DRAFT WRITTEN FINDINGS OF THE WASHINGTON STATE NOXIOUS WEED CONTROL BOARD

SCIENTIFIC NAME: *Celastrus orbiculatus*

SYNONYMS: *Celastrus articulatus var. Orbiculatus, Ilex leucantha, Catha articulata, Celastrus articulates, Celastrus articulatus var. humilis, Celastrus articulatus var. papillosus, Celastrus crispulus, Celastrus insularis, Celastrus jeholensis, Celastrus lancifolius, Celastrus orbiculatus f. aureoarillatus, Celastrus orbiculatus var. aureoarillatus, Celastrus orbiculatus f. major, Celastrus orbiculatus f. papillosus, Celastrus orbiculatus var. papillosus, Celastrus orbiculatus var. punctatus, Celastrus orbiculatus var. strigillosus, Celastrus strigillosus, Celastrus tatarinowii, Celastrus versicolor* (Plants of the World Online)

COMMON NAMES: roundleaf bittersweet, climbing spindleberry, staff vine, Oriental bittersweet, Oriental staff vine, Asiatic bittersweet

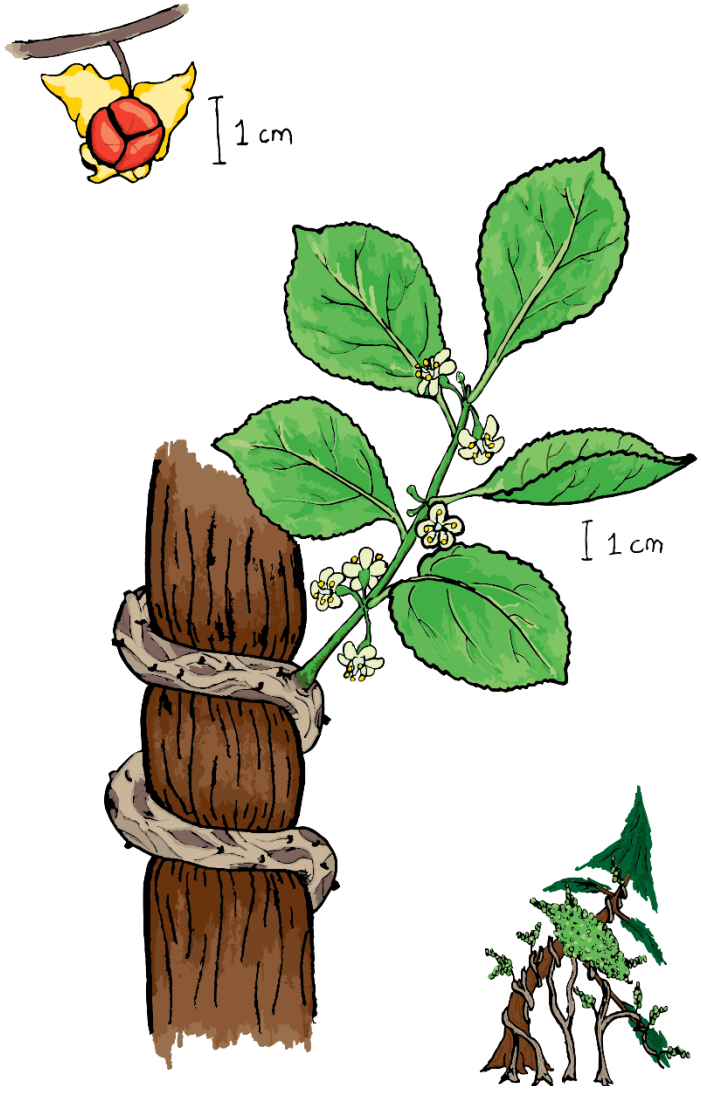
FAMILY: Stafftree family, Celastraceae

LEGAL STATUS: Considered for Class A listing

DESCRIPTION AND VARIATION

OVERALL HABIT:

Round leaf bittersweet is a vigorous, deciduous, woody vine (liana) with a twining growth habit (Leicht-Young *et al*., 2007; Pavlovic *et al*., 2016). It can climb, as a twining vine, to heights exceeding 30 meters (100 ft), utilizing other plants as support (Leicht-Young *et al*., 2007). In open areas with low vegetation, it can form dense, self-supporting thickets which readily spread via root suckering (Patterson, 1974).



Roundleaf bittersweet illustration by Anne Schuster.

Top: bark. Middle: leaves. Bottom: male flower. Photos by Tom Erler.

STEMS:

Mature stems are terete to slightly striate, woody, grayish to dark brown in color, initially glabrous but becoming rougher with age (Leicht-Young *et al*., 2007; McKenzie-Gopsill & MacDonald, 2021). Noticeable lenticels are typically present. Persistent bud scales, especially those at leaf nodes, become spine-like (up to 2 cm, less than 1 inch), affording it purchase when twining. (Berry, 2018; Leicht-Young *et al.,* 2007; McKenzie-Gopsill & MacDonald, 2021; Silveri *et al.,* 2001). Older stems of round leaf bittersweet can reach diameters of 10 cm (4 in), sometimes even 14 cm (5.5 in) (McKenzie-Gopsill & MacDonald, 2021).

Younger stems are light to dark brown, terete to slightly striate, and often have noticeable lenticels (Leicht-Young *et al*., 2007; McKenzie-Gopsill & MacDonald, 2021). Buds are small, ovoid to subglobose, often with spiny projections on the outer scales (McKenzie-Gopsill & MacDonald, 2021).

LEAVES:

Leaves are highly variable, alternate, and glabrous (McKenzie-Gopsill & MacDonald, 2021). They are typically obovate to suborbicular but can also be ovate or oval-oblong (Hou, 1955; Leicht-Young *et al*., 2007; McKenzie-Gopsill & MacDonald, 2021). Leaf margins are crenate-serrate, with a cuneate to obtuse base, and an acute to rounded tip. Petioles are 1–3 cm long (Leicht-Young *et al*., 2007 McKenzie-Gopsill & MacDonald, 2021). Leaves are deciduous and typically exhibit brilliant yellow fall coloration. In early spring, emerging leaves exhibit a distinctive conduplicate folding (folded flat against each other along the mid-vein (Leicht-Young *et al.*, 2007).

FLOWERS:

Flowers are inconspicuous, relatively small (4–10 mm diameter, a tenth to less than half of an inch) with five green sepals and five greenish-white or pale yellow, oblong petals. They are borne on short (2–5 mm) pedicels that are articulated. Flowers typically occur in clusters of 3–7 in short axillary cymes along stems, rarely terminal. (Hou, 1955; Leicht-Young *et al*., 2007; McKenzie-Gopsill & MacDonald, 2021). The nectar disk is shallow and membranous. Male flowers often have reduced petals and sepals

with five exaggerated stamens attached to the disk margin and a rudimentary pistil. Female flowers are slightly larger with reduced, sterile stamens, a tri-lobed stigma, prominent style and well-developed, superior, 3-celled ovary. (Hou, 1955).

Cluster of fertile berries. Photo by Leslie Mehrhoff, University of Connecticut

FRUITS/SEEDS:

The distinctive, ornamental fruits are spherical capsules 6–8 mm (less than a third of an inch) in diameter. Green while immature, the outer, leathery ovary wall changes to bright yellow as they ripen (September–October). When fully ripe the capsule splits open, revealing 3 to 6 dark brown seeds enclosed by a bright red, fleshy aril (Dreyer *et al.,* 1987; Hou, 1955; Leicht-Young *et al*., 2007; McNab & Loftis 2002). Fruits persist on the vines well into winter and provide an important food source for birds during the colder months (Pavlovic *et al.,* 2007b).

ROOTS:

Roots are woody, fibrous and highly adventitious, spreading laterally for long distances (4+ m or 13+ ft), facilitating clonal expansion, and enabling survival following mechanical damage (Pavlovic *et al.,* 2016). Round leaf bittersweet spreads rapidly through root suckering (Patterson, 1974; Williams & Timmins, 2019; Pavlovic *et al*., 2016). Roots contain orange to bright orange bark, a distinctive characteristic that assists in its identification (Pavlovic *et al.,* 2016).

Roots, note the orange tint. Photo by Tom Erler.

SIMILAR SPECIES:

American bittersweet, *Celastrus scandens*, is native to the midwestern US, but not present west of the Rockies (iNaturalist). In American bittersweet, the yellow outer casing of the fruit capsule is yellow, and the fruits grow from the end of stems, rather than from between leaf axils. Additionally, American bittersweet flowers are yellow-

ish, rather than white-ish, and when the plants are leafing out, the leaves curl inwards from both sides towards the midvein, rather than lightly folding along the midvein (Pavlovic *et al.*, 2007a).

The only woody vines that grow in Washington, common ivy (*Hedera helix, Hedera hibernica*), Clematis species, and honeysuckles (*Ionicera sp.*), all look very different from round leaf bittersweet, at all life stages (Burke Herbarium).

King County infestation of 40+ year old woody vines. Photo by Tom Erler.

HABITAT:

C. orbiculatus grows in a variety of disturbed and undisturbed habitats, including forests, woodlands, old fields, riparian areas, hedgerows, coastal dunes and marshes (Leicht-Young *et al*., 2007).

Within this wide range of habitat tolerance, the vine tends to occur in areas where environmental parameters associated with light, moisture, soil chemistry, topography and competition are relatively less suited to its congener, the native C. scandens, an occurrence often cited as possible evidence for habitat displacement or competitive advantage for the exotic vine (Dreyer *et al.,* 1987; Ellsworth *et al.,* 2004; Fike and Neiring, 1999; Leicht, 2005; Leicht-Young *et al.,* 2007; McNab & Loftis, 2002; Pande *et al.,* 2007; Pooler, 2002; Silveri *et al.,* 2001).

BIOLOGY

GROWTH AND DEVELOPMENT:

C. orbiculatus has developed a broad set of life-history adaptations to cope with variability in available resources (especially water and light) making it highly competitive in many ecosystems (Ellsworth *et al*., 2004a; 2001; Leicht & Silander 2006; Leicht-Young *et al*., 2007; McNab & Loftis, 2002; Pande *et al.,* 2007).

Seedlings establish under very low light intensities, persisting in deep shade (e.g., forested under-stories; Leicht & Silander 2006), and showing a significant increase in both aboveground and belowground growth in response to in-creased light (Patterson, 1975). Plants grown in conditions equivalent to those found in forests or beneath a leafy canopy are more slender, elongate stems in

proportion to plant mass and increase the ratio of leaf area to total biomass (Ellsworth *et al*., 2004; Leicht & Silander 2006).

Following a disturbance that thins the canopy, increases light penetration provides newly available small diameter stems, it responds by an initial rapid shoot elongation (often 3 meters, or 10 feet, of growth in 1 growing season), quickly reaching heights more than 12 m (40 ft) within several growing seasons, blanketing surrounding trees and shrubs in a dense, contiguous curtain of leafy growth (McNab & Loftis, 2002; Pavlovic & Leicht-Young, 2011). However, this increase in growth occurs with reduced diameter and overall lower biomass than plants experiencing lower growth under less-disturbed canopies (Leicht-Young *et al*., 2011; McNab & Loftis 2002).

Plants experiencing higher levels of sunlight may grow taller, have a larger biomass, and thicker leaves in comparison to the low biomass and lower growth rate (relative to total plant mass), with higher mortality seen in deeply shaded plants that do not have an opportunity to ascend towards increased light (Dreyer *et al.,* 1987, Leicht-Young *et al.,* 2007, Silveri *et al.,* 2001). Although considered a shade-tolerant species, *C. orbiculatus* requires full sun to reproduce sexually (Silveri *et al*., 2001).

REPRODUCTION:

Seed dispersal is facilitated by birds, small mammals, and humans (McKenzie-Gopsill and MacDonald, 2021). Bird dispersal is a primary mode of long-distance spread (Tibbetts, 2000).

Germinating seedlings. Photo by Tom Erler.

Seeds require cold stratification for optimal germination (Williams & Timmins, 2019). This process is often improved by seed removal from the fruit. Germination rates can be high (71-95%) and occur primarily in the spring and summer (Patterson, 1974; Dreyer *et al*., 1987).

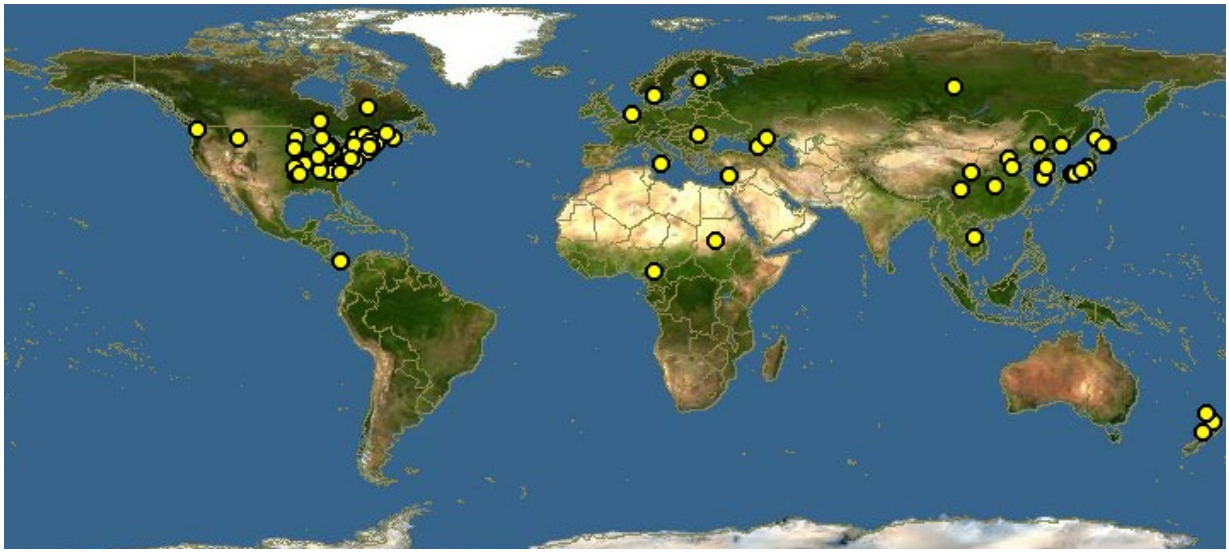
Seed banks are typically short-lived (Van Cleef & Stiles, 2001; Ellsworth *et al*., 2004), but the species is a prolific seed producer, ensuring a constant supply of germinants (McKenzie-Gopsill & MacDonald, 2021).

Round leaf bittersweet also reproduces vegetatively through resprouting and root-suckering (Dreyer *et al.,* 1987; Pavlovic *et al.,* 2016). These strategies enable the plant to persist following disturbance and contribute to local spread (McKenzie-Gopsill & MacDonald, 2021).

GEOGRAPHIC DISTRIBUTION

NATIVE DISTRIBUTION

Endemic to temperate eastern Asia: central & northern Japan, Korea, several regions of China north of the Yangtze River, far eastern Russia, southern Sakhalin Island (Hou, 1955; McKenzie-Gopsill & MacDonald, 2021; Zhu *et al.,* 2020), where it occurs in lowland slopes or thickets (Fike & Niering, 1999).



Global populations, from DiscoverLife.

NON-NATIVE DISTRIBUTION

C. orbiculatus is now naturalized in much of the eastern United States (from Maine south to Georgia; west to Arkansas, Missouri, Iowa, and Minnesota, and into southern portions of Canada (Leicht-Young *et al*., 2013; McKenzie-Gopsill and MacDonald, 2021; McNab and Loftis, 2002; Patterson, 1974; Zaya *et al.,* 2015, 2017).

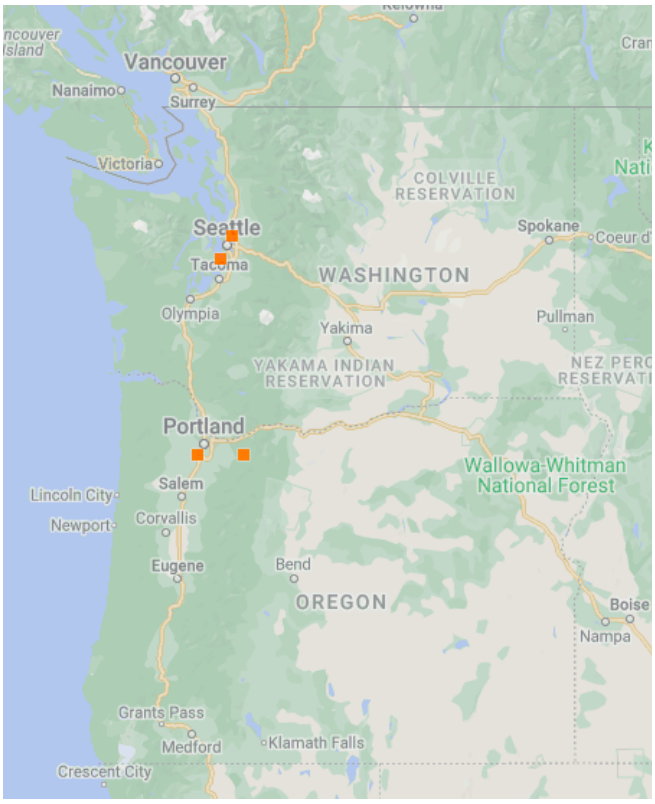
It is present in New Zealand primarily in the North Island with isolated populations in the South Island. Naturalized populations have been reported since 1981 in both the North and South islands of New Zealand and are typically small (Williams & Timmins 2019). It has been introduced into Europe where naturalized populations are mostly reported from disturbed areas in or near urban and residential settings (van Valkenburg, 2018). The U.K. is the only European country where *C. orbiculatus* has been observed in woodlands (Tibbetts, 2000).

HISTORY:

Not many historical records in the Pacific Northwest, due to being uncommonly sold in nurseries. One record is present from 1975 in Washington (Consortium of Pacific Northwest Herbaria).

WASHINGTON:

One infestation was documented by King County Noxious Weed Control Program staff at Wax Orchard, a new park on Vashon Island, on October 18th, 2023 (Tom Erler, 2024). The property formerly operated as a nursery in the mid to late 1900's (Vashon-Maury Island Beachcomber). The population comprised large diameter (up to 15 cm/6 in), heavy vines hanging and sprawling through mixed alder, cottonwood, and Douglas fir canopy up to a height of approximately 70 feet (21.33 m) and showed damage to both the upper canopies and girdling of trunks. Smaller, whip-like vines scrambled and layered in both moist and dry soils. Several fruiting plants demonstrated the presence of both male and female plants. In a follow up survey on May 30, 2024, seedlings were found within the known footprint of the existing population (Tom Erler, 2024).



iNaturalist records in Washington and Oregon.

NEARBY TO WASHINGTON:

OREGON:

In September 2023, the WeedWise program in Clackamas County collected a specimen for the OSU herbarium and it was determined to be *Celastrus orbiculatus* by James Mickley (Curator, OSU Herbarium) despite no fruit present (which could be a result of the repeated control attempts by landowner). The vines were demonstrating vigorous vegetative regrowth and sprawling among and constricting wetland-type plants at multiple levels of structural diversity. In late April 2024, a second population of round leaf bittersweet was discovered in Clackamas County and confirmed by James Mickley (Tom Erler, 2024).

IDAHO:

There are no known occurrences of *C. orbiculatus* in Idaho.

BRITISH COLUMBIA:

There are no known occurrences of *C. orbiculatus* in British Columbia.

CALIFORNIA

There are no known occurrences of *C. orbiculatus* in California.

LISTINGS:

In the U.S., round leaf bittersweet is listed most Midwest and Atlantic Coast states, with the exceptions of Michigan, Ohio, Iowa, Connecticut, and Florida. Round leaf bittersweet is also on New Zealand's National Pest Plant Accord (New Zealand Plant Conservation Network, 2020), and considered invasive in the European Union (van Valkenburg, 2018).

Round leaf bittersweet climbing to the canopy. Photo by Tom Erler.

ECONOMIC AND ECOLOGICAL IMPORTANCE

DETRIMENTAL:

This species impacts forestry practices in its nonnative ranges primarily via: increasing the probability of windthrow as its stems intertwine with those of neighboring plants (i.e., increasing the amount of edge as it forms "edges" across trees) making tree stems and even whole canopies more likely to snap, bend or be uprooted from their anchor (Leicht Young *et al*., 2009, 2013), and, reducing overall timber product quality by diminishing tree and stem vigor due to the constriction of xylem sap and phloem sap flow, as well as damaging stem form from excessive girdling resulting in distorted bole shape (McNab and Loftis 2002), with the cumulative cost of these impacts most obvious following timber harvests where there has been damage to neighboring and non-targeted vegetation during harvesting of trees containing thick intertwined tangles of bittersweet vine (Silveri *et al.,* 2001; McNab & Loftis 2002).

Costs of removing invasive *C. orbiculatus* to facilitate recovery or regeneration in natural settings add additional economic losses that are borne by a variety of public agencies or institutions (Hoosein and Robinson, 2018).

Native ecosystems are negatively affected, due to the following invasion mechanisms: vigorous growth, blanketing, and girdling native tree and shrub stems; root suckering that generates clonal spreading; abundant, long-distance seed dispersal (predominantly by birds); a plastic and responsive life cycle; its impact on community processes, such as soil nutrient and chemistry cycling; and its ability to occupy and thrive in many diverse, unstable, habitats ranging from dune ecosystems to shaded forests and agricultural field margins (Albright *et al*., 2009; Browder, 2011; Dreyer *et al.,* 1987; Fike & Niering, 1999; Leicht & Silander, 2006; Leicht-Young & Pavlovic, 2012; Leicht-Young *et al.,* 2007, 20091987; McNab & Loftis, 2002; Patterson 1974; Silveri *et al.,* 2001; Steward *et al.,* 2003). In these invaded areas, forest composition and function may be permanently altered, especially when early detection and intervention fail (Fike and Niering 1999).

Leaves and woody vine. Photo by Tom Erler.

Invasive *C. orbiculatus* threatens the genetic identity of the native American bittersweet (*C. scandens*) through hybridization. Although all naturally occurring hybrids detected to date are derived from a C. scandens seed parent (suggesting pollen flow is unidirectional; Zaya *et al*., 2015) there is concern that widespread propagule pressure and limited access to conspecific pollen in wild populations will contribute to a decline in C. scandens genetic integrity (Zaya *et al.,* 2017; Pooler *et al*., 2002).

Round leaf bittersweet has been documented as a host for spotted lanternfly, which threatens agricultural commodities (Murman *et al.,* 2020).

BENEFICIAL:

While the species' historic use and popularity in North American horticulture declined once its noxious properties became apparent, it still provides economic returns for those cultivating it as: a cash crop for harvest as dried or "fall foliage" stems, garlands, and wreaths and as bonsai and as potted seedlings, primarily sold via seasonal catalogs and wholesale distributors. (Del Tredici, 2014).

Demand persists as crafters utilize its long stems (covered in fall-persistent brilliant red, orange or yellow-orange capsules containing scarlet aril encasing dark seeds) to form wreaths, garlands and arrangements, particularly sought-after for their ornamental attributes that enhance both secular and religious holidays, weddings and memorial ser-vices throughout its introduced range in North America (Dreyer *et al.,* 1987; Williams & Timmins 2003).

Potential pharmaceutical and medical applications as antifungal or antimicrobial agents as well as a possible chemo-therapeutic agent, and its efficacy for the treatment of certain disorders (such as arthritis or diabetes) have recently been shown or noted, but its commercial development remains minimal (Shen *et al.,* 2019; Zhixiang & Funston, 2008).

C. orbiculatus fruits and seeds are an important winter food source for birds, contributing to their nutritional support during lean periods, particularly because its berries persist for longer than most native species (Dreyer *et al*., 1987). The flowers are attractive to various insect pollinators, as confirmed in studies where fruit development and seed set increased with an abundance of hymenopteran visitors (McNab & Loftis 2002).

Regrowth after cutting.
Photo by Tom Erler.

CONTROL

MECHANICAL:

Hand-pulling is useful as a control strategy for recently established or for individual, smaller plants but is most effective during spring and fall when soil moisture content is at optimum levels to allow removal of roots (Lynch *et al.,* 2011; Wooten, 2013).

However, to avoid generating an abundance of root suckers that can proliferate as a clonal colony (Patterson, 1974; Dreyer *et al.*, 1987), all portions of root system and runners must be completely extracted, and seeds should not be allowed to develop or germinate for several years following treatments (Chandler, 2011; Williams & Timmins, 2003; Pavlovic *et al.,* 2016; Zaya, 2013). Thus, for practical application, hand-pulling is unlikely to succeed with established, widely dispersed or higher-density infestations where vines or fruits occur beyond arm's reach.

These practices work best if consistently implemented annually and for at least five years since long-term seedling viability in the soil remains a potential. However, if root segments, runners, and sprouting buds or other propagules persist they readily produce an abundant number of adventitious roots which

give rise to additional shoots com-pounding future eradication challenges (Dreyer *et al*., 1987, Williams & Timmins, 2003).

Girdling has been suggested as a method of controlling climbing plants, by disrupting water and sap flow, with a follow up chemical control 60 d after girdling (Lynch *et al.,* 2011; Wooten, 2013); however, for round leaf bittersweet girdling alone does not consistently reduce vine abundance since regeneration can occur from dormant or adventitious buds above, as well as from roots below, the girdle wound.

Cutting or mowing is similarly not recommended as a control strategy as cut stems readily resprout at stem or collar buds, as well as at the root collar, where they also readily produce root-suckers (Lynch, 2009).

Cutting can, however, control the lateral spread of larger vines that might cause physical damage to neighboring vegetation and can diminish seed production. Repeated mowing of regrowth, as a surrogate for browsing, can exhaust root carbohydrate reserves; but irregular mowings typically conducted by homeowners actually favor root suckering and clonal spread (Dreyer *et al.*, 1987).

While prescribed fire is routinely used to remove excess "ladder fuels," regenerate rare species, and control infestations of undesirable vegetation (including certain invasive plant and woody species) (Pande *et al.,* 2007) there is minimal consensus on the suitability of this control measure when considering the long-term control of invasive round leaf bittersweet (Pavlovic *et al.,* 2016). Small stems readily succumb to heat treatment, and may reduce the seed bank, though thicker stems can persist, underground root suckers can still spread, and a crown fire would often be needed to remove much of the seeds higher in the canopy. Additionally, the open areas created by fire can lead to high levels of germination (Kuhman *et al.,* 2013; Pavlovic & Leicht Young, 2016).

Empty understory after removal. Photo by Tom Erler.

CULTURAL:

Limiting disturbance, such as clearing land for development, can help prevent the spread of round leaf bittersweet (McNab & Loftis, 2002). Continued monitoring of known infestations is crucial for successful control. Educating horticulturalists and the public about the invasive nature of round leaf bittersweet and promoting the use of native alternatives can help prevent further introductions (Dreyer *et al.*, 1987). Early detection and rapid response (EDRR) strategies for managing incipient, isolated or sparse infestations have been undertaken by various land stewardship entities, such as federal, state,

Top and bottom: Cut stump herbicide treatment. Photos by Tom Erler.

county, and regional groups, (Pavlovic *et al.,* 2012). These include volunteer-led and citizen science-oriented invasive control efforts that have the additional benefits of informing the wider public and garnering popular support for restoration and conservation goals (Zaya, 2013). Preventing the sale of *C. orbiculatus* or round leaf bittersweet and promoting the use of native species has been attempted. These control strategies often run up against existing trade (and aesthetic) incentives in horticulture and elsewhere (Del Tredici 2014), in addition to limitations and costs of enforcement.

BIOLOGICAL:

There are presently no approved biological control methods, including fungi, viruses or bacteria that can reliably infect and destroy round leaf bittersweet populations.

CHEMICAL:

Herbicide application appears to be the most effective control strategy. The two broad spectrum systemic herbicide compounds that have yielded consistent and positive results in mitigating infestation in its introduced range are glyphosate and group 4 herbicides, particularly triclopyr (Burhans, 2012; Dreyer *et al.*, 1987; McNab & Loftis 2002).

Foliar application of glyphosate or triclopyr ester has proven to be very effective when sprayed on smaller vines, where foliage is readily accessible and incidental spray damage to non-target vegetation can be avoided (Lynch, 2009). These sprays are considered most effective if applied during the autumn months (i.e., shortly before initiation of winter dormancy; Dreyer *et al.*, 1987), as water and nutrients being transported down from aboveground portions are shuttled to the roots and would transport the systemic compound more efficiently. The application of cut stem and basal bark treatment methods using higher concentration solutions on thicker vine stems can also achieve

satisfactory results but can take an extended time (months) for plant tissue above and below treated sites to begin wilting (Burhans, 2012; Dreyer *et al.*, 1987; Lynch, 2009).

In King County, the round leaf bittersweet was treated on February 8th, 2024, with different methods including a cut stump treatment of 50% triclopyr (Garlon3A) applied at 48-50 degrees. A site revisit on May 30th, 2024, demonstrated 100% control 15 weeks after treatment (Tom Erler, personal communication, 7/24/2024). In Oregon, in October 2023, the WeedWise program sprayed round leaf bittersweet foliage using a 0.5% imazapyr formulation (Tom Erler, 2024).

RATIONALE FOR LISTING

Round leaf bittersweet has a wide array of detrimental economic and environmental consequences resulting from its rampant, destructive growth and spread. It is not frequently sold by nurseries or online in Washington. It is easy for the general public to identify round leaf bittersweet, due to the fact that no other woody vines that grow in Washington look at all like it. Control measures are effective with follow up maintenance. Eradication of the few known populations of *C. orbiculatus* in Washington is very feasible, while a listing would help stop future infestations.

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