Washington Invasive Ranking System

Washington Natural Heritage Program

Centaurea solstitialis (Yellow Starthistle)

Assessed by
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Ecological Impact Rank: **High** (82)	Confidence: **High** (75)
Management Difficulty Rank: Moderate (63)	Confidence: Moderate (50)
Biological Characteristics of Invasiveness: High (77)	Confidence: High (79)
Concern Related to Distribution and Abundance: Moderate (62)	Confidence: High (70)

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Ranking Notes

None

Legal Listings

Washington State Weed Board: Class B

Washington Invasive Species Council: Yes

Section 1: Distribution and Abundance

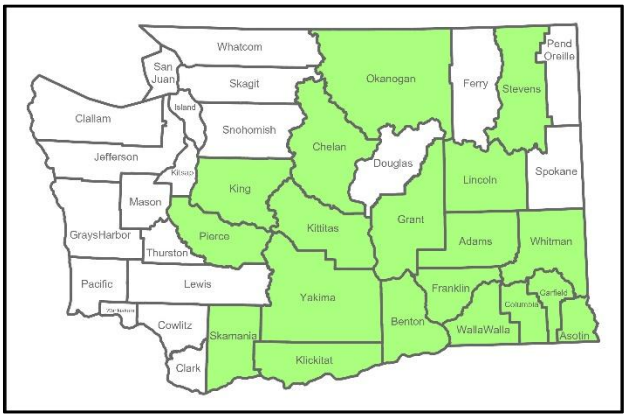

Figure 1. Distribution of counties where *Centaurea solstitialis* has been documented in Washington State (CPNWH, 2023; EDDMapS, 2023; iNaturalist Contributors, 2023).

Q1: Current Range Size in Washington

Rating: Moderate

Confidence: High

Centaurea solstitialis is found in 49% counties in Washington State (CPNWH, 2023; EDDMapS, 2023;

iNaturalist Contributors, 2023). Washington, Oregon, California, and Idaho have the largest populations of *Centaurea solstitialis* in the United States (Innes & Zouhar, 2021).

Source: Informal publication, Herbarium records and other observations

Q2: Current Trend in Total Range

Rating: Moderate

Confidence: High

Based on herbarium records and iNaturalist observations, *Centaurea solstitialis* appears to be increasing its range primarily along the Columbia River east of the Cascades in Washington State (CPNHW, 2023; iNaturalist Contributors, 2023).

Source: Herbarium records and other observations

Q3: Proportion of Potential Range Currently Unoccupied

Rating: Low

Confidence: High

Models predict that *Centaurea solstitialis* will spread throughout Washington, but will remain most abundant in the eastern half of the state (EDDMapS, 2023).

Climate change is expected to increase abundance and range of *C. solstitialis* (Dukes et al., 2011).

Source: Published research, Model predictions

Q4: Local Range Expansion or Change in Abundance

Rating: Moderate

Confidence: Low

Based on herbarium records and iNaturalist observations from the last 20 years, *Centaurea solstitialis* abundance and local range appears to be increasing south of the Snake River and in the vicinity of The Dalles on the Columbia River, but it does not appear to be increasing local range or abundance significantly in the rest of the state (CPNWH, 2023; iNaturalist Contributors, 2023).

However, in some other parts of the Northwest, *C. solstitialis* populations have been decreasing over the last 20 years. For example, biocontrol introductions have visibly decreased population density of this species in north-central Idaho, the center of *C. solstitialis* abundance for that state (EDDMapS, 2023).

Source: Professional expertise, Herbarium records and other observations

Q5: Diversity of Ecosystems Invaded

Ecosystem types: Grassland & Shrubland, Semi-Desert (includes Shrub-steppe)

Rating: Low

Confidence: Moderate

Centaurea solstitialis prefers open, disturbed upland habitats, and is often found in annual and perennial grasslands, shrub steppes, oak savannas, open woodlands, and openings in forests. In the Pacific Northwest, this species invades perennial grasslands and sagebrush steppe. In Washington, it can appear in many communities from below lower treeline to montane elevations, though it is most likely to occur in south-facing grasslands in the southeastern portion of the state. *Centaurea solstitialis* may establish in some riparian areas, but this is not common. This species grows best in deep, well-drained silt-loam or loam soils but can also grow in shallow, rocky soils. In Washington, abundance appears to be related to the soil's ability to hold moisture, with populations producing more seeds in moist soils (Innes & Zouhar, 2021).

Centaurea solstitialis' highest impacts are in areas with Mediterranean-type climates, though it can also establish in semi-arid climates like the Great Basin, and sometimes occurs in deserts, coastal regions, and at high elevations in California and Nevada. This species prefers cool, wet winters, which allow seeds to germinate and develop deep taproots before spring (Innes & Zouhar, 2021).

Source: Informal publication, Professional expertise

Section 2: Biological Characteristics

Q6: Aggressive Mode of Reproduction

Rating: Yes

Confidence: Moderate

Centaurea solstitialis is a winter annual or occasionally biennial species that reproduces from seed. This species produces two types of seeds. A study in Washington found that the average *C. solstitialis* plant produced 180 seeds. Data from Washington also found *C. solstitialis* populations could produce 1,940 seed per square foot in a wet year, and 470 seeds per foot in a dry year. However, in nursery conditions, this species can produce up to 100,000 seeds per plant. *Centaurea solstitialis* can produce flowers and seeds for several months to year-round if it does not experience drought or frost conditions. Propagule pressure is usually the most important factor in this species invasion of undisturbed or otherwise less than ideal habitats. Seeds are eaten by birds and insects—including biocontrol species—but *C. solstitialis* produces abundant seed; in some cases, populations may persist even when biocontrol species are present (Innes & Zouhar, 2021).

Centaurea solstitialis plants are self-incompatible and rely on pollinators (most importantly introduced honeybees) to reproduce. Floral visitors are abundant and diverse (Innes & Zouhar, 2021).

Source: Published research, Informal publication, Professional expertise

Q7: Innate Potential for Long-Distance Dispersal

Rating: Yes

Confidence: High

Seeds spread short distances by wind and gravity but can also be transported longer distances by animals and water. The majority of achenes have barbed plumes that readily attach to humans and animals (Innes & Zouhar, 2021).

Source: Informal publication, Professional expertise

Q8: Potential to be Spread by Human Activities

Rating: Yes

Confidence: High

Centaurea solstitialis was likely introduced to North America in the 1800s through contaminated alfalfa shipments. Long distance dispersal of this species is enabled through movement of animals, including livestock, as well as vehicles and other equipment. Populations of *C. solstitialis* frequently spread along travel corridors (e.g., roads and trails). Use of contaminated mulch in restoration and other activities has also resulted in introductions of *C. solstitialis* (Innes & Zouhar, 2021).

Source: Informal publication, Professional expertise

Q9: Allelopathy

Rating: Yes

Confidence: High

Centaurea solstitialis is generally considered to be allelopathic and allelopathy likely contributes to this species' invasiveness. Not all studies have confirmed allelopathy in *C. solstitialis*, so allelopathy may vary by population (or some plant species may be more resistant to its effects). The allelopathic chemical produced by this species is also toxic to horses (Innes & Zouhar, 2021) and herbivory can increase allelopathy in this species (Becerra et al., 2020). It releases a bitter tasting chemical when damaged.

Source: Published research, Informal publication, Professional expertise

Q10: Competitive for Limiting Abiotic Factors

Rating: Yes

Confidence: Moderate

Centaurea solstitialis is highly competitive for water and can deplete soil moisture where it occurs—sometimes so much that it reduces its own germination success in the next year. This species can grow deep roots (longer than 6 feet) and exploit fissures in rock to obtain water in dry areas. These deep roots make *C. solstitialis* more drought tolerant than some annual grasses it co-occurs with (e.g.,

Taeniatherum caput-medusae), and roots can be deeper than the roots of co-occurring perennial grass species as well (Innes & Zouhar, 2021). Basal rosettes overwinter in Washington, and can have roots up to 2 feet deep by spring, giving this species an advantage over plants that are dormant in the winter (Innes & Zouhar, 2021).

Centaurea solstitialis is more competitive for abiotic factors in its introduced range than in its native range. Multiple introductions have resulted in novel genotypes, which can increase competitive ability and adaptability to a wider range of conditions. Competitive release from perennial grasses that have evolved with *C. solstitialis,* and escape from disease-causing agents are also important factors in the success of this species in its introduced range. Replacement of native perennial grass communities with introduced annual grass communities throughout the western U.S. may also have left an unexploited niche for *C. solstitialis* to exploit. This species is more competitive against early season, shallow rooted annuals, and less competitive against species that share the same niche (e.g., late-flowering, deep taproots) (Innes & Zouhar, 2021).

However, *C. solstitialis* is less competitive against diverse plant communities, with deep-rooted perennials being most able to outcompete this species for water and light. Restoring vegetation communities is a recommended management tool to resist invasions or re-invasions by this species (Innes & Zouhar, 2021).

Source: Informal publication

Q11: Growth Form

Rating: Yes

Confidence: High

Centaurea solstitialis frequently grows as monocultural stands that exclude other species (Innes & Zouhar, 2021).

Source: Informal publication, Professional expertise

Q12: Germination Requirements

Rating: No

Confidence: Moderate

Centaurea solstitialis germinates best in moist, disturbed soils, but this species can germinate under a wide range of conditions and disturbance is not required for establishment. Propagule pressure is usually the most important factor in invasion of undisturbed or otherwise less than ideal habitats. Increases in spring moisture can also increase the likelihood of *C. solstitialis* germinating in undisturbed areas in Washington. However, the conditions where this species can establish in undisturbed areas are relatively limited, and seedlings are more likely to be unhealthy and experience mortality in undisturbed habitats (Innes & Zouhar, 2021).

Source: Informal publication

Q13: Invasiveness of Other Plants in Genus

Rating: Yes

Confidence: High

Several other species in this genus are invasive in Washington and other states in the Pacific Northwest, including several species of knapweed and at least one other species of star-thistle.

Source: Professional expertise

Q14: Shade Tolerance

Rating: Low/insignificant

Confidence: High

Centaurea solstitialis usually occurs in areas with little or no overstory canopy, does not tolerate shade, and usually does not occur in areas with tall shrubs, forbs, grasses or late season annuals that can shade it out. This species roots grow more slowly in shaded conditions, and shading may reduce its ability to flower and produce viable seed (Innes & Zouhar, 2021).

Source: Informal publication, Professional expertise

Q15: Disturbance Tolerance

Rating: Yes

Confidence: High

Centaurea solstitialis is most invasive and productive in disturbed areas. This particularly includes areas of human disturbance such as hayfields, orchards, vineyards, old fields, roadsides and railroad tracks. Rangelands and pastures, particularly ones allowed to be overgrazed, also provide opportunities for introduction or increases of this species. In the Blue Mountains in Washington and Oregon, areas grazed by cattle and elk are readily invaded by *C. solstitialis*. While fire kills adult plants, it provides excellent habitat for establishing new populations (Innes & Zouhar, 2021).

Source: Informal publication, Professional expertise

Q16: Propagule Persistence

Rating: >5 years

Confidence: High

Centaurea solstitialis forms both a transient and a long-term seedbank, and seeds can remain viable for up to 10 years in Washington. However, most of this species' seeds germinate readily and do not appear to be innately dormant. Dormancy may instead develop when dispersed seeds do not find conditions conducive to germination—only a small number of total seed production will become dormant. Germination in *C. solstitialis* is related to light, moisture, and temperature (Innes & Zouhar, 2021).

Source: Informal publication

Q17: Palatability

Rating: Yes, plant is unpalatable

Confidence: Low

Centaurea solstitialis is toxic to horses, causing neurological damage when consumed, but sometimes horses will seek it out anyway. Other grazers, including mules and burros, can eat *C. solstitialis* without danger. Cows, sheep, and goats will graze this species when it is young, but avoid it once spines develop. Grasshoppers are also known to eat *C. solstitialis* (Innes & Zouhar, 2021).

Some sources describe *C. solstitialis* as palatable and nutritious to livestock, at least when young (Innes & Zouhar, 2021). Researchers studying the effects of *C. solstitialis* on plant communities have found this species vulnerable to herbivory and sometimes use exclosures to protect experimental plots from herbivory (e.g., Dukes et al., 2011; Becerra et al., 2020). Other resources—and the general public perception—regard this species as poor forage (NWCB, 2024).

Source: Published research, Informal publication, Professional expertise

Section 3: Ecological Impact

Q18: Impact on Ecosystem Abiotic Processes

Abiotic Processes: Fire, Hydrology, Nutrient dynamics

Rating: Moderate

Confidence: Moderate

Centaurea solstitialis is highly competitive for water and depletes soil moisture more and later in the season than annual and perennial grasses. This can temporarily disrupt soil moisture dynamics and reduce water availability for co-occurring species, sometimes even across seasons. *Centaurea solstitialis* changes soil nutrient availability and adult plants may increase inorganic nitrogen in the soil (Innes & Zouhar, 2021). A study found that increased nitrogen generally benefits *C. solstitialis* above co-occurring species (Dukes et al., 2011).

Source: Published research, Informal publication, Professional expertise

Q19: Impact on Ecosystem Structure

Rating: Moderate

Confidence: Moderate

Centaurea solstitialis has competitive effects on both native and introduced species. This species can outcompete native, dominant bunchgrasses and convert ecosystems to ruderal ecosystems dominated by annuals. Some observations have found that this species can alternate dominance with *Bromus tectorum* when they co-occur (Innes & Zouhar, 2021).

Source: Published research, Informal publication

Q20: Impact on Ecosystem Composition

Rating: High

Confidence: High

Centaurea solstitialis can reduce native species abundance and diversity across trophic levels by displacing native plant species, reducing habitat and food for native animal species, and changing the composition of microbial communities (Innes & Zouhar, 2021). This species can also reduce biomass and diversity of co-occurring forbs, reducing both species richness and percent cover, likely due to allelopathy and water competition (Becerra et al., 2020).

Source: Informal publication

Q21: Impact on Particular Native Species

Rating: Unknown

Confidence: Not Rated

Centaurea solstitialis is described as a threat to some rare native plants, including the federally endangered *Silene spaldingii*, which is present in southeastern Washington (Innes & Zouhar, 2021; WNHP, 2024). However, absent further details and given *C. solsitialis'* high impact on community composition, it is difficult to say if any particular species is more strongly affected by *C. solstitialis* than the co-occurring plant community.

Source: Informal publication, Professional expertise

Q22: Observed Ability to Invade Undisturbed Ecosystems

Rating: Moderate

Confidence: Moderate

Centaurea solstitialis can invade undisturbed habitats if neighboring populations provide high propagule pressure, but they are more successful in disturbed habitats (Innes & Zouhar, 2021).

Source: Informal publication

Q23: Observed Ability to Invade Naturally Disturbed Ecosystems

Rating: Yes

Confidence: High

Centaurea solstitialis is most successful in disturbed areas, especially where litter has been removed and bare soil is exposed. However, it is less competitive against intact native plant communities, even in naturally disturbed habitats, and most successful in areas where human disturbance or management have already damaged native plant communities (e.g. conversion of native perennial grasslands to invasive annual grasslands) (Innes & Zouhar, 2021).

Source: Informal publication, Professional expertise

Section 4: Management Difficulty

Q24: General Management Difficulty

Rating: Moderate

Confidence: Low

The best management for *Centaurea solstitialis* is prevention, particularly by minimizing soil disturbance and maintenance of native plant communities. This includes managing for perennial species and diverse communities that are competitive against *C. solstitialis*, reducing propagule pressure by treating patches of *C. solstitialis* before they flower and fruit, preventing transportation of seeds by equipment, feed, and livestock, and monitoring and immediately addressing small populations when found (Innes & Zouhar, 2021).

Small populations of *C. solstitialis* can be managed or eradicated by hand-pulling (taking care to remove and properly dispose of all the above-ground parts of the plant) and herbicides. Large populations usually require a combination of long-term management techniques. Effective treatments include fire or mowing combined with grazing, herbicides, and biocontrol agents. Restoration of native vegetation communities, and ongoing monitoring and treatment of new populations is important for preventing reinvasion. The goals of long-term management of this species are to deplete the seed bank and establish desirable vegetation that can outcompete *C. solstitialis* (Innes & Zouhar, 2021).

Several biocontrol agents are available for managing *C. solstitialis*, including six insect species that attack flowers and seeds and one pathogen that attacks the vegetative portions of the plant. Most research suggests that biocontrol agents alone can reduce spread, but do not eliminate *C. solstitialis* populations (Innes & Zouhar, 2021). However, in Idaho County, Idaho, a release of *C. solstitialis* seed predators significantly reduced the abundance of this species, even on the overgrazed hillsides it had previously dominated—suggesting that biocontrols can be a successful management tool. Idaho and Nez Perce Counties are at the epicenter of *C. solstitialis* in Idaho (EDDMapS, 2023).

Source: Informal publication, Professional expertise, Reported observations

Q25: Minimum Time Commitment

Rating: Moderate

Confidence: Moderate

Preventing seed rain can reduce *Centaurea solstitialis* seed banks significantly in 3–4 years, but continued monitoring is still required to keep populations from reestablishing. Small populations can be removed by hand-pulling or herbicide in the amount of time it takes to significantly reduce the seedbank, but large populations likely require multiple management techniques and ongoing management to control (Innes & Zouhar, 2021). The assessor has observed in north-central Idaho that successful releases of biocontrol agents have greatly reduced management efforts for local landowners.

Source: Informal publication, Professional expertise

Q26: Impacts of Management on Native Species

Rating: Moderate

Confidence: Moderate

The use of broadscale herbicide treatment to knock back *Centaurea solstitialis* occurances can have a significant and permanent effect on native plant communities. At one site in Idaho, several native species that were present before broadcast herbicide treatment in 1995 (e.g. *Lomatium*, *Primula*, and *Veronica* species), have not been observed in the years since (M.F. Wiebush, pers. comm. 2024). Active restoration may be required to recover the native plant community after initial treatments for *C. solstitialis*. While broadcast herbicide treatments may have lasting effects on co-occurring native plants, available biocontrols for *C. solstitialis* have been relatively effective, at least in parts of Idaho, without spillover effects on native species.

Reduction of *C. solstitialis* can also increase abundance of invasive annual grasses like *Bromus tectorum* and *Taeniatherum caput-medusae*. Use of fire may have fewer negative effects on native species; *C. solstitialis* flowers and sets seed later than most associated native species, and prescribed fire to control this species is most effective after grasses have gone to seed. However, maintenance and restoration of native grassland and prairie communities is a necessary part of reducing and preventing *C. solstitialis* invasion, so most effective long-term management of this species may benefit co-occurring native species (Innes & Zouhar, 2021).

Source: Informal publication, Professional expertise

Q27: Inaccessibility of Invaded Areas

Rating: Low

Confidence: Moderate

Long-distance dispersal of *Centaurea solstitialis* is most frequently from human activity and it frequently expands along roads and trails (Innes & Zouhar, 2021), suggesting it usually occurs in relatively accessible locations.

Source: Informal Publication

Q28: Sociopolitical Implications of Management

Rating: Moderate/Low

Confidence: High

In southwestern Oregon, land managers may be restricted in pulling *Centaurea solstitialis* and related species once they start flowering because they are a floral resource for the federally endangered Franklin's bumblebee (*Bombus franklini*). *Centaurea solstitialis* is also used by honeybees, and beekeepers

could potentially have concerns about treating this species.

However, *C. solstitialis* has significant negative effects on rangeland quality and is poisonous to horses, suggesting that agricultural communities, at least, will have fewer objections to controlling this species. For example, in north-central Idaho, private landowners have initiated successful releases of biocontrol agents to reduce populations of *C. solstitialis* on their property and neighboring lands.

Source: Professional expertise

Additional Comments

None

References

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