
COMMONWEALTH of VIRGINIA

Management Plan for Two-horned Trapa (*Trapa bispinosa* var. *iinuami* Nakano)



Virginia Department of Conservation and Recreation
Division of Natural Heritage
Natural Heritage Technical Report 22-15
July 2022



Department of Conservation & Recreation

CONSERVING VIRGINIA'S NATURAL & RECREATIONAL RESOURCES

Management Plan for Two-horned Trapa (*Trapa bispinosa*)

Prepared by

A.G. Sweany and Kevin Heffernan

Virginia Department of Conservation and Recreation
Division of Natural Heritage

600 East Main St., 16th Floor
Richmond, VA 23219

This report should be cited as follows:

Sweany, A.G., and Kevin Heffernan. 2022. Management Plan for Two-horned Trapa (*Trapa bispinosa*). Natural Heritage Technical Report 22-15. Virginia Department of Conservation and Recreation, Division of Natural Heritage. Richmond, Virginia. 13 pp. plus appendix.

Table of Contents

| | |
|--|----|
| Acknowledgments | 1 |
| Introduction | 2 |
| Life History | 2 |
| Introduction and Spread | 3 |
| Impacts | 6 |
| Control | 6 |
| Regulation | 7 |
| Management Plan | 8 |
| Citations | 11 |
| Appendix A – DCR Two-horned Trapa Fact Sheet | 13 |

Figures

| | |
|--|---|
| Fig. 1. Images of two-horned trapa | 3 |
| Fig. 2. Map of two-horned trapa occurrences in Virginia and Maryland | 4 |
| Fig. 3. Screenshot of the two-horned trapa map dashboard | 4 |
| Fig. 4. Mats of two-horned trapa on Burke Lake | 5 |
| Fig. 5. Aerial view of a pond infested with two-horned trapa | 6 |

Acknowledgements

The authors thank Nancy Rybicki (United States Geologic Survey-retired), who has gone above and beyond to document two-horned trapa and call attention to the threat it poses to the health of our ponds, lakes, streams and rivers, and from whom we received excellent data, first-hand knowledge, and persistent encouragement. Additional information and insight came from Ian Pfingsten (USGS), Sara Tangren (District of Columbia Partnership for Regional Invasive Species Management), and John Odenkirk (Department of Wildlife Resources). We are indebted to Mike Naylor and the Mid-Atlantic Panel on Aquatic Invasive Species for the *Water Chestnut in the Chesapeake Bay: A Regional Management Plan*, which effectively guided management of European water chestnut and served as a template for this publication. Funding for our work came from the USFWS Aquatic Nuisance Species Task Force (ANSTF). Much gratitude goes to the USFWS who staff the ANSTF program, including Don MacLean, Sandra Keppner, Gabe Gries, and Heidi Himes. Many thanks go to the DWR and Fairfax county staff and regional volunteers who have put many hard sun-soaked and sweaty hours into removing two-horned trapa from local lakes and ponds. Finally, the authors thank members of the Trapa Task Force who generously discussed and reviewed this plan.

Introduction

Two-horned trapa (*Trapa bispinosa*), also known as two-horned water chestnut, was first identified in the U.S. in Pohick Bay, Lorton, Virginia, in 2014. Originally thought to be the first colony of the highly invasive Eurasian water chestnut (*Trapa natans*), a highly invasive species which was eradicated from Virginia decades ago. Morphological differences in this new *Trapa* population led to the determination that this was a different species with a similar threat. Eurasian water chestnut produces 4-horned seed pods, while the seed pods of the new discovery have only 2 horns and two smaller, pseudo spines. Through DNA analysis and morphological comparison of *Trapa* specimens from around the world, the new Virginia colony of *Trapa* was identified as *T. bispinosa* in 2019. (Chorak et. al, 2019) The native range of this species includes Taiwan, Korea, Japan and China. (Hseih, 1994)

Due to the similar rapid, dense growth of the two *Trapa* species, the spread of two-horned trapa threatens to undo the multi-million dollar efforts made by the US Army Corps of Engineers and natural resource partners over several decades to eradicate Eurasian water chestnut from the Chesapeake Bay watershed. This plant has the potential to spread throughout Virginia and beyond, with more colonized waters in the region found each year. All *Trapa* species are non-native in the U.S and are considered invasive plants that require early detection and rapid response due to the historic and present impact of Eurasian water chestnut in the Mid-Atlantic and Northeast regions.

Life History

Two-horned trapa is a floating, annual, aquatic plant with submerged stem and roots. It prefers full sun in freshwater tidal rivers, streams, ponds, reservoirs, lakes and wetlands; relatively shallow, slow moving or still water. Roots are long and anchor the plant into the mud in waters up to 12 feet deep (Pfungsten, 2021). Fan-shaped leaves have doubly serrated margins and form a central rosette. Floating leaves are green above with red undersides, each leaf having a distinct “inflated” petiole that allows the plant to float. Beginning in June, small, four-petaled, pink flowers emerge from the rosette center. Two-horned trapa may flower and produce fruit from June until frost. Seed pod is a large drupe (1.5-2 in) with two opposing “horns.” Two-horned trapa dies in late autumn with frost. Seeds can lie dormant for at least two years, while the upper range of seed dormancy is debated. A high majority of *Trapa* species seeds (97-100%) will germinate in the first or second year after they are produced (Kunii, 1988).

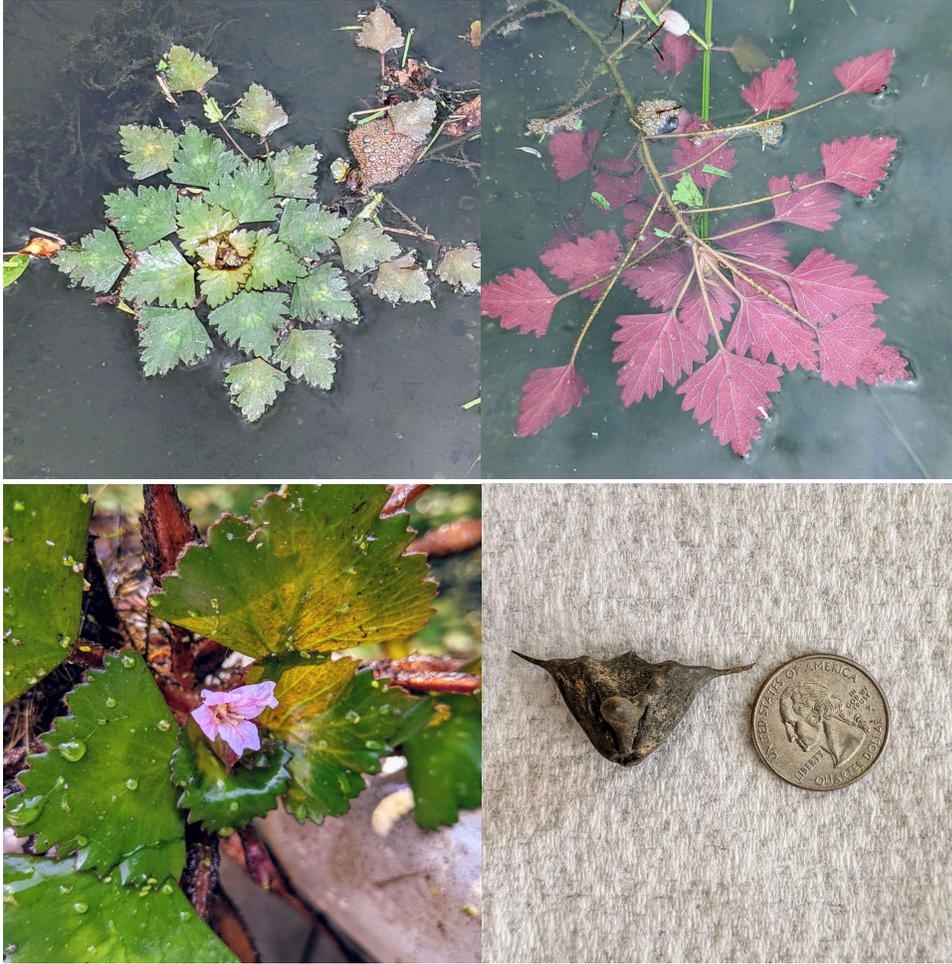


Figure 1. Two-horned trapa. Clockwise from top left: Rosette of floating leaves; underside of leaves showing characteristic color; flower; seed pod. Photos by Kevin Heffernan, DCR.

Introduction and Spread

Two-horned trapa was possibly introduced as an ornamental (Pfungsten and Rybicki, 2022), but it is not known to be in the horticultural trade as a live plant. Dried seeds are offered on Internet sites. Two-horned trapa spreads outside of cultivation and has been identified in over seventy water bodies in Northern Virginia across 6 counties, 4 of which have current known populations. New infestations of two-horned trapa are documented each year in Northern Virginia. Though only identified in Virginia 2014, it may have been spreading in the state for decades, with two records from 1995 in Westmoreland and Stafford counties retroactively identified as two-horned trapa. The seed pods of two-horned trapa can cling to the feathers of waterfowl, especially resident Canada geese (*Branta canadensis*), animal fur, rope, clothing, and wooden materials, allowing dispersal between neighboring water bodies (Rybicki et al 2019; Hummel & Kiviat, 2004). Ongoing survey efforts of neighboring water bodies within 2 to 3 miles of known two-horned trapa sites, as well as waters on the borders of the current known extent will help clarify the distribution and trend of spread.

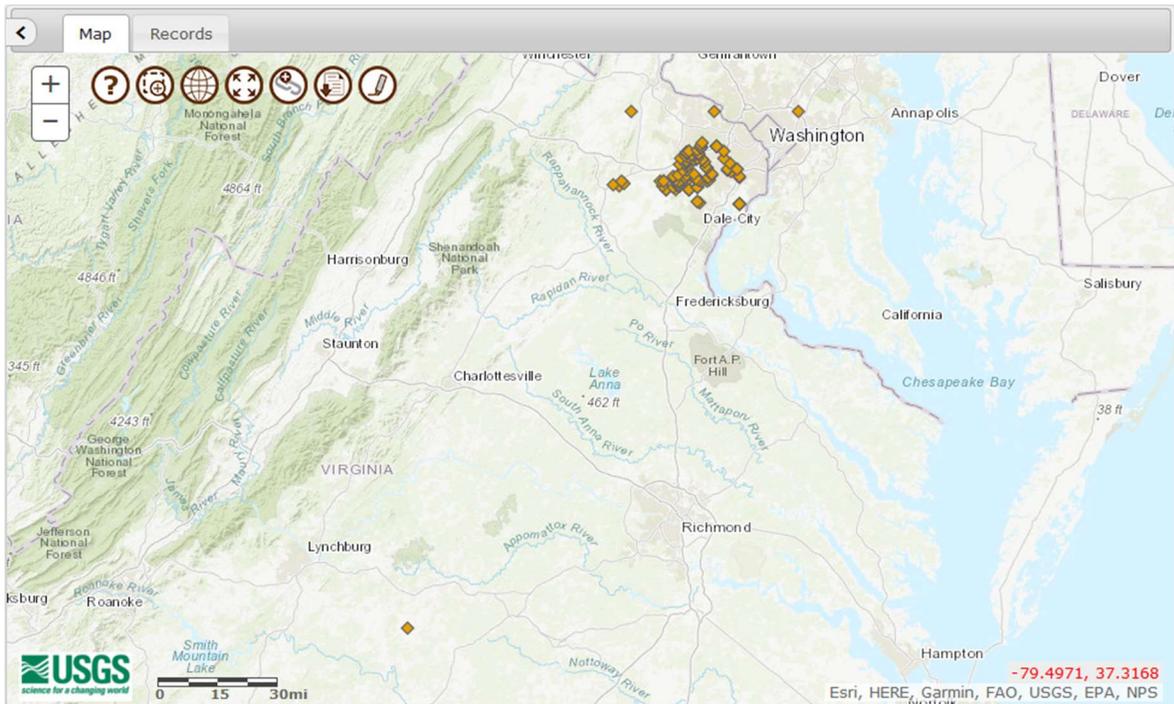


Figure 2. Map of two-horned trapa occurrences in Virginia and Maryland. There are 124 occurrence records as of July 2022. Map from the [USGS Nonindigenous Aquatic Species database](#).

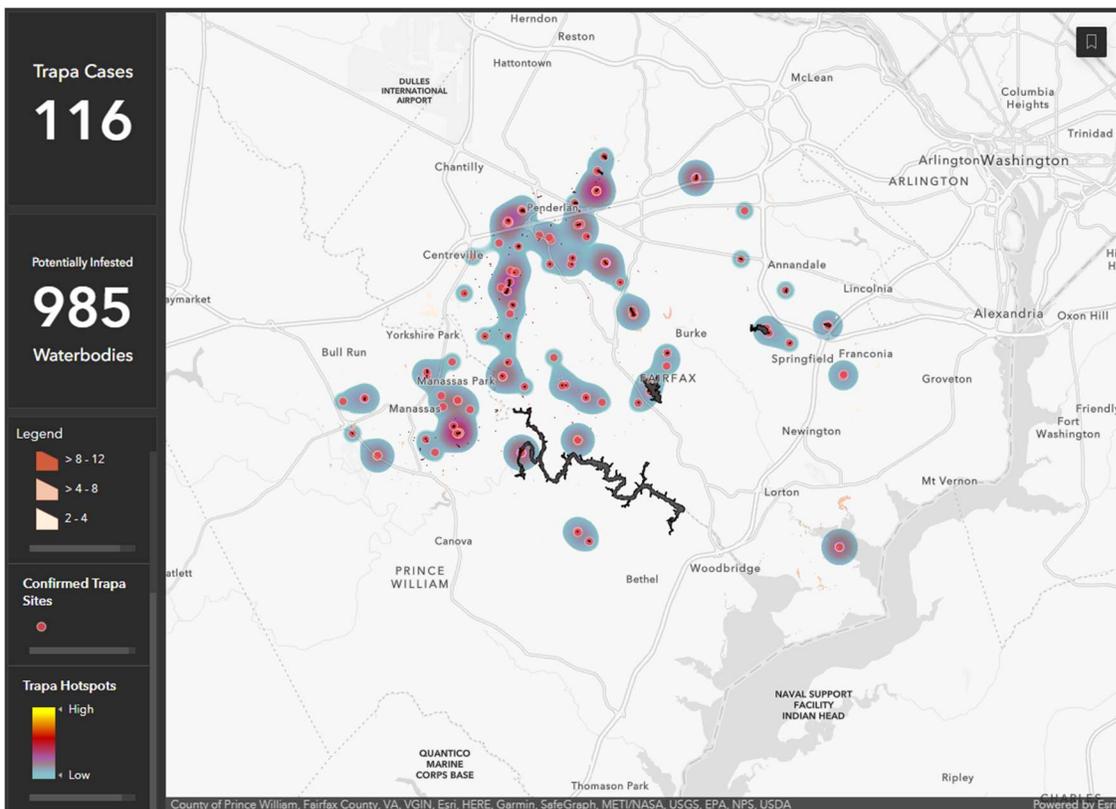


Fig. 3. Two-horned trapa dashboard allows users to see infestation hotspots and waterbodies at risk according to proximity to known trapa occurrences. [See the DCR map online](#).

Impacts

1. Ecological

Trapa sp. forms dense floating mats that spread and cover slow-moving bodies of water. These mats inhibit up to 95% of light from penetrating into the water. (Hummel and Kiviat, 2004) Similar to the devastating impacts of Eurasian water chestnut, two-horned trapa has the potential to obstruct water flow, reduce dissolved oxygen (leading to fish kills among other negative impacts), shade out submerged aquatic vegetation, and outcompete native aquatic plants. (DiTomaso et al. 2013; Strayer 2010) Reciprocal competitive effects have been documented between *Trapa* sp. and American eelgrass (*Vallisneria americana*), with both reducing the reproductive activity of the other when co-occurring (Dodd et al. 2021). Waters covered in *Trapa* sp. result in lower quality foraging habitat for waterfowl (Hummel and Kiviat 2004).



Figure 4. Mats of two-horned trapa lining Burke Lake reservoir in Fairfax, VA. Photo by AG Sweany, DCR.

2. Recreational and Commercial

Water bodies overgrown with two-horned trapa may lose recreational, fishing, aesthetic and boating value. Seed pods that wash onto shore are sharp enough to pierce through clothing and shoes, causing

injury. Private property owners with infested ponds or lakes may perceive or experience a decrease in property value and usage ability, or suffer the costs of management.



Figure 5. Aerial view of a pond infested with two-horned trapa in Northern Virginia. Photo by Kevin Heffernan, DCR.

3. Economic

Two-horned trapa infestations are costly to land managers and private property owners. Though straightforward if done carefully, the management and eradication of this species is time consuming and requires several years of follow up effort to be successful. While herbicide application decreases the cost of labor, the product itself can be expensive. One 7.5 acre site required nearly \$1,500 of Flumioxazin at 200 ppb to treat. (John Odenkirk, pers. comm.) Hand removal requires estimated hundreds of person hours to be effective and requires a minimum of 2-5 years of thorough efforts. (Nancy Rybicki, pers. comm.) If two-horned trapa spreads into the nearby Potomac River, there is great potential for significant economic impacts.

Control

Control efforts are ongoing at many sites. Hand removal is labor and time intensive, but effective. Research into the efficacy of chemical treatments is ongoing. Due to the similarities between the two species, practical management methodology is similar to that of European water chestnut. For large scale removal, mechanical harvesting and chemical control measures can be used in conjunction.

As an example of the costs associated with *Trapa sp.* removal, the management of *Trapa natans* in Lake Champlain by Vermont and New York state agencies cost a total of \$9.6 million between 1982 and 2011. New York state Invasive Species Information reports that in years when funding decreased, the weed

rapidly grew back and expanded its coverage of the lake. (New York Invasive Species Information 2019) This is consistent with other reports that control efforts must be completed for several years to reach eradication.

1. Manual Removal

Hand removal efforts must be thorough and repeated for an estimated 2 to 5 years if completed prior to seedset, and several years longer if efforts are incomplete. (Nancy Rybicki, pers. comm.) Hand harvesting is effective in small bodies of water, or ponds or lakes where the entire infestation is accessible by wading or by boat. Plants should be removed from the water, prior to when plants begin to seed in late June to early July to prevent seed bank development. Plant matter may be left in the sun to dry out, then burned, buried, or bagged. Seeds that fall into the sediment will sprout the following year, or may lay dormant for at least two years.

Further research of the costs of hand-pulling two-horned trapa is desired. Currently there is little formal documentation on cost of this method. In one case, 1.25 acres of *T. bispinosa* coverage in a Northern Virginia pond required and estimated 640 person hours to remove all plants in the first year. (Nancy Rybicki, pers. comm.) If large populations of *T. bispinosa* develop, mechanical harvesting is an effective practice that may become necessary to clear clogged waterways.

2. Chemical Control

Research into the efficacy of various chemical treatments on *two-horned trapa* is ongoing by the US Army Corps of Engineers. Private lake management companies in Northern Virginia currently utilize flumioxazin and imazamox with good results to manage *two-horned trapa*. A combination of diquat and flumioxazin reportedly works well, or diquat can be used alone (with a surfactant) to reduce treatment costs. (John Odenkirk, pers. comm.) 2,4-D and glyphosate have been used against *Trapa natans* in the past, but are anecdotally less effective against *two-horned trapa*. Recommended timing of treatment is late spring to mid-summer before most plant flower and fruit (John Odenkirk, pers. comm).

3. Biological Control

The water lily leaf beetle (*Galerucella birmanica*) has shown promising results against *Trapa* sp., but host specificity tests have resulted in minor though not insignificant unintended herbivory on native watershield (*Brasenia schreberi*) (Ding et al. 2006). Further research into biological control agents is needed.

Regulation

State

Two-horned trapa is currently under consideration for listing as a noxious weed in the state of Virginia. A risk assessment has been completed and the determination on its status is forthcoming as of July 2022.

Federal

Two-horned trapa is not federally regulated. In 2016, USDA - APHIS conducted a risk assessment of *Trapa natans*, which included an assessment *Trapa bispinosa*, (then considered a synonym of *T. natans*) and determined it to be of high risk (USDA-APHIS, 2016).

Management Plan

Goal: Eradicate populations of two-horned trapa while they are small to minimize spread, reduce ecological impact, and prevent costly, large-scale removal efforts.

A. Leadership, Coordination and Regulatory Authority

Needs: A coordinated state and regional effort to limit the spread and establishment of new populations of two-horned trapa.

Objective: Form and designate an official leadership group to promote coordination efforts across jurisdictions.

Actions:

1. Establish a leadership group with representatives from state agencies, local jurisdictions, private natural resource partners, and D.C. and Maryland natural resources partners.
2. Meet periodically to coordinate and standardize efforts and share new information and control methodology.

B. Prevention

Needs: State and watershed-wide early detection, rapid response monitoring effort of current and new infestations to minimize the risk of spread into new areas.

Objective 1: Educate the public, private landowners, land managers and natural resource personnel on identification of two-horned trapa, prevention of spread, and reporting methods.

Actions:

1. Design and implement outreach materials and online resources to educate target audiences and prevent further spread.
2. Standardize reporting methods.
3. Encourage the use of EDDMapS.org, iNaturalist.org, and other mapping and reporting tools.

Objective 2: Expand and coordinate two-horned trapa monitoring programs.

Actions:

1. Review monitoring needs
 - a. Assess and identify gaps in monitoring needs by county.
 - b. Identify priority sites to monitor for pioneer populations.
 - c. Evaluate and standardize existing monitoring protocols.
2. Improve monitoring efforts based on identified needs by jurisdiction
 - a. Expand monitoring capacity: enlist volunteer organizations, resources from natural resource agencies or other organizations.

- b. Establish clear goals for monitoring, such as 25% of priority sites in a given time frame.
3. Coordinate long-term monitoring and periodically assess effectiveness of both monitoring methods and control/eradication practices.
 - a. Formulate methods to provide up to date information online on agency and partner webpages and accessible GIS Maps.

Objective 3: Encourage local municipalities to engage in two-horned trapa control, monitoring and prevention efforts.

1. Develop training or information materials for local government land managers to implement.
2. Develop and share a Best Management Practices (BMP) manual to municipal managers, parks staff, natural resource personnel, clubs etc.

C. Control and Management

Needs: Publicly accessible, up to date information on status of management and eradication efforts and approved treatment methods. Apply treatment efforts appropriate to priority sites.

Objective 1: Clarify the threats two-horned trapa faces to the environment, the fresh waters of Virginia and neighboring states as well as to the Potomac River and Chesapeake Bay watershed.

Actions:

1. Conduct an assessment of the economic and financial impacts of two-horned trapa.
 - a. Include potential costs of management if infestations spread into Potomac River or other large bodies of water.
 - b. Estimate current costs of management: state and local natural resource staff, volunteer hours, herbicide application, etc.

Objective 2: Publish a publicly accessible GIS map of infestations and determine priority areas in need of management action.

Actions:

1. Conduct a review of known infestation locations, current and yearly site conditions, type of water body, aerial coverage and density.
2. Identify a central contact point (person, agency, group) that compiles reports on sightings and archives and shares updates with participating natural resource managers, local jurisdictions and other relevant partner organizations

Objective 3: Review current eradication and control measures and make standardized recommendations

Actions:

1. Conduct a formal review of chemical, mechanical and biological control methods in the laboratory and/or in the field.
 - a. Provide for funding to conduct research into the cost and effectiveness of these methods.
2. Consult with state and federal agencies for compliance and potential new eradication and control measures.
3. Review legislation and local regulations that provide access to properties for surveys, containment, control and eradication.
4. Develop site specific Integrated Pest Management plans specific to each site
 - a. Create protocol to determine sites that pose the greatest threat.
 - b. Implement control method that is the most practical and effective for each individual site.

Objective 4: Implement control and eradication methods as formulated by this plan at priority sites.

Actions:

1. Develop a work plan that best fits the needs of each site to be managed.
2. Implement work plan by determining the appropriate control methods.
 - a. Complete follow up surveys to determine the success of the given control method at the given site.

D. Communication and Information Access

Needs: Interagency communication. Designation of a central contact point/person. Creation of a DCR two-horned trapa web page and other online resources.

Actions:

1. Develop means to communicate and share up to date information on sightings, report verification and management.
2. Designate a central contact
 - a. Hire for or expand capacity for VA DWR, or other state or local agency, staff person(s) to take on coordination responsibilities.

III. Citations

Chorak, G. M., Dodd, L. L., Rybicki, N., Ingram, K., Buyukyoruk, M., Kadono, Y., Chen, Y. Y., & Thum, R. A. (2019). Cryptic introduction of Water Chestnut (*Trapa*) in the Northeastern United States. *Aquatic Botany*, 155, 32–37.

<https://doi.org/10.1016/j.aquabot.2019.02.006>

Ding, J., Blossey, B., Du, Y., & Zheng, F. (2006). *Galerucella birmanica* (Coleoptera: Chrysomelidae), a promising potential biological control agent of water chestnut, *Trapa natans*. *Biological Control*, 36(1), 80–90.

<https://doi.org/10.1016/j.biocontrol.2005.08.001>

DiTomaso, J.M., G.B Kyser et al. 2013. *Weed Control in Natural Areas in the Western United States*. Weed Research and Information Center, University of California. 544 pp.

Dodd, L. L., Harms, N. E., & Schad, A. N. (2021). Reciprocal competitive effects of congeneric invaders, *Trapa natans* L. and *Trapa bispinosa* Roxb. var. *iinumai* Nakano, in established Freshwater Plant Cultures. *Aquatic Botany*, 1, 103419.

<https://doi.org/10.1016/j.aquabot.2021.103419>

Hsieh, C.F. 1994. Onagraceae. Page 899 in *Flora of Taiwan*. 2nd edition. Editorial Committee of the Flora of Taiwan. Taiwan, China.

Hummel, M., & Kiviat, E. (2004). Review of World Literature on Water Chestnut with Implications for Management in North America. *J. Aquat. Plant. Manage.*, 42, 17–28.

Kunii, H. (1988). Longevity and germinability of buried seeds in *Trapa* sp. *Mem Fac Sci Shibane University*, 22, 83–91.

New York Invasive Species Information. Water Chestnut. (2019, September). Retrieved March 17, 2022, from http://nyis.info/invasive_species/water-chestnut/

Pfingsten, I.A., and N. Rybicki., 2022, *Trapa bispinosa* var. *iinumai* Nakano: U.S. Geological Survey, Nonindigenous Aquatic Species Database, Gainesville, FL, <https://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=2974>, Revision Date: 2/7/2022, Access Date: 3/7/2022

Rybicki, N, Swearingen J, and J. Odenkirk, 2019, Teaming up to Tackle Two-horned Trapa: A Highly Invasive New Species of Water Chestnut, Invader of the Month (July, 2019), Maryland Invasive Species Council (<http://mdinvasives.org/iotm/july-2019/>)

Strayer, D. L. (2010). Alien species in fresh waters: Ecological effects, interactions with other stressors, and prospects for the future. *Freshwater Biology*, 55, 152–174.
<https://doi.org/10.1111/j.1365-2427.2009.02380.x>

USDA-APHIS [United States Department of Agriculture – Animal and Plant Inspection Service]. 2016. Weed Risk Assessment for *Trapa natans* L. (Lythraceae) – Water chestnut – (Version 1) Available online at https://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/downloads/wra/Trapa-natans.pdf [Accessed September 29, 2021]

Appendix A

Virginia Department of Conservation and Recreation Two-horned Trapa Fact Sheet

INVASIVE PLANT ALERT

EARLY DETECTION INVASIVE PLANT SPECIES IN VIRGINIA

Two-horned Trapa, Two-horned Water Chestnut

(*Trapa bispinosa* var. *iinumai*)

Threat

Two-horned trapa is an invasive aquatic plant first identified in the U.S. in Pohick Bay, Fairfax, Virginia, in 2014. Originally thought to be the first colony of the highly invasive Eurasian water chestnut (*Trapa natans*) in Virginia in decades, differences in the seeds of the two plants led experts to believe this was a new threat. Eurasian water chestnut bears four-horned seed pods. The Virginia colony of the new water chestnut – with seed pods of only two “horns” – was identified as *Trapa bispinosa* var. *iinumai* in 2019 (Chorak et. al, 2019).

Two-horned trapa may have already been spreading in the Potomac watershed for over a decade. Its spread threatens to undo the multi-million dollar, decades-long efforts to eradicate Eurasian water chestnut. As of late 2021, this is the only watershed in the country known to contain two-horned trapa, but this plant has the potential to spread throughout Virginia and beyond.

All *Trapa* species are non-native in the U.S and are considered early detection-rapid response invasive plants. The United States

Department of Agriculture Animal and Plant Health Inspection Service ranks Eurasian water chestnut as a high-risk “major invader” (USDA-APHIS 2016). Both *Trapa* species form dense floating mats that spread and cover slow-moving bodies of water. The barbed *Trapa* seed pods can attach to waterfowl and disperse into neighboring waters. Like Eurasian water chestnut, two-horned trapa has the potential to obstruct water flow, inhibit recreational and commercial use of waterways, shade out submerged aquatic vegetation and outcompete native aquatic plants.



Report Sightings

If you believe you have found two-horned trapa **or** the related Eurasian water chestnut, please report your sighting. Accurate location information and detailed photos (leaves, fruit, seeds, flowers, rosette and landscape context) are very helpful.

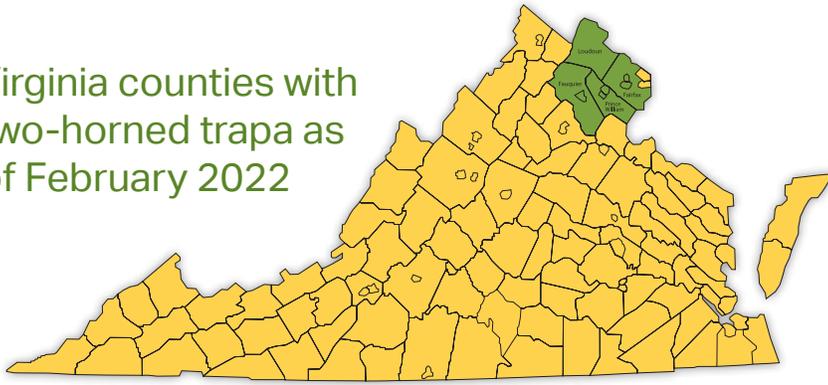
- Use the online mapping tool *Early Detection and Distribution Mapping System* (www.eddmaps.org) by creating a free account and following the instructions.
- Smartphone users may use the free **EDDMapS** app, which can be found in the Apple App Store or Google Play Store.
 - Negative reports (water bodies where you did **not** find *Trapa*) are also useful. Negative reports can be submitted using **EDDMapS**.

Description

Two-horned trapa is a floating, annual, aquatic plant with submerged stem and roots. The long roots anchor the plant into the mud in waters up to 12 feet deep (Pfungsten, 2021). The fan-shaped, central leaves have doubly serrated margins and form a rosette. Floating leaves are green above with red undersides, each leaf having a distinct “inflated” petiole that allows the plant to float. Small, four-petaled, pink flowers emerge from the rosette center beginning in June. Two-horned trapa may flower and fruit from June until frost. The seed pod is large (1.5-2 inches) with two opposing “horns.” Due to cold temperatures, two-horned trapa dies back in late autumn. Seeds can lie dormant for at least two years. Two-horned trapa can be confused with the invasive Eurasian water chestnut, which produces a four-horned seed pod, white flowers and entirely green leaves. Two-horned trapa has a two-horned seed pod, pink flowers and leaves with red undersides. The non-native mosaic plant (*Ludwigia sedioides*) has a similar leaf and growth form, but is significantly smaller with yellow flowers. Creeping water primrose (*Ludwigia peploides*) is a floating, non-native plant with lance or oval-shaped leaves. Its elongated stems sprawl across the water’s surface. (Though they share a common name, *Trapa* species are unrelated to the water chestnut popular in Chinese cuisine.)

INVASIVE PLANT ALERT – Two-horned Trapa

Virginia counties with two-horned trapa as of February 2022



Distribution

As of late 2021, two-horned trapa is known to occur at over 70 locations in northern Virginia, including the counties of Fairfax, Fauquier, Prince William, and most recently, Loudoun County. Some historic observations recorded before 2014 thought to be Euroasian water chestnut have since been reclassified as two-horned trapa. Stafford and Westmoreland counties have records from 1995 retroactively identified as two-horned trapa, but those counties have not been monitored to determine if those colonies persist today. Two-horned trapa has not been found outside of Virginia, and management efforts are underway at many sites.

Habitat

Any freshwater body such as tidal rivers, streams, ponds, reservoirs, lakes and wetlands. Relatively shallow, slow moving or still water.

Control

Proceed with caution: barbs of Trapa seed pods are sharp and may pierce gloves or shoes and cause injury.

Two-horned trapa colonies may be removed by hand or mechanically. Hand-pulling has been shown to reduce Trapa sp. effectively, but waters should be monitored yearly for plants emerging from seed. Removing all plants before they go to seed in late June to early July will help reduce the population over time. Continued control efforts will likely be necessary for several years. Plants may be left in the sun to dry out, then burned, buried or bagged. For private pond management, see <https://dwr.virginia.gov/fishing/private-pond-management/>.

Two-horned trapa look-alike plants

Eurasian water chestnut



Mosaic plant



TO REPORT A SIGHTING:

Online mapping and reporting tool:
<http://eddmaps.org>

Smartphone app:
EDDMapS

DCR online form:
www.invasivespeciesva.org/report-sightings

SOURCES

Chorak, Gregory M., et al. "Cryptic Introduction of Water Chestnut (Trapa) in the Northeastern United States." *Aquatic Botany*, vol. 155, Apr. 2019, pp. 32–37.

Maryland Department of Natural Resources. "Water Chestnut," on the website: <https://dnr.maryland.gov/waters/bay/Pages/Water-Chestnut.aspx>. [Accessed November 2021]

Pfingsten, I.A., and N. Rybicki. 2021. *Trapa bispinosa* var. *iinumai* Nakano, webpage at U.S. Geological Survey, Nonindigenous Aquatic Species Database. <https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=2974> [Accessed January, 2022]

Rybicki, Nancy, and Jill Swearingen. 2019. "Teaming up to Tackle two-horned trapa: A Highly Invasive New Species of Water Chestnut," Maryland Invasive Species Council website <https://mdinvasives.org/iotm/july-2019/> [Accessed November 2021]

USDA-APHIS [United States Department of Agriculture – Animal and Plant Inspection Service]. 2016. Weed Risk Assessment for *Trapa natans* L. (Lythraceae) – Water chestnut – (Version 1) Available online at https://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/downloads/wra/Trapa-natans.pdf [Accessed September 29, 2021]

Virginia Botanical Associates. 2021. Digital Atlas of the Virginia Flora. www.vplantatlas.org [Accessed November 2021]

Photo credits:

Two-horned trapa (*Trapa bispinosa*)
Kevin Heffernan, VA DCR.

Two-horned trapa (*Trapa bispinosa*)
Lynne Dodd USACE

Two-horned trapa (*Trapa bispinosa*) seed pods.
Kevin Heffernan, VA DCR.

Eurasian water chestnut (*Trapa natans*) Leslie J. Mehrhoff, University of Connecticut, Bugwood.org

Mosaic plant (*Ludwigia sedioides*) Shaun Winterton, Aquarium and Pond Plants of the World, Edition 3, USDA APHIS PPQ, Bugwood.org