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Authors: Axtell, Annie E., DiTommaso, Antonio, and Post, Angela R.

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Invasion Alert

Lesser Celandine (*Ranunculus ficaria*): A Threat to Woodland Habitats in the Northern United States and Southern Canada

Annie E. Axtell, Antonio DiTommaso, and Angela R. Post*

Lesser celandine (*Ranunculus ficaria*) is an ephemeral perennial introduced to North America from Europe for ornamental use. This species is becoming widespread in shady, moist woodlands and lawns in the northern United States and southern Canada. Despite its invasive attributes, lesser celandine continues to be marketed by the nursery sector. A hardy and easy plant to grow, lesser celandine has a dense compact growth form that makes it ideal for border plantings and showy flowers that make it a desirable garden species for early spring color. The species easily escapes cultivation, colonizing primarily moist woodland habitats. Once established, lesser celandine creates a monoculture and is purported to displace native ephemeral species. Several factors make control of lesser celandine difficult, including a large root structure, which facilitates clonal reproduction and spread. The ephemerality of lesser celandine results in a relatively brief window in which to apply control measures. Land managers need to be aware of this common garden species as a potentially invasive weed and need to be able to differentiate it from the similar native marsh marigold. Effective management strategies are needed to protect native woodland understory species and biodiversity in natural and seminatural areas of affected regions.

Nomenclature: Lesser celandine, *Ranunculus ficaria* L.

Key words: Ranunculaceae, invasive species, understory vegetation, spring ephemeral, ornamental.

Lesser celandine (*Ranunculus ficaria* L.) is an herbaceous member of the Ranunculaceae (buttercup family), subfamily Ranunculoideae, tribe Ranunculeae (USDA-ARS 2007). Synonyms for *Ranunculus ficaria* include *Ficaria verna* Huds., *Ficaria grandiflora* Robert, and *Ficaria ranunculoides* Moench (Taylor and Markham 1978). Additional common names for lesser celandine include fig buttercup, figroot buttercup, figwort, pilewort, buttercup ficaria, bulbous buttercup, and small crowfoot (Creber and Wrobel 1996; ODA 2009). The earliest herbarium collection from the United States was from Pennsylvania in 1867 (Philadelphia County, Pennsylvania, *Burke s.n.*, PH).

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*Integrated Pest Management Arborist, Cornell Plantations; Associate Professor, Department of Crop and Soil Sciences; Graduate Research Associate, Department of Plant Biology, Cornell University, Ithaca, NY 14853. Corresponding author's E-mail: ad97@cornell.edu

The USDA-NRCS (2010) currently reports 21 Pacific Northwest, Northeast, Mid-Atlantic, and Central states; the District of Columbia; and four Canadian provinces with documented populations. In addition, populations have recently been documented from Maine (University of Maine Cooperative Extension 2008), North Carolina (Krings et al. 2005), and Texas (Nesom 2008). Lesser celandine is similar in vegetative appearance to marsh marigold (*Caltha palustris* L.), a species native to eastern wetlands of the United States. However, marsh marigold differs from lesser celandine in that it produces flowers with five to nine yellow sepals and no petals, and does not produce tubers or bulbils. To distinguish them before flowering it is best to examine the root system, which for marsh marigold will be short, stout, and fleshy, whereas lesser celandine will have numerous fig-shaped tubers. Also, in wetlands and stream edges, marsh marigold does not form extensive, continuous mats of vegetative growth as does lesser celandine (Swearingen 2005).

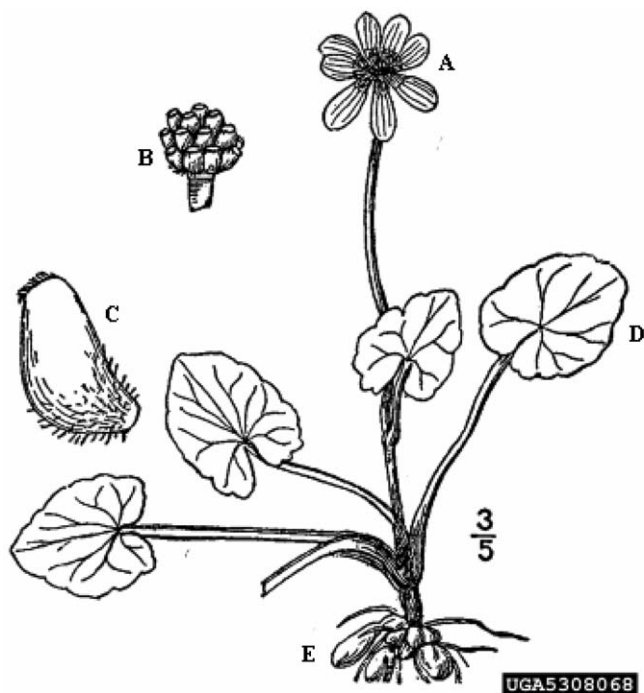


Figure 1. Lesser celandine (*Ranunculus ficaria* L.): (A) 8 to 12 yellow petals, (B) globose fruit, (C) beakless achene, (D) thick cordate leaves, and (E) tuberous roots (Britton and Brown 1913; USDA-NRCS 2008).

Description, Growth, and Development

Lesser celandine is a low-growing herbaceous perennial that can reach a height of 30 cm (Fernald 1950) (Figure 1). Growing in a mounded basal rosette, individual plants can grow to a diameter of 30 cm (Newcomb 1977). Leaves are stalked and tightly packed (Taylor and Markham 1978) on succulent stems 10 to 30 cm long (Fernald 1950). Fleshy, glabrous, dark-green leaves can vary from cordate to oblong with entire or sinuate-crenately toothed margins (Gleason and Cronquist 1991) and range from 40 to 80 mm wide and 40 to 90 mm long (Sell 1994). Three (rarely 4) green sepals are present and are 5 to 8 mm long (Fernald 1950).

Flowers are yellow, about 2 to 6 cm wide (Sell 1994), and rise singly above the leaves on petioles 10 to 30 cm tall, (Taylor and Markham 1978). Each flower has narrowly obovate petals that fade to a whitish color with age. The number of petals on each flower varies greatly across the species, ranging from 6 to 26 with double bloom varieties displaying up to 60 petals (Krings et al. 2005). Achenes are pubescent, beakless, and 3 to 4 mm long (Fernald 1950). A dense root mass anchors the plant and consists of fibrous adventitious roots and clavate (i.e., club-shaped) tubers 5 to 100 mm long (Taylor and Markham 1978). After flowering, some subspecies produce pale bulbils in the leaf axils (Sell 1994).

Since the original report in 1935 of at least two races of lesser celandine present in Britain, there has been debate on the morphological differences between the two races and their accepted diagnostic features (Metcalf 1938; Sell 1994; Læggaard 2001). Two forms, a diploid ($2n = 16$) and a polyploid ($2n = 32$), were identified and exhibited variable morphology. Polyploid individuals were characterized by the production of bulbils in the axils of leaves whereas bulbils were absent in diploid individuals (Marsden-Jones 1935). Differentiation between the two forms and validation of acceptable names has had variable success (Krings et al. 2005). Heywood and Walker (1961) suggested that reliable morphological data for identifying subspecies can only be collected by observing the plant throughout the flowering and fruiting period to senescence. Using this method and noting differences in flower size and stem length in addition to presence of bulbils, Sell (1994) proposed that five subspecies be recognized in Europe (Table 1).

After confirming and applying this subdivision of the species through an extensive review of herbaria collections, Post et al. (2009) confirmed that all five subspecies are present in the United States. *Ranunculus ficaria* subsp. *calthifolius* has the widest distribution and *R. ficaria* subsp. *chrysocephalus* the most limited distribution. This difference in distribution reflects the dates of introduction for these subspecies based on herbarium vouchers: *Ranunculus ficaria*

Table 1. Key distinguishing five subspecies of *Ranunculus ficaria* L. [(Adapted from Sell (1994)].

1.	Leaf blades to 8 cm wide by 9 cm long; petioles to 28 cm long; flowers 60 mm diameter; achenes to 5.0 mm wide by 3.5 mm long	
2.	Stems rather robust, but straggling (spreading out); bulbils present in leaf axils after flowering.	subsp. <i>ficariiformis</i>
2.	Stems robust and erect; without bulbils in leaf axils after flowering	subsp. <i>chrysocephalus</i>
1.	Leaf blades to 4 cm wide by 4 cm long; petioles to 15 cm long; flowers to 40 mm diameter; achenes to 3.5 mm wide by 2.2 mm long	
3.	Leaves crowded at base with few on short stems	subsp. <i>calthifolius</i>
3.	Leaves less crowded at base and more numerous on the elongated stems	
4.	Bulbils not present in leaf axils after flowering; achenes well-developed.	subsp. <i>ficaria</i>
4.	Bulbils present in leaf axils after flowering; achenes poorly developed.	subsp. <i>bulbilifer</i>

subsp. *calthifolius* was first documented in 1867, and *R. ficaria* subsp. *chrysocephalus* in 1975.

Lesser celandine is an ephemeral species whose emergence is purported to be stimulated by increased light availability within the leafless canopy of forested habitats in early spring (Swearingen et al. 2002). Most growth occurs when light availability, photoperiod, and temperature transition from winter levels to spring levels; plants become dormant during the summer months (Taylor and Markham 1978). Flower production varies between the five subspecies (Marsden-Jones 1935) but appears to be correlated with water availability. Plants from the subspecies *R. ficaria* subsp. *bulbilifer* reproduce almost exclusively through vegetative and clonal propagation, producing mostly nonviable seeds. The remaining subspecies all produce viable seed (Metcalf 1939). Marsden-Jones (1935) harvested achenes from both diploid and polyploid plants growing in various counties in England and found that 63% and 2% of achenes were viable, respectively. Even in viable seed, the embryo is not fully developed after it is shed from the plant but requires an after-ripening period to mature.

The aerial bulbils that are formed in the axils of leaves store starch and have adventitious buds, similar to subterranean tuberous roots. A primary difference between the two structures is the negative geotropism of the axillary bulbil, causing it to grow towards the sun vs. the positive geotropism of the tuberous root, causing it to grow into the soil. Additionally, the bulbils originate from an axillary bud whereas the root develops from a terminal bud (Metcalf 1938).

Voucher Specimens. Four voucher specimens have been provided for each subspecies. For a more complete list of U.S. vouchers, see Post et al. (2009).

***Ranunculus ficaria* L. subsp. *bulbilifer*.** *United States: Maryland, Baltimore County: Hill 13552*, 17 Apr 1984 (BRIT, GH, MARY, MO, MSC, NY-2 sheets, POM); *New York, Bronx County: Swift R432/37*, 28 Apr 1939 (NY); *Pennsylvania, Berks County: Brumbach 7910*, 5 May 1972 (BH, NA-2 sheets, NY); *Virginia, Fairfax County: Bradley & Frederickson 9954*, 13 Apr 1976 (WVA).

***Ranunculus ficaria* L. subsp. *calthifolius* (Reichenb.) Arcangeli:** *United States: Kentucky, Campbell County: Buddell II 108*, 12 Apr 1981 (NY); *Maryland, Anne Arundel County: Longbottom 1460*, 4 Apr 1991 (MARY); *Ohio, Clark County: Cusick 30056*, 31 Mar 1992 (OS); *Tennessee, Knox County: DeSelm s.n.*, 17 Mar 1977 (TENN).

***Ranunculus ficaria* L. subsp. *chrysocephalus* P.D. Sell:** *United States: Maryland, Prince Georges County: Wirick 05*, 27 Mar 1977 (MARY); *New York, Tompkins County: Dress 15977*, 18 May 1996 (BH); *Oregon, Benton County: Zika 11065*, 31 Mar 1991 (OSC); *Washington, King County: Zika & Jacobson 13733*, 17 May 2002 (WTU).

***Ranunculus ficaria* L. subsp. *ficaria*:** *United States: District of Columbia: Pollard 776*, 29 Apr 1896, (MSC);

Massachusetts, Hampshire County: Mehrhoff 21611, 24 Apr 2002, (CONN, MASS); *New Jersey, Mercer County: Glenn 5386*, 18 Apr 2001 (BKL); *Pennsylvania, Delaware County: Brinton s.n.*, 30 Apr 1892, (PH-3 sheets); *West Virginia, Wood County: Grafton s.n.*, 12 Apr 2003 (WVA).

***Ranunculus ficaria* L. subsp. *ficariiformis* (F.W. Schwartz) Rouy & Fouc:** *United States: New York, Bronx County: Mori & Gracie 18815*, 17 Apr 1988 (GH, MO, NY); *North Carolina, Wake County: Krings 1271*, 11 Apr 2005 (AUA, F, FLAS, GA, LSU, MISS, NCSC-2 sheets, NCU, TEX, UNA, US, USF, USCH, VDB); *Pennsylvania, Delaware County: Long 23006*, 26 May 1920 (PH); *Texas, Tarrant County: Nesom FW08-18*, Mar 2008 (NCSC).

Importance

Detrimental Impacts. Its ephemeral growth habit and vegetative reproduction make lesser celandine an increasingly problematic weed. All five subspecies appear to have similar vegetative dispersal capabilities through spreading tubers (Post et al. 2009) making them equally troublesome in that respect. However, plants producing bulbils will most likely have greater dispersal capability than plants not possessing this feature. Verheyen and Hermy (2004) studied the colonizing capacity of several herb-layer species in Belgian forests including lesser celandine. A high colonizing capacity has been associated with a short generation time (i.e., emergence to seed set), viability of bulbils, and effective dispersal. Verheyen and Hermy (2004) demonstrated that bulbils of *R. ficaria* species showed the highest germination rate relative to other forest-floor species studied (i.e., 80% germination in control containers and 60% in treatment plots established on the forest floor). Lesser celandine's life cycle is short, with less than 30% of seedlings surviving past 400 d (Verheyen and Hermy 2004). As this species occupies more of the forest floor, dense carpet-like colonies likely prevent established native species from completing their life cycle. In turn, resident wildlife populations dependent on native species for food and shelter may be negatively impacted (Swearingen 2005), although this effect has not been experimentally tested. Bulbils are believed to be spread after being accidentally unearthed and carried by animals; they may also be transported by water, which would likely increase colonization of riverbanks (Swearingen 2005). In turf, lesser celandine can colonize large areas, especially in moist, shaded locations, preventing the establishment of favorable grass species (Weston 2007). Mowing turf is a disruptive operation that may promote the spread of aerial bulbils in these systems (Reisch and Scheitler 2009). Moreover, in late June, lesser celandine plants senesce leaving unsightly bare ground that is subject to colonization by other weedy species. Lesser celandine contains several well-known

compounds including saponins, tannins, ascorbate (vitamin C), protoanemonin, and anemonin (Chevallier 1996). Protoanemonin present in the fresh leaves is toxic to most mammals. It can cause sickness in livestock but rarely causes death (Taylor and Markham 1978). When the leaves are dried, this compound volatilizes, rendering leaves nontoxic (Shearer 1938).

Beneficial Impacts. Documented human uses of lesser celandine range from use as foodstuff to use for medicinal purposes. The young nontoxic tubers were eaten raw (North 1967) or boiled, dried, and ground for flour, and the leaves were boiled and consumed as a vegetable (Mithen et al. 2001). Historically, lesser celandine has been used for the treatment of hemorrhoids (Chevallier 1996) and the high vitamin C content of the young leaves made it a useful treatment for scurvy (North 1967). Lesser celandine is still recommended in current herbal guides for treatment of hemorrhoids by applying an ointment of raw leaves in cream or lanolin to the affected area (De Bañraclí Levy 1991; Chillemi and Chillemi 2007). The protoanemonin found in fresh leaves is an irritant but can also be used as an antibacterial agent (Chevallier 1996). Lesser celandine is also used as a garden plant and many ornamental hybrids of lesser celandine are available for purchase in the United States and Canada.

Legislation. Lesser celandine has been reported to be invasive in 10 states (Connecticut, Delaware, Maryland, New Jersey, Oregon, Pennsylvania, Texas, Virginia, Wisconsin, West Virginia) and the District of Columbia and is currently banned in Connecticut and Massachusetts because of its noxious-weed status (USDA-NRCS 2010). However, plants can still be purchased for ornamental use elsewhere (Swearingen 2005).

Geographical Distribution

Lesser celandine is native to the northern African countries of Algeria, Libya, Morocco, and Tunisia; temperate Asia; and most of Europe (USDA-ARS 2007). The species has naturalized in New Zealand (Webb et al. 1995), Australia (Foreman and Walsh 1993), and North America. The USDA (USDA-NRCS 2010) lists 21 Pacific Northwest, Northeast, Mid-Atlantic, and Central states; the District of Columbia; and four Canadian provinces with documented populations (Figure 2). In addition, populations have recently been documented in Maine (University of Maine Cooperative Extension 2008), North Carolina (Krings et al. 2005), and Texas (Nesom 2008). Though it is not documented, lesser celandine should be expected in Vermont, northern California, and Iowa based on climatic requirements. Other states not currently reporting lesser celandine are likely too arid for widespread

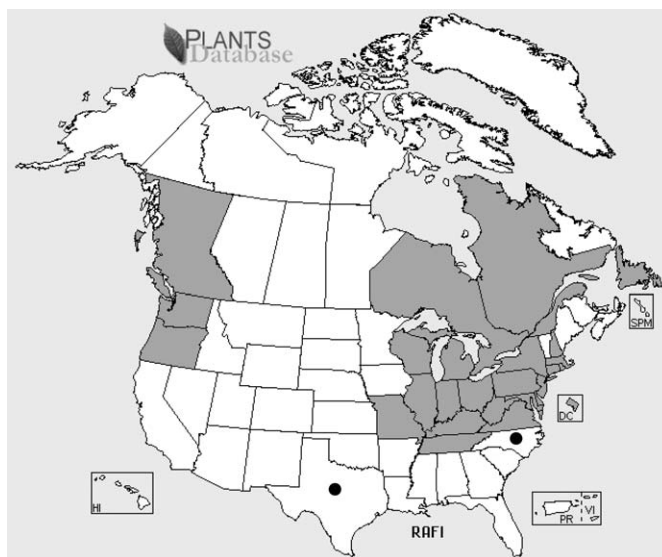


Figure 2. Distribution of lesser celandine in North America. Modified from USDA-NRCS (2008). ● Indicates states where recent collections were made but have not been updated in the USDA-ARS PLANTS Database. These collection data (from North Carolina and Texas) have been submitted to the USDA-ARS so their current distribution map for lesser celandine can be updated.

establishment of this species; however, if introduced into an irrigated habitat in these states, establishment is possible.

Habitat

Climatic Requirements. Lesser celandine can grow in a variety of habitats with varying temperature regimes. There are no optimum day/night temperature reports for this species, but in general, lesser celandine requires a chilling temperature between 4 and 6 C for several weeks and then day temperatures between 15 and 20 C for reproduction (Taylor and Markham 1978). Above 20 C, plants senesce and remain dormant. The species requires a moist environment and, in the United States, occurs in areas with yearly rainfall totals above 800 mm. However, where introduced, lesser celandine can colonize irrigated sites where yearly rainfall requirements are not met (Post et al. 2009). It has been reported in its native range to occur from sea level to 1,900 m as long as there are moist sites available for colonization (Taylor and Markham 1978; Sell 1994).

Communities in Which the Species Occurs. In its native range, lesser celandine is associated with moist, deciduous forests often dominated by *Quercus* spp. (oaks). In the United States, the species has been collected under the shade of *Quercus macrocarpa* Michx. (bur oak) in Lake County, IL; *Populus deltoides* Bartram ex. Marsh (yellow poplar) in Eaton, MI; *Quercus/Acer* (oak/maple) forest in

Bronx County, NY, and Harford County, MD; *Acer platanoides* L. (Norway maple) in Baltimore County, MD; and *Platanus occidentalis* L. (sycamore) in Howard County, MD. In its introduced range it should be expected primarily in disturbed or undisturbed, moist, deciduous forests and as a weed in lawns and horticultural plantings. Lesser celandine is also expected to occur in urban areas including drainage areas and ditch banks.

Description of Infested Sites. All subspecies of *R. ficaria* are expected to have similar habitat requirements. Soils can be heavy or light and range in pH from 4.4 to 6.9 (Taylor and Markham 1978). Post et al. (2009) reported the most common habitat occurrence for all lesser celandine subspecies is to be adjacent to a water source. Plants thrive in mesic environments on the banks of rivers, streams, lakes, and ponds, as well as in wetland sites. This contributes to the spread of the species along major waterways because tubers, bulbils, seeds, and small plants may be dislodged by swift-moving or seasonal flood waters and transported downstream. This phenomenon was confirmed through firsthand observation in the spring of 2006 in Wake County, NC, where the banks of a local stream were found infested with lesser celandine, and inspection ~ 1 km upstream revealed a large source population in a shaded lawn. Most states in which lesser celandine occurs report large populations growing in dense mats along waterways to the exclusion of most other vegetation. The majority of sites are shaded and vary from being seasonally moist to wet year-round. Lesser celandine is less commonly naturalized on open ground in full sun but can be found if moisture levels are sufficient. Abandoned and waste areas, floodplains, alluvial woods, shaded turf, stream and riverbanks, pond margins, swamps, bogs, marshes, and all seasonally wet shade are areas where lesser celandine may colonize to the exclusion of other species. Land managers should monitor sites fitting this description first, if they suspect lesser celandine in their area.

Chemical Control

There is a paucity of replicated field research on the control of lesser celandine. The recommended timing for control of lesser celandine that has minimal impact on native wildflowers is late winter to early spring (Swearingen 2005). The perennial habit and extensive root system of lesser celandine make contact herbicides less effective than systemic herbicides. Swearingen (2005) suggested using a 1.5% concentration of a 39 to 41% glyphosate isopropylamine salt solution and a nonionic surfactant for spot treatments. Management of this species in Cornell Plantations Natural Areas near Ithaca, NY, has shown promising results using the glyphosate rates recommended by Swearingen (2005). Eradication in areas with extensive

populations has not been achieved, but returning to the sites for several seasons has resulted in reductions of more than 50% in the area covered by lesser celandine (D. Levy, personal communication).

Annual application of 7.93 g ai ha⁻¹ of metsulfuron and a nonionic surfactant used to spot treat lesser celandine in meadows within the Cornell Plantations Arboretum resulted in a 60 to 70% reduction in the area covered by lesser celandine after 3 yr (D. Levy, personal communication). However, limited to no control was noted where applications occurred within 3 d after mowing. Weston (1997) indicated that a selective broadleaf postemergence herbicide containing triclopyr or clopyralid could be effective for the control of lesser celandine, but these reports need to be confirmed with replicated trial data. Two other promising herbicides currently being evaluated for their efficacy on lesser celandine include a fall application of the preemergence herbicide oxadiazon in turf and the preemergence granular herbicide flumioxazin in landscape ornamentals (A. F. Senesac, personal communication).

Cultural and Mechanical Control

Although lesser celandine growth decreases after coppicing (i.e., stems repeatedly cut down to near ground level) (Salisbury 1925; Taylor and Markham 1978), the short active life cycle of the plant each year prevents carbohydrate starvation from being a single-season control option. The digging of plants from small infestations may be possible but all tubers must be removed and destroyed for effective control. As the extent of the infestations increase, mechanical removal becomes less practical and more likely to inadvertently facilitate the spread of lesser celandine. In natural areas, the significant soil disturbance required to successfully remove all plant parts is highly disruptive and undesirable (Swearingen 2005).

Potential for Biological Control

There are currently no biological agents available for control of lesser celandine. Taylor and Markham (1978) noted the lack of recorded insects that feed on lesser celandine, identifying only the larvae of *Olindia ulmana* [Hübner, 1823] (*Olindia schumacherana* [Fabricius, 1787]), a common non-host-specific moth in Britain. Lesser celandine was recorded as a probable source of food for lepidopteran larvae of *Camptogramma bilineata* L. after hibernation (Knill-Jones 1982). Plant pathogens that have been identified on lesser celandine include the host-specific fungal rust *Uromyces ficariae* (Schumach) Lev. (Minter and Tykhonenko 2002); downy mildew (*Peronospora ficariae* Tul.) (Hall 1998); fungal leaf spot (*Entyloma ficariae* Thüm. & A.A. Fisch. Waldh.) (Mordue 1998); fungal rusts

Uromyces dactylidis Otth and *U. rumicis* (Schumacher) G. Winter; smut fungi *Urocystis ficariae* (Unger) Moesz and *Entyloma ranunculi-repentis* Sternon (Termorshuizen 2005); fungal leaf spot *Septoria ficariae* Desm.; and fungal leaf gall *Synchytrium anomalum* Schroet. (Taylor and Markham 1978). Heil and Ploss (2006) reported minimal induced disease resistance in lesser celandine but noted that its ephemeral habit may allow it to grow and reproduce under low pathogen pressure. The ephemeral nature of lesser celandine reduces viable biocontrol options. The existence of many native members of the Ranunculaceae in North America, several being closely related to the target species, also reduces the chances of identifying effective host-specific biocontrol agents.

Discussion

More frequent reports of the spread of lesser celandine in North America, especially during the last 20 yr, suggest that this species may have transitioned out of the lag phase of population growth (Sakai et al. 2001; Post et al. 2009) and into the rapid expansion phase since being first reported to have escaped cultivation in Pennsylvania 142 yr ago. The first 40 yr after introduction constitutes the lag phase for lesser celandine and two subspecies recognized by Post et al. (2009) have already entered the rapid expansion phase. It is expected that the other three subspecies will follow the same pattern and expand their current range rapidly in the next 100 yr. Marketing by the nursery industry of a wide variety of lesser celandine hybrids has likely contributed to the increase in prevalence and spread. Given the threat posed to moist woodland native species and biodiversity in many regions of the United States and Canada, it is surprising that more information on the spread and control of lesser celandine is not available. One of the primary objectives of this review is to raise awareness of the threat posed by lesser celandine as a potential invasive, one capable of decreasing biodiversity and displacing native species, and to stimulate research that will lead to the development of effective management strategies for the control of lesser celandine in natural and seminatural areas.

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