort** exceeded 80 shoots/m², with total shoot densities 10 to 100 times greater.

Light appears to have a positive impact on stem densities [12,44,56]. Overall stem densities, including seedlings, reached 2,019 shoots/m² in an open powerline right-of-way and 780 shoots/m² in a shaded, midsuccessional forest gap [56]. One **pale swallow-wort** study near Toronto found 267 stems/m² in an open area and 99 stems/m² in an adjacent partially shaded site [12]. However, another study found that light availability did not affect **pale swallow-wort** stem densities, aboveground nonreproductive biomass, or total aboveground biomass [59,60].

Measured densities of **black swallow-wort** populations were not reported as of 2009.

Life span: Observations and herbaria collections indicate that **pale swallow-wort** plants may live in excess of 70 years [43,56].

Other: A study from a central New York hardwood forest demonstrated that **pale swallow-wort** forms associations with native arbuscular mycorrhizal fungi and may increase the occurrence of native arbuscular mycorrhizal fungi in the soil [25]. In greenhouse studies, **pale swallow-wort** survival was greater in old field soils with native arbuscular mycorrhizal fungi than in sterile soils [60].

Raunkiaer [53] life form:
Hemicryptophyte
Geophyte

SEASONAL DEVELOPMENT:
Swallow-worts have similar phenology, which may vary by geographic region and local site characteristics such as light availability, precipitation, and temperature [3,46,47,56,60]. Seed germination may occur in either fall or spring [15,32,43,56]. Though no study to date (2009) examined the prevalence of fall versus spring germination, one study described a flush of **pale swallow-wort** germination beginning in early September. Because fall-germinating plants may establish before swallow-wort cohorts and native species that germinate in spring, the authors speculated that fall germination was advantageous [15]. Shoots die back to the ground every winter [41,42], though dead stems may persist through the winter and subsequent seasons, twined around supporting vegetation. Overwintering is by seeds and buds on the root crown [15]. Water and energy stored in the woody rhizomes facilitate rapid early season growth [16].

In New York, **pale swallow-wort** stem growth begins in early April [56]. In northern New York, maximum height growth is achieved in late June or early July [59,60]. Flowers are typically produced from May until late July. Peak flowering ranges from the end of May to mid-July and may vary by study area, between years (attributed to temperature), and with light availability [56,59,60]. Peak follicle production also varies by study area and light availability, ranging from the end of June to the beginning of September [56,59,60]. A fact sheet from New York describes wind dispersal of seed occurring from late July into early fall [42]. In the Ottawa area, follicles first open in September, and plants continue to release seeds through November [8].

In New York, **black swallow-wort** flowering first begins in mid-May, peaks in mid- to late June, and ends by early July. One study found that flowering begins 2 weeks earlier in southerly sites and lasts a month longer in shady sites [46,47]. **Black swallow-wort** flowers persist for 6 to 8 days [32,46,47]. Pollinators were observed during flower production, from mid-May to early July [46,47]. In New York, wind dispersal of seeds begins in late July to early August in open areas and continues throughout summer and fall [41].

REGENERATION PROCESSES:

- [Pollination and breeding system]
- [Seed production]
- [Seed dispersal]
- [Seed banking]
- [Germination]
- [Seedling establishment and plant growth]
- [Vegetative regeneration]

Swallow-worts reproduce sexually [46,47,60]. Asexual regeneration from the root crown and lower stem nodes is well documented [12,16,21,43,45,46,51,60,70].

One potential barrier to successful reproduction is low light levels; **pale swallow-wort** plants exhibit lower seed production [56,59], occurrence of polyembry [60], germination rates [15,59], and seedling survival and growth [31,59] in low-light than high-light environments. **Pale swallow-wort** may persist without sexual reproduction in shaded sites and flower after disturbance increases light availability [15,56].

Pollination and breeding system: Swallow-worts have open- and self-pollination [46,47,60]. Seeds generated from **black swallow-wort** self-pollination had somewhat lower viability than cross-pollinated seeds (4.2% versus 11.1%), though the difference was not significant [46].

The primary pollinators of **black swallow-wort** are small, unspecialized flies, mostly blowflies and flesh flies, that are attracted by the purple flower color and rotting fruit nectar odor [46,47]. Flies, bees, wasps, and beetles have been observed visiting **pale swallow-wort** flowers [12].

Seed production: Swallow-wort seeds may have multiple embryos; on average, a seed contains 2 to 3 embryos [8,32,56,59,60]. In northern New York, each **pale swallow-wort** follicle produced an average of 15 seeds, with a mean of 2 viable embryos/seed [59,60]. **Pale swallow-wort** plants from high-light environments are more likely to produce seeds with multiple embryos than plants from low-light environments [60].

In an old field dominated by **pale swallow-wort** in northern New York, each **pale swallow-wort** stem produced an average of 17 follicles, though some produced as many as 100 [59,60]. **Pale swallow-wort** plants found on 2 open sites in New York produced more seeds than plants on shaded sites [56,59]. Sheeley [56] found that plants in shaded sites were less fecund, having fewer flowers and fruits; the mean annual seed output for the shaded, midsuccessional hardwood forest gap site was 1,330 seeds/m², while it was 2,090 seeds/m² at an open site along a powerline right-of-way [56]. A field study in northern New York found that highest seed production occurred on sites with intermediate light levels; these sites produced a mean of 32,000 seeds/m² compared to 28,000 seeds/m² on shaded sites. However, the authors noted that lower seed production on shaded sites still resulted in a large quantity of seed [59].

Seed production may vary by region. Smith [60] found that **pale swallow-wort** plants in a northern New York field site produced 7.5 times more follicles and 3 times more seeds/follicle than plants sampled by Sheeley [56] just slightly farther south in New York; seed output was as high as 35,244 seeds/m² at the more northerly site. The author suggests soil characteristics, interactions with other plants, and genetic variability as possible explanations for this difference [60].

Seed production by **pale swallow-wort** may vary by patch density. In an old field study near Ottawa, the reproductive output of **pale swallow-wort** individuals was strongly influenced by the size of the experimental patch in which they were growing. Individuals in dense patches (81 plants/m²) had 3 times the follicle and seed production as individuals in sparse patches (1 plant/m² or 9 plants/m²) [7].

Seed dispersal: Swallow-wort seeds are dispersed by wind [8,16,41,42,56,60]. Seeds dispersing from an established

pale swallow-wort stand near Ottawa traveled at least 197 feet (60 m), though the majority of seeds (83%) fell directly beneath the source population. The seeds that dispersed farther tended to be smaller, though even large seeds were "competent" dispersers [37,38]. In a field trial, **pale swallow-wort** seeds traveled up to 59 feet (18 m) from a 4.9-foot-high (1.5 m) release point. Half of the seeds fell within 8.2 feet (2.5 m) of the release point. Seed weight was a significant predictor of dispersal distance, with light seeds traveling farther than heavy seeds (P=0.0001) [8]. It is noted in a field guide that most **black swallow-wort** seeds fall within a few meters of the parent plant [32].

Seed banking: As of 2009, there was very little information pertaining to seed banking for swallow-worts, and the speculations presented in the literature were contradictory. A field guide stated that a seed bank had not been confirmed for **black swallow-wort** [32].

DiTommaso observed that a small fraction of **pale swallow-wort** seeds may survive in the soil for 4 years, though the majority germinate the first year (DiTommaso 2009, personal communication [14]). A fact sheet suggests **pale swallow-wort** seed banks may be depleted in =5 years [42] (see Cultural control). A field study found seeds planted on the soil surface were more likely to remain dormant for 1 or 2 years before emerging than seeds planted 0.4 inch (1 cm) below the soil surface, leading the authors to speculate that the presence of a seed bank is "apt to be the norm" in **pale swallow-wort** populations [38]. A review states that "anecdotal observations suggest that large seed banks may be formed in established colonies, which would greatly affect herbicide management techniques and costs" [16]. In contrast, based on a classification scheme by Thompson and Grime [63], Sheeley [56] suggests that a "large, persistent seed bank would not form" for **pale swallow-wort**.

Germination: Swallow-wort germination rates are considered high. In the laboratory, 49% germination was obtained from overwintered, open-pollinated **black swallow-wort** seeds collected from disturbed, sunny sites [46]. Laboratory germination rates of **pale swallow-wort** generally range between 30% and 50% [8,12,15,56], and some authors speculate that rates in the field could be higher [15].

Neither species requires dormancy or stratification for seeds to germinate [12,16,32,46,47,56]. However, a preliminary test on **pale swallow-wort** showed germination rates improved with stratification (unpublished study cited in [59]), and cold-storage treatments are often used in laboratory germination trials for **pale swallow-wort** [8,15,56,60]. **Black swallow-wort** seeds collected from disturbed, sunny sites and allowed to overwinter had a laboratory germination rate of 49%, while those forced to germinate immediately after collection in September had a 28% germination rate [46].

Light availability may influence germination rates. In the laboratory, the highest germination rates were observed from **pale swallow-wort** seeds collected from open old fields (P<0.0001) [15]. Some speculate that after herbicide treatment of mature **pale swallow-wort** plants in an old field in New York, increased light stimulated germination of dormant **pale swallow-wort** seeds [3]. However, in laboratory trials, there was no significant difference in germination rates between **pale swallow-wort** seeds planted alone or with 3-week old grasses as potential competitors for light [8].

Seedling establishment and plant growth: There was no information regarding **black swallow-wort** seedling establishment and plant growth as of 2009.

Pale swallow-wort seedlings demonstrate high first-year survivorship; one old field study documented survivorship of 71% to 100% [38], while another old field study documented survivorship at >50% (unpublished data cited in [7]).

Light may increase **pale swallow-wort** seedling survivorship and growth. In old field experiments in northern New York, density of **pale swallow-wort** seedlings was always highest in high-light plots and lowest in low-light plots [59]. Similarly, after germination in a laboratory setting and outplanting into an old field, 2- and 3-year-old **pale swallow-wort** seedlings had higher survival, height, and aboveground biomass on open sites compared to shaded sites. However, seedlings in shaded sites had a "strong capacity" to tolerate deep shade [31]. Interactions with other plants may also impact the growth of **pale swallow-wort** seedlings. Seedlings grown with grasses were significantly smaller than those grown without grasses in a laboratory trial (P<0.0001) [8]. Though the authors discuss this interaction in terms of competition, no specific resources were tested.

After establishment, individual plant and population growth of **pale swallow-wort** is often linked to light availability.

One study found that mature stems in low-light environments were significantly longer than those in high-light environments ($P<0.0001$) [56], while a second study found that stems in low- and intermediate-light environments were significantly longer than those in high-light environments ($P<0.05$) [59,60]. Observations in northern New York confirmed plants in low- and intermediate-light environments had thick stems and large, thin leaves along long internodes while **pale swallow-worts** in high-light environments had short, thin stems and small, thick leaves located along short internodes. Plants in the low- and intermediate-light environments were more likely to climb over and "smother" adjacent vegetation [59].

See Stand size and/or population structure for information on stand densities.

Vegetative regeneration: Regardless of whether or not these species commonly reproduce via rhizomes, it is clear that swallow-worts can regenerate vegetatively from an intact [43,45,46,51,60,70] or fragmented root crown [12,16,43] and from buds on lower stem nodes [16,21]. For example, root crowns of sexually mature **pale swallow-wort** plants from New York that had been dug, divided, and tossed onto bare soil during a dry July established, grew, and reproduced the following season (Lawlor, personal communication cited in [16]). Anecdotally, Lumer and Yost [46] observed that **black swallow-wort** sprouted after the soil had been removed to a depth of more than 16 inches (40 cm). Sprouting allows swallow-wort populations to persist and can make control of target populations difficult (see Control), but it may not play a major role in population expansion [16,70].

SITE CHARACTERISTICS:

Range of sites: Swallow-worts inhabit a broad spectrum of habitats, invading both early- and midsuccessional upland plant communities ranging from open fields to wooded areas. Swallow-worts are associated with disturbed [1,16,18,43,56] and "waste" areas [16], such as transportation corridors [16,34,41,42,43], railroad embankments [16,41,43,52,61], limestone quarries [16,41,42,43], no-till cropping systems [16,42,70], cultivated grounds [41,42], pastures [16,43,70], old fields [8,41,42], and Christmas tree plantations [16,42,70]. They are also found close to human habitation, in gardens [16,41,70], lawns [16,70], shrubbery [70], city green-spaces [8], hedgerows [16,41,42,70], and fencerows [16,52,70]. Once escaped from such areas, they may easily spread into nearby, less disturbed habitats [8,16,49,56], such as a variety of deciduous and mixed-forest types [16,34,41,42,43,52,56,70], shrubby habitats [5,41,42,43,70], and wood edges [5,61]. Either species may colonize areas along rocky outcrops, rivers and streams that experience spring flood scouring, and coastal areas that experience hydrologic extremes [16]. While some references associate swallow-worts mainly with upland areas [41,42], **black swallow-wort** also occurs in wetlands and above the high tide line of some rocky coastal areas, where it tolerates relatively high salt concentrations [41,49]. **Pale swallow-wort** is less likely to grow near gardens than **black swallow-wort** and more likely to grow on roadsides or in wildlands [16,56]. Field observations, herbaria specimen data, and distributional patterns suggest that **pale swallow-wort** is more effective at dispersal and better able to establish in a variety of habitats [16,57]. While **black swallow-wort** forms dense colonies over a wide region in southern Ontario and Quebec, it is more scattered in occurrence and generally has fewer outlying plants around infestation areas than **pale swallow-wort** [16].

Climate: In North America, **black swallow-wort** occurs in areas with mean January temperatures ranging from 11.3 °F (-11.5 °C) (at Quebec, Quebec) to 33.3 °F (0.7 °C) (at New York, New York); mean July temperatures ranging from 66.7 °F (19.3 °C) (at Quebec, Quebec) to 79.5 °F (26.4 °C) (at St Louis, Missouri); and mean annual precipitation ranging from 25 inches (631 mm) (at St Paul, Minnesota) to 48 inches (1,206 mm) (at Boston, Massachusetts). Climate in its North American range is generally cooler (or more extreme) and wetter than in its native range. At least one North American population at Riverside, California, occurs at a site that is warmer and drier than sites in its native range. Mean temperatures are 66.4 °F (19.1 °C) in January and 93.7 °F (34.3 °C) in July, and annual precipitation is 10 inches (255 mm) [16].

In North America, **pale swallow-wort** occurs in areas with climatic conditions similar to its native Ukraine [16]. Mean January temperatures range from 14 °F (-10 °C) (at Ottawa, Ontario) to 33.3 °F (0.7 °C) (at New York, New York); mean July temperatures range from 69.3 °F (20.7 °C) (at Ottawa, Ontario) to 79.5 °F (26.4 °C) (at St Louis, Missouri); and mean annual precipitation range from 31 inches (776 mm) (at Toronto, Ontario) to 48 inches (1,206 mm) (at Boston, Massachusetts). Monthly growing season climate records from a site near an invasive population of **pale swallow-wort** are presented below [15].

Weather and climate descriptions for the growing season at Aurora, New York [15]				
Month	Temperature (°F)		Precipitation (inches)	
	2002	30-year average	2002	30-year average
April	48.0	45.3	3.3	3.3
May	52.7	57.6	5.0	3.2
June	66.7	66.7	4.5	4.1
July	72.1	71.2	0.8	3.3
August	71.6	69.6	1.5	3.6
September	66.0	62.1	4.9	4.2
October	49.3	50.9	3.1	3.2
November	39.2	40.5	2.9	3.4
Average	58.3	57.9	26	28.2

Elevation: Specific elevation ranges swallow-worts were not documented as of 2009. One **pale swallow-wort** population in north-central New York occurred at an elevation of 382 feet (116 m) [56]. One review states that in France, **black swallow-wort** populations occur from sea level to 1,600 feet (500 m) elevation [16].

Soil and topography: Ecosystems on well-drained, stony soils are often densely colonized, but because their extensive root systems enable them to obtain water during droughts [12,16], swallow-worts can tolerate a wide moisture regime [16]. Swallow-worts also tolerate a wide range of soil pH [16]. In New York, the soil pH of **pale swallow-wort** study sites ranged from 5.3 to 8 [3,25,44,56].

In North America, **pale swallow-wort** prefers calcareous soils [16,70]. Soil and topographical associations may include shallow soils over limestone bedrock [16,44,45,56,70], silty and sandy loams [16,60,70], glacial till [16], deep loams of upland woods [16,70], rocky and clay-loam based ravines [16,70], alluvial woods [16,44], calcareous cliffs [16,44,70], talus slopes [16,44,70], and rocky or gravelly shores [16]. In the eastern Ukraine, **pale swallow-wort** grows on "stony soil in meadow steppes and outcrops and is usually associated with calcium and carbonates" (Onyschenko, personal communication cited in [16]).

Compared to **pale swallow-wort, black swallow-wort** is apparently not associated with lime or alkaline soils, though populations often occur over limestone bedrock. Populations also grow over igneous substrates or on sandy areas with low pH [5,16,41]. In New England, **black swallow-wort** occurs above the high-tide mark on rocky coastal shores and on offshore islands. In Ontario and Quebec, infestations are often on roadsides where soils are usually alkaline and often salinized from deicing salts. One review describes that in France, **black swallow-wort** is found on slopes and stony, dry areas [16].

Flooding: One review states that swallow-worts are intolerant of prolonged flooding but tolerate seasonal flooding [43].

Disturbance: While swallow-worts are most commonly associated with disturbed habitats [1,16,18,43,56], the disturbances that create such habitats (e.g., road corridors [16,34,41,42,43], agricultural fields and pastures [8,16,41,42,43,70], railroad embankments [16,41,43,52,61], and limestone quarries [16,41,42,43]) are usually associated with human activities. Natural disturbances that might allow invasion or proliferation of these species are less documented. Fact sheets for swallow-worts suggest disturbed areas along ice-scoured riverbanks and talus slopes provide "acceptable" habitats [41,42]. Similarly, an Element Stewardship Analysis for **black swallow-wort** indicates that naturally disturbed habitats—such as the ice-scoured banks of the Connecticut River, streamsides exposed to forceful spring snowmelts, and globally rare alvar systems exposed to severe flood and/or drought hydrologic cycles—may be potential invasion sites for **black swallow-wort** [43]. Ecological disturbances that create canopy gaps in a forest environment would likely stimulate increased growth and reproduction of existing swallow-wort populations [56,59].

SUCCESSIONAL STATUS:
In general, both swallow-wort species thrive in early-successional, disturbed habitats with abundant sunlight [1,5,8,16,18,34,41,42,43,52,56,70]. Where these habitats (e.g., roadsides, pastures, old fields) are created and/or maintained by long-term human disturbance and may contain other weedy species, swallow-wort presence alone may not alter successional trajectories. Swallow-wort populations may impact succession in open habitats that still have a large component of native species; Christensen [12] states that swallow-worts are "a particular threat in wooded remnants with large edge to interior ratio, and open habitats which contain native plant communities".

Authors have observed that swallow-wort populations can establish in disturbed, early-successional areas and then spread into adjacent, undisturbed, later-successional habitats [16,56,60]. The water and energy stored in belowground biomass helps swallow-worts tolerate shade [60]. One study demonstrated that even **pale swallow-wort** seedlings tolerate deep shade [31]. One review states that **pale swallow-wort** is "often" found in the forest understory near Ontario, associated with dominant overstory tree species such as eastern redcedar, eastern whitecedar, white ash, prickly-ash, eastern hop hornbeam, sugar maple, and basswood [16]. Once established, **pale swallow-wort** populations in shaded, late-successional communities may persist for decades [56], where they may disrupt successional pathways and ecosystem function [12].

When disturbance creates an opening in a late-successional community, swallow-wort populations respond with increased reproduction and growth [56,59]. In such cases, swallow-wort populations may spread in forest gaps, reducing native understory and overstory species.

FIRE EFFECTS AND MANAGEMENT

SPECIES: Cynanchum louiseae, C. rossicum

FIRE EFFECTS:

Immediate fire effect on plant: As of this writing (2009), there was no available literature describing the immediate effects of fire on swallow-worts. Fire likely only top-kills swallow-wort plants and does little damage to belowground parts (see Fire adaptations and plant response to fire). It is possible that severe fire may kill mature swallow-wort plants, although this response has not been documented. Because they have not yet had time to develop a substantial root crown, fire would likely kill swallow-wort seedlings [43]. No information was available on fire effects on or heat tolerance of swallow-wort seeds.

Postfire regeneration strategy [62]:
Surface rhizome and/or a chamaephytic root crown in organic soil or on soil surface

Rhizomatous herb, rhizome in soil
Caudex or an herbaceous root crown, growing points in soil
Initial off-site colonizer (off site, initial community)
Secondary colonizer (on- or off-site seed sources)

Fire adaptations and plant response to fire: As of 2009, there was very little information regarding specific adaptations of swallow-worts to fire. The ability of swallow-worts to sprout from the root crown or lower stem nodes following mechanical treatments [21,43,44,45,51] suggests that they could sprout after fire if the root crown was not subjected to lethal temperatures. Because the root crown of the **pale swallow-wort** is generally more than 0.4 inch (1 cm) below the soil surface, the heat from a fire may not damage it [43]. For example, an unpublished study in New York noted that **pale swallow-wort** plants sprouted from the root crown after a spring prescribed fire, growing and reproducing the following season (unpublished 1999 study cited in [43]).

Two studies described the continued presence of **black swallow-wort** after fire but did not specify whether the propagule source was on site (vegetative regeneration or seed) or off site (seed). One study documented an increase in **black swallow-wort** cover the growing season immediately following a dormant-season (April) cut-and-burn treatment (from 19.8 to 34.5% cover) [54]. Trabaud [64] found that **black swallow-wort** maintained its presence for at least 3 years following a September prescribed fire in a Kermes oak (*Quercus coccifera*) scrubland in the Mediterranean area of southern France.

Sheeley [56] speculated that the elimination of competing vegetation after fire would enhance the growth and fecundity of surviving **pale swallow-wort** plants.

Because their seeds are wind dispersed, it is likely that swallow-worts may establish after fire from off-site seed sources; it was suggested that wind patterns in and around the Great Lakes area are largely responsible for the spread of **pale swallow-wort** in the region [60]. This dispersal strategy—combined with higher density [12,44,56], seed production [38,56,59], occurrence of polyembry [60], germination rate [15,59], and seedling survival and growth [31,59] in high-light environments—suggests that **pale swallow-wort** may increase in postfire conditions. Because it established and persisted for at least 3 years following a June prescribed fire in southern France, Trabaud [64] classified **black swallow-wort** as a "foreign plant" that can "colonize with help of fire". The ability of both species to germinate in the fall [15,32,43,56] could give the swallow-worts an advantage, allowing plants seeded from off-site sources to establish the fall following a fire, before the spring germination of other plants.

Because seed bank information is lacking for both species, it is not known whether they can establish from a seed bank after fire. Swallow-wort seeds apparently lack specific adaptations for surviving fire (see Seeds), so seeds on the soil surface would probably not survive fire.

FUELS AND FIRE REGIMES:

- **Fuels**
- **Fire regimes**

Fuels: There was very little information on the fuel characteristics of either swallow-wort species as of 2009. **Black swallow-wort** was one of a number of invasive species tested for combustion characteristics in a laboratory study. As a group, invasive vines (including **black swallow-wort**) had a significantly higher average effective heat of combustion (P=0.0003) and total heat release (P=0.0134) than noninvasive vines. The authors speculated that invasive species with relatively high values for these characteristics could change fuel characteristics of an area to the extent that fire regimes could be altered. This change would likely occur in areas where the invasive species replaced species with relatively low combustion values. The authors further suggested that the presence of these invasive species "in forests and overgrown fields represents a live fuel load that could be problematic in dry conditions if they also produce enough biomass to release more heat, overall, than the natural vegetation under the same conditions. Crowning and replacement fires could be more likely where these invasive species comprise a large proportion of the fuel bed." However, the authors caution that since combustion values are independent of other factors that affect flammability (e.g., fuel moisture, arrangement of fuels in 3-dimensional space, plant phenology), more than just these values must be considered when projecting flammability potential for a whole plant or fuel bed [13].

Another characteristic of swallow-worts that could potentially impact fuel properties is their physical growth pattern. Swallow-worts are climbing vines and may persist twined around vegetation in the understory and into the forest canopy through multiple seasons [15]. A fact sheet noted that in open-field habitats where shoots grow densely clumped and have little supporting vegetation to climb on, **black swallow-wort** replaced previously established grasses and goldenrods, leading to a complete change of physical structure [41]. The ability of growth pattern or change in structure to substantially alter fuel loads and fire behavior had not been tested as of 2009.

Fire regimes: While it is unclear what type of fire regime swallow-worts are best adapted to, they most commonly occur in northern hardwood forests (see Habitat Types and Plant Communities) that experience long fire-return intervals (see the Fire Regime Tables). Wind and insects are more common disturbance agents than fire in northern hardwood forests, and fire-return intervals in these forests have been estimated at several hundred to several thousand years (e.g., [20]). Swallow-worts may also occur on sites with potential natural vegetation that is adapted to more frequent fire, such as oak-hickory communities. It is not clear whether swallow-wort populations would alter fire regimes.

FIRE MANAGEMENT CONSIDERATIONS:

Potential for postfire establishment and spread: To date (2009), there were no published North American studies documenting swallow-wort presence after fire. In the Mediterranean area of southern France, Trabaud [64] noted **black swallow-wort** established and persisted for at least 3 years following a June prescribed fire in a Kermes oak scrubland. The ability of swallow-worts to disperse by wind and the success of **pale swallow-wort** in high-light environments suggests that either species has the potential to be problematic in postfire habitats, especially if seed sources are nearby (see Regeneration Processes). The ability of swallow-worts to germinate in the fall [15,32,43,56] could also be advantageous, because plants seeded in from off-site sources could potentially establish the fall following a fire, before the spring germination of other plants.

Preventing postfire establishment and spread: Preventing invasive plants from establishing in weed-free burned areas is the most effective and least costly management method. This can be accomplished through early detection and eradication, careful monitoring and follow-up, and limiting dispersal of invasive plant seed into burned areas. Specific recommendations include:

- incorporate cost of weed prevention and management into fire rehabilitation plans
- acquire restoration funding
- include weed prevention education in fire training
- minimize soil disturbance and vegetation removal during fire suppression and rehabilitation activities
- minimize the use of retardants containing nitrogen and phosphorus
- avoid areas dominated by high priority invasive plants when locating firelines, monitoring camps, staging areas, and helibases
- clean equipment and vehicles prior to entering burned areas
- regulate or prevent human and livestock entry into burned areas until desirable site vegetation has recovered sufficiently to resist invasion by undesirable vegetation
- monitor burned areas and areas of significant disturbance or traffic from management activity
- detect weeds early and eradicate before vegetative spread and/or seed dispersal
- eradicate small patches and contain or control large infestations within or adjacent to the burned area
- reestablish vegetation on bare ground as soon as possible
- avoid use of fertilizers in postfire rehabilitation and restoration
- use only certified weed-free seed mixes when revegetation is necessary

For more detailed information on these topics, see the following publications: [2,23,67].

Use of fire as a control agent: As of 2009, there were very few studies testing fire to control swallow-worts, and most studies were not targeting swallow-worts. Limited information suggests that fire, alone or in conjunction with other treatments, may not control swallow-wort populations. In New York, **pale swallow-wort** plants survived fire and reproduced the following growing season (unpublished 1999 study cited in [43]). Similarly, Trabaud [64] documented a **black swallow-wort** population surviving and maintaining its presence for 3 years following a September prescribed fire in southern France.

The combination of fire with other techniques may not improve the success of control efforts. A study in central New York combined mechanical and fire treatments to control invasive shrubs. **Black swallow-wort** was not a target species for the study, but some data were presented for this species. Compared to a control plot, **black swallow-wort** cover decreased slightly in a mow (June 2001, July 2002)-and-burn (August 2001) combination (from 6.3% to 5.3% cover), slightly increased in a mow (June 2001)-and-mow (July 2002) combination (from 13.6% to 14.5% cover), and increased greatly in a dormant-season cut-and-burn (April 2002) combination (from 19.8% to 34.5% cover) [54]. The results of this study suggest that combining fire with mechanical treatments did not control **black swallow-wort** populations on this site.

The limited nature of existing control studies highlights the need for additional study on the use of fire as a control agent for swallow-worts.

MANAGEMENT CONSIDERATIONS

SPECIES: Cynanchum louiseae, C. rossicum

IMPORTANCE TO WILDLIFE AND LIVESTOCK:

Palatability and/or nutritional value: There is little evidence to suggest that swallow-worts are an important forage item for wildlife or livestock. In a study of herbivory patterns on native and invasive species in Canada, **pale swallow-wort** was described as "virtually damage-free." Both swallow-worts were among the most invasive and least damaged plants in this study [9]. While one review stated that white-tailed deer likely grazed **pale swallow-wort** in exclosure studies in New York and Ontario [16], another report claims that white-tailed deer avoid both species [43].

Anecdotal evidence suggests the swallow-worts may be poisonous to some livestock; one review mentions that a domestic goat died after being fed **pale swallow-wort** (Panter, personal communication cited in [16]), and **black swallow-wort** is listed as a poisonous plant in Greece [36]. There are observations of cattle eating **pale swallow-wort** in New York, though it is avoided by horses [16,43].

Importance to other wildlife species: There is some documentation of birds and small mammals incorporating swallow-wort seed comas and stem fibers into their nests [16,27]. Near Ottawa, the seed comas and stem fibers of **pale swallow-wort** were used in the nests of the yellow warbler, Baltimore oriole, warbling vireo, red-eyed vireo, house sparrow, song sparrow, and red-winged blackbird. Also, 90% of the winter nests of meadow voles examined contained **pale swallow-wort** stem fibers, comas, and follicles. The author speculated that meadow voles may stockpile seeds for consumption, though this behavior was not observed [27].

Swallow-worts may negatively impact insect communities. In old fields near Ottawa, **pale swallow-wort** plants supported the lowest abundance of arthropods compared to other common plant species. The authors found that some feeding guilds (gall-makers and miners) were absent entirely from **pale swallow-wort** stands, and these stands supported few pollinators relative to stands of other plant species [19].

Because of the similarity of swallow-worts to the monarch butterfly's native host, common milkweed (*Asclepias syriaca*), the potential for invasive swallow-worts to negatively impact monarch populations is receiving research attention. In both laboratory and field settings, monarch larvae that were either ovideposited on or given one of the swallow-worts for food rarely survived [10,11,17,29,50]. However, in laboratory ovideposition tests, monarchs showed a strong preference for native milkweed hosts and usually avoided ovidepositing on either **black** or **pale swallow-wort** [10,11,17,50]. In examinations of old fields in Rhode Island, it was difficult to find intact monarch eggs on **black swallow-wort**. Egg densities on **black swallow-wort** were greatest in areas where common milkweed was relatively rare [10,11]. Due to the results of these studies, it is suggested that the main threat to monarch populations is not inappropriate ovideposition, but the potential of the nonnative swallow-worts to displace native milkweed populations [11,17]. Both factors may interact to create an ovideposition sink for monarchs, though the impact may vary by region [10].

Cover value: Information on the importance of swallow-worts as wildlife cover is limited. Dense populations of **pale swallow-wort** may provide protection to small rodents from raptor predation in winter, though no empirical data supported this suggestion as of 2005. The extreme density of swallow-wort cover that occurs in some situations has been anecdotally linked to a decrease in nesting grassland birds (Smith, personal communication cited in [16]). An unpublished study completed by The Nature Conservancy documented a significant negative correlation between **pale swallow-wort** cover and the number of breeding grassland birds such as the savannah sparrow (P=0.01), eastern meadowlark (P<0.0021), and bobolink (P<0.0001); these birds were absent in pure stands of **pale swallow-wort** (The Nature Conservancy, unpublished 2004 study cited in [16]).

OTHER USES:
One review cites a number of references indicating that **black swallow-wort** has been used as a laxative, diaphoretic, diuretic, emetic and antitumor agent in Europe [70]. Extracts from **pale swallow-wort** roots also show broad-spectrum antifungal activity (Smith and Arnason, personal communication cited in [7]). Reviews state that **pale swallow-wort** was grown at the Ottawa Central Experimental Farm from 1940 to 1942 as part of a wartime study of possible rubber substitutes [16,43,56].

IMPACTS AND CONTROL:
Impacts: Information regarding the impacts of **black** or **pale swallow-wort** on invaded communities includes evidence that swallow-worts may displace existing vegetation [41,42,43], threaten rare plants, and negatively impact at least one rare ecosystem. Swallow-worts are of great management concern in the globally rare alvar ecosystem of the Lower Great Lakes Basin [16,41,42,43,56,60]. Reviews note the potential replacement of the federally endangered Jessop's milkvetch (*Astragalus robinsii*) by **black swallow-wort** and Hart's-tongue fern (*Asplenium scolopendrium*) by **pale swallow-wort** [16,41,42,56,60]. Displacement of native plant species may lead to detrimental effects on host-dependant species such as the monarch butterfly [10,11,17,29,50]. **Pale swallow-wort** may also have a negative effect on some grassland bird species [16] (see Cover value). It has altered soil microbial communities [25] and insect communities [19] (see Botanical description and Importance to other wildlife species).

European swallow-wort infestation. Photo by Leslie J. Mehrhoff, University of Connecticut, Bugwood.org.

A stewardship report documents 2 areas in New York where **pale swallow-wort** populations increased from occasional patches to large stands in 50 to 100 years; one stand now covers 12 acres (5 ha) and the other 74 acres (30 ha) [43]. Similar information was not available for **black swallow-wort** populations as of 2009.

A fact sheet states that the sap of the pale swallow-wort causes an allergic reaction in some people [28].

Control: Control of swallow-worts is complicated by some of their life history attributes. For example, swallow-worts have very effective seed dispersal [43]; one author speculates that prevailing winds off the Great Lakes have facilitated **pale swallow-wort** spread in the region [60]. Land management activities may also contribute to seed dispersal for both species; mature plants and seeds may be harvested during haymaking operations and moved to new sites when the hay is transported [43] and potentially when it is consumed. Furthermore, the ability of swallow-worts to regenerate vegetatively makes control efforts difficult (see Vegetative regeneration).

In all cases where invasive species are targeted for control, the potential for other invasive species to fill their void must be considered, no matter what method is employed [6]. Information presented in the following sections may not be comprehensive and is not intended to be prescriptive in nature. It is intended to help managers understand the ecology and control of swallow-worts in the context of fire management. For more detailed information on control of **black** or **pale swallow-wort**, consult the references cited here or local extension services.

Fire: For information on the use of prescribed fire to control this species, see Fire management considerations.

Prevention: It is commonly argued that the most cost-efficient and effective method of managing invasive species is to prevent their establishment and spread by maintaining "healthy" natural communities [48,58] (e.g., by avoiding road building in wildlands [66] and monitoring several times each year [33]). Managing to maintain the integrity of native plant communities and identification of the causal factors enhancing ecosystem invasibility are likely to be more effective than an emphasis on controlling the invader [30].

Prevention of swallow-wort infestations is difficult because of the wide distribution of both species and their ability to easily disperse numerous seeds via wind. Establishment of large monospecific stands may be prevented by manually removing isolated individuals and small patches before they spread, perhaps using some of the mechanical techniques [43] described in Physical and/or mechanical control.

Cultural: There is limited information on the use of cultural practices to control swallow-wort populations. In central New York, glyphosate and triclopyr herbicide application was followed by native rye grass (*Elymus* spp.) plantings to investigate whether rye grasses could effectively suppress **pale swallow-wort**. Drought conditions persisted during the study period, and the rye grasses failed to establish after germination. However, the author speculated that using species that provide early season light competition (e.g., broadleaved natives) might be an effective control strategy because swallow-worts accomplish most of their growth early in the growing season [44]. A fact sheet suggests that invasive **pale swallow-wort** populations might be brought under control by plowing and planting an annual crop that persisted until the **pale swallow-wort** seed bank was depleted, possibly as long as 5 years [42]. However, this strategy may not be feasible or appropriate in wildlands.

Physical and/or mechanical: Several physical or mechanical measures have been attempted to control swallow-worts, although these strategies have proved problematic due to the regeneration capacity of swallow-worts (see Vegetative regeneration). To date (2009), all of the research in this field comes from attempts to control **pale swallow-wort** populations and involves either using physical barriers to cover or smother plant populations, cutting and mowing, or digging up plants.

Using a physical barrier to cover or smother populations: On the Fletcher Wildlife Garden near Ottawa, several methods for controlling **pale swallow-wort** infestations were tested, with variable results. Mulching materials, including thick leaf cover, landscape cloth, or multiple layers of newspapers were used to suppress **pale swallow-wort** growth around the bases of trees and shrubs. Though some **pale swallow-wort** plants penetrated through the mulches, they occurred in much lower densities than on sites without mulch [21].

Fletcher Wildlife Garden staff also attempted smothering **pale swallow-wort** plants with a heavy tarp. Pretreatment density of swallow-wort was not mentioned for this study. After 1 year, some plants had grown through holes in the tarp, but no plants could be seen under intact parts of the tarp. No seedlings were visible, suggesting the tarp had prevented the germination of the previous years' seeds. Upon removal of the tarp after 2 years, only a few plants were found and were manually dug out [21].

A group called Urban Forest Associates also attempted to smother **pale swallow-wort** plants in an open field near Toronto. Plastic sheeting was applied to block light and appeared to effectively prevent **pale swallow-wort** growth while intact. However, the sheeting was repeatedly torn open by animals, which ultimately allowed **pale swallow-wort** to recover to pretreatment levels (Urban Forest Associates, unpublished 1996 study cited in [12]).

Cutting or mowing: Several cutting or mowing strategies have been used to control **pale swallow-wort** populations. In general, these programs have not succeeded because swallow-worts sprout from stem nodes or from the root crown after damage [21,43,44,45,51]. In many cases, repeated clippings or mowings were necessary, making this type of control long-term and labor-intensive [3,12,21].

In one project in Ottawa, Fletcher Wildlife Garden staff tried cutting **pale swallow-wort** flowerheads before seed set. However, the plants sprouted rapidly below the cut and sent up new flowerheads. Three or 4 additional cuttings were needed to prevent growth and reproduction. The group decided this treatment was impractical, especially for widespread infestations. Mowing to stop seed production and dispersal was also attempted, though the ideal time for mowing based on plant phenology coincided with bird nesting, and the treatment had to be delayed. Consequently, multiple mowings were needed [21]. Urban Forest Associates also attempted to mow **pale swallow-wort** plants in an open field near Toronto. Repeated mowing reduced average stem height but did not ultimately reduce cover to a "satisfactory" extent [12]. In New York, experimental plots of **pale swallow-wort** that were clipped in June and July had greater stem densities than unmanaged plots by September. Repeatedly clipped stems still produced seed occasionally [3].

Fact sheets for both species claim that mowing will not eradicate populations but can be used to prevent a seed crop if done in early to mid-July [41,42]. In one study, **pale swallow-wort** seedlings and mature plants were clipped at different times during the growing season near Ottawa. This study concluded that the best time for controlling population spread with a single cutting treatment was after the first fruits were produced but before fruits fully developed, on or near 26 June in the study region [51].

Digging: Digging up plants may control swallow-wort populations, though it would likely only be practical for small populations or isolated plants [45]. Because broken root crowns left on or in the ground may sprout, care must be taken to remove and dispose of the entire root crown [43,44].

See Integrated Management for projects that combine physical and mechanical techniques with other control methods.

Biological: The potential for biocontrol has not been studied for either **black** or **pale swallow-wort**. Both species appear to have few pests, diseases, or other biocontrols in North America [43]. Some reviews suggest that insect and fungal groups from the plants' native range that prey on these or other swallow-wort species should be investigated [16,43]. Biological control of invasive species has a long history that indicates many factors must be considered before using biological controls. Refer to these sources: [69,72] and the Weed Control Methods Handbook [65] for background information and important considerations for developing and implementing biological control programs.

No evidence suggests grazing can effectively control swallow-wort populations (see Palatability and/or nutritional value). Authors anecdotally observed cattle grazing on **pale swallow-wort** in New York; however, **pale swallow-wort** quickly reestablished in the pastures within a few years of cattle removal, especially where **pale swallow-wort** populations were present on adjacent land [16]. Similarly, another author observed that grazing cattle suppressed **pale swallow-wort,** but plants rebounded once pastures were abandoned. Horses avoid it, which may encourage **pale swallow-wort** infestation if growth from other plants is reduced [43]. Reviews state that grazing and trampling could stimulate sprouting from stem leaf axils and perennating buds on the root crown [16,43], though no data are given to support this statement.

Chemical: There has been some experimentation on the use of herbicides to control swallow-wort populations. In general, these studies suggest that chemical control alone is not effective, and long-term reapplication is needed to sustain control [12,41,42,44,45]. General guidelines for cut-stem and foliar application of chemicals are available in fact sheets for both **black** [41] and **pale** [42] **swallow-wort**.

In central New York, the effectiveness of foliar spray and cut-stem applications of glyphosate and triclopyr was investigated during the growing season. The chemical treatments lowered **pale swallow-wort** plant density, cover, and biomass compared to untreated plots, though not by the targeted 90%. Foliar spray applications were more effective than cut-stem applications. However, foliar application of herbicides may be difficult because swallow-worts twine around shrubs and trees. Reapplication would be required for long-lasting control, because a flush of **pale swallow-wort** seedling growth was observed after treatment. If herbicides are used, application during the reproductive stage is advised; plants treated with glyphosate aborted their flowers and made no further reproductive effort the year of treatment [44,45].

Urban Forest Associates also used herbicides on **pale swallow-wort** in an open field near Toronto. Repeated applications of 5% glyphosate were needed to strongly limit regrowth the following year, and living buds were found on some roots 1 year after repeated treatments. Single applications did not reduce cover satisfactorily 1 year after treatment (Urban Forest Associates, unpublished 1996 study cited in [12]).

A New York study found that **pale swallow-wort** plants treated with triclopyr in June did not produce seed within that growing season. After herbicide application, there was a reduction in **pale swallow-wort** cover and an increase in the cover of other vegetation, though most of these species were nonnatives. The authors speculate that the loss of both adult and seedling swallow-wort plants led to a reduction in light competition and likely stimulated the germination of dormant seeds of other species [3].

See Integrated Management for projects that combine chemical application with other control methods.

Integrated management: A number of sources advocate an integrated management approach to the control of **black** and **pale swallow-wort** populations [12,43,51]. However, only a few studies have combined control techniques to investigate the efficacy of integrated management.

One study in New York investigated **pale swallow-wort** response to 4 treatments: (1) June herbicide application, (2) June clipping, (3) June and July clipping, and (4) a combination of June herbicide application with July clipping. The study found that one application of triclopyr, regardless of clipping, suppressed **pale swallow-wort** populations through postapplication growing seasons 1 and 2. On chemically treated compared to untreated plots, cover was reduced by 81%, and stem density was reduced by 86%. Adding clipping to the chemical treatments resulted in no significant difference in swallow-wort cover; chemical treatment alone was as effective as the combination treatments [3].

The combination of fire with other control methods may not improve the success of control efforts (see Use of Fire as a Control Agent).

APPENDIX: FIRE REGIME TABLES

SPECIES: Cynanchum louiseae, C. rossicum

These Fire Regime Tables summarize characteristics of fire regimes for vegetation communities in which **black swallow-wort** or **pale swallow-wort** may occur based on descriptions in available literature. Follow the links in the tables to documents that provide more detailed information on these fire regimes. These tables do not include plant communities across the entire distributional range of either swallow-wort. For information on other plant communities in which these swallow-worts may occur, see the Expanded FEIS Fire Regime Table.

- Black swallow-wort
- Pale swallow-wort

Fire regime information on vegetation communities in which **black swallow-wort** may occur. This information is taken from the LANDFIRE Rapid Assessment Vegetation Models [40], which were developed by local experts using available literature, local data, and/or expert opinion. This table summarizes fire regime characteristics for each plant community listed. The PDF file linked from each plant community name describes the model and synthesizes the knowledge available on vegetation composition, structure, and dynamics in that community. Cells are blank where information is not

available in the Rapid Assessment Vegetation Model.

Great Lakes Northeast

Great Lakes

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Great Lakes Forested					
Northern hardwood maple-beech-eastern hemlock	Replacement	60%	>1,000		
	Mixed	40%	>1,000		
Northern hardwood-eastern hemlock forest (Great Lakes)	Replacement	99%	>1,000		
Oak-hickory	Replacement	13%	66	1	
	Mixed	11%	77	5	
	Surface or low	76%	11	2	25

Northeast

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Northeast Forested					
Northern hardwoods (Northeast)	Replacement	39%	≥1,000		
	Mixed	61%	650		
Northern hardwoods-eastern hemlock	Replacement	50%	≥1,000		
	Surface or low	50%	≥1,000		
Appalachian oak forest (dry-mesic)	Replacement	2%	625	500	≥1,000
	Mixed	6%	250	200	500
	Surface or low	92%	15	7	26

*Fire Severities—
Replacement: Any fire that causes greater than 75% top removal of a vegetation-fuel type, resulting in general replacement of existing vegetation; may or may not cause a lethal effect on the plants.
Mixed: Any fire burning more than 5% of an area that does not qualify as a replacement, surface, or low-severity fire; includes mosaic and other fires that are intermediate in effects.
Surface or low: Any fire that causes less than 25% upper layer replacement and/or removal in a vegetation-fuel class but burns 5% or more of the area [26,39].

Fire regime information on vegetation communities in which **pale swallow-wort** may occur. This information is taken from the LANDFIRE Rapid Assessment Vegetation Models [40], which were developed by local experts using available literature, local data, and/or expert opinion. This table summarizes fire regime characteristics for each plant community listed. The PDF file linked from each plant community name describes the model and synthesizes the knowledge available on vegetation composition, structure, and dynamics in that community. Cells are blank where information is not available in the Rapid Assessment Vegetation Model.

Great Lakes Northeast

Great Lakes

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Great Lakes Forested					
Northern hardwood maple-beech-eastern hemlock	Replacement	60%	>1,000		
	Mixed	40%	>1,000		
Northern hardwood-eastern hemlock forest (Great Lakes)	Replacement	99%	>1,000		
Oak-hickory	Replacement	13%	66	1	
	Mixed	11%	77	5	
	Surface or low	76%	11	2	25

Northeast

Vegetation Community (Potential Natural Vegetation Group)	Fire severity*	Fire regime characteristics			
		Percent of fires	Mean interval (years)	Minimum interval (years)	Maximum interval (years)
Northeast Forested					
Northern hardwoods (Northeast)	Replacement	39%	≥1,000		
	Mixed	61%	650		
Eastern white pine-northern hardwoods	Replacement	72%	475		
	Surface or low	28%	>1,000		
Northern hardwoods-eastern hemlock	Replacement	50%	≥1,000		
	Surface or low	50%	≥1,000		

*Fire Severities—

Replacement: Any fire that causes greater than 75% top removal of a vegetation-fuel type, resulting in general replacement of existing vegetation; may or may not cause a lethal effect on the plants.

Mixed: Any fire burning more than 5% of an area that does not qualify as a replacement, surface, or low-severity fire; includes mosaic and other fires that are intermediate in effects.

Surface or low: Any fire that causes less than 25% upper layer replacement and/or removal in a vegetation-fuel class but burns 5% or more of the area [26,39].

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