Do Knot Fret: Invasive Species Management at Rock Creek Park, Washington, D.C.

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August 2024

Abstract

This report seeks to estimate how much knotweed (Reynoutria japonica), contributes to streambank soil erosion in Rock Creek Park (RCP), Washington DC, and the costs and benefits of implementing management actions to reduce knotweed presence. Given that knotweed growth can exacerbate sediment pollution through erosion, and knotweed has been rapidly expanding its range in RCP, potential actions to reduce this are a ripe area of study. In this investigation, multiple methods were used to gain an understanding of knotweed management techniques, including a literature review, contacting experts, doing field work, and using GIS. The findings showed that approximately 261,303 ft^2, or six acres, and approximately 17,774 feet of streambank along Rock Creek is infested with knotweed. According to expert estimates, it would cost $20,262.36 to implement management for the knotweed infestation at RCP. Implementing management would lead to a reduction of 13,226,277 pounds of sediment. There would be a reduction of 652.75 pounds of sediment per dollar spent on knotweed management implementation.

Introduction

Covering over 64,000 square miles and encompassing six states, the Chesapeake Bay watershed holds more than 18.5 million residents. However, the health of the watershed has seen significant decline since the 1970s. This not only represents a threat to the more than 36,000 animal species in the watershed, but also to residents of the states surrounding the Bay and its tributaries. The restoration of the Chesapeake Bay and its rivers and streams is vital to the protection of ecosystem, plant, animal, and human health (Chesapeake Bay Program, n.d.).

Around the 1880s, Reynoutria japonica, referred to in this report as knotweed, was introduced to the North American continent as an ornamental plant. Knotweed is an upright herbaceous perennial native to East Asia that typically grows 3.3-10 feet tall. It has a deep taproot system and is rhizomatous, meaning it can spread laterally via a network of underground stems that produce rapidly growing stalks in the spring. The rhizomes can extend up to sixty-five feet horizontally (Templeton, Gover, Jackson, & Wurzbacher, 2020). Knotweed encompasses a variety of different species, like giant, hybrid, and Japanese, however it was not differentiated by species for the purposes of this report.

Once grown solely within botanical and private gardens, knotweed has become an invasive species throughout a wide array of environments, including in forest buffers around streams and rivers. Its native habitat on Mt. Fuji, Japan, knotweed has evolved to being the primary colonizer following volcanic disturbance—an environment poor in nitrogen sources until volcanic matter has broken down. As a consequence of its high capacity to acquire, efficiently use, and store nitrogen it in its rhizomes for the next growing season, the plant has adapted to growing as fast as it can within a nitrogen-poor environment (Urgenson, 2006).

This fast growth rate gives knotweed a temporal 'leg up' on its competitors; it can grow, spread, and embed itself with the resources it had stored before other plants can become established. This is advantageous to its spread within disturbed or newly planted and managed riparian forest buffers (RFBs), and can damage or slow restoration projects, costing organizations valuable time and money (Chesapeake Bay Program, 2018). However, knotweed not only presents a threat in terms of growth rates, it also exacerbates streambank erosion. Being a perennial species, knotweed dies during the fall and winter seasons, allowing for the dead knotweed stems to be washed away by water and ice flow during storm events. Once the stems have been washed away, the riverbank is exposed to scouring by water and ice, contributing to soil erosion — a major contributor of sediment pollution in the Bay.

Sediment pollution leads to suspended particulates remaining in the waters of the Chesapeake Bay — turbid conditions that prevent sunlight from penetrating the water column and halt the process of photosynthesis for the aquatic plants that live in the Bay. This causes a reduction in food supply and shelter for young fish and other aquatic fauna. Similarly, excess sediment pollution can contribute to the further spread of nutrient and chemical pollution by binding to those pollutants and carrying them further out into the Bay and the food web. The benefits to reducing sediment pollution are not only environmental, but also impact the people who use the Bay recreationally and economically. Accumulating sediment can clog ports of entry, affecting commercial shipping and recreational boating. Contaminated fish and shellfish can result in the spread of illnesses, reducing the ability for the people dependent on the Bay to do their jobs (Chesapeake Bay Program, 2024).

RFBs provide various beneficial impacts throughout the watershed, including filtering nutrients, pesticides, and animal waste from agricultural runoff; stabilizing eroding banks; filtering sediment runoff; and providing shade for fish and other aquatic organisms. Knotweed damages RFBs by displacing native vegetation, lowering the aforementioned benefits of RFBs. This report will quantify the potential benefits of implementing knotweed management and contribute to the large-scale long-term efforts to improve the health of the Bay through an investigation of the impacts knotweed has on streambank sediment erosion in RCP.

Methods

Summary of Approach

To achieve the objectives of this report, multiple methods were used to gain an understanding of knotweed. Through a review of the literature, information was gathered on the knotweed's role in soil erosion. The authors of the studies found in the review were contacted using the snowball sampling method. Finally, knotweed was mapped by visually examining both sides of Rock Creek, located in Rock Creek Park, Washington DC.

Literature Review

Google and Google Scholar were used as search engines to study the impact of knotweed on soil erosion. Using a combination of the terms 'knotweed,' 'erosion,' 'sediment erosion,' and 'soil erosion,' five articles were found that were relevant to the investigation. The authors of these articles were also asked if they had any further literature they were aware of regarding the subject matter.

Contacting Experts

Email was used to conduct short semi-structured interviews with experts to learn about gaps and obstacles to the management of knotweed. Participants were identified using the snowball sampling method, by first reaching out to the authors of studies on knotweed and its impact on soil erosion. These authors were then asked to recommend others to contact, in a manner similar to a growing snowball rolling down a slope. Using the same method of sampling, Extension agents from the University of Pennsylvania, University of Maryland, Pennsylvania State University, and other institutions with noxious weed management offices were emailed to get a better understanding of the price of knotweed management. Participant recommendations yielded further experts to contact.

Field Work

Only the portion of Rock Creek in RCP was mapped, the tributaries of Rock Creek were not mapped. RCP was chosen to be the site of knotweed examination because of its travel distance from the Chesapeake Bay Program office in Annapolis, availability of walkable trails, and the presence of knotweed along Rock Creek. RCP was mapped for knotweed presence by visually examining both sides of the creek while traversing the creek on foot. Knotweed was mapped in the smartphone application ArcGIS Field Maps. This information was then transferred into ArcGIS Pro for further analysis. Knotweed was not differentiated by species.

Literature Review

How Knotweed Contributes to Sediment Pollution:

Knotweed increases soil erosion along river and stream banks due to its ability to choke out native species, become a monoculture, and then die-off en masse in winter, leaving riverbanks disproportionately exposed to erosive forces. One study found that, on average, riverbanks with knotweed experienced three more centimeters of soil erosion than riverbanks without knotweed. Certain conditions along streambanks, such as the slope of the bank or being located on an islet, interacted with knotweed, further exacerbating soil erosion. This constitutes to an additional soil loss of 3,000—5,330 tons (Matte, Boivin, & Lavoie, 2021). Two other studies found that knotweed could contribute 9—29 cm (Arnold & Toran, 2018) and 6 cm (Kaehler, 2023) of streambank erosion.

While capable of sexual reproduction, knotweed primarily spreads through asexual propagation via vegetative fragments that appear after flooding and significant erosion. Additionally, due to knotweeds competitive advantage over native species, it can cause a loss of riparian trees and vegetation, and thus a "detrimental effects on the bank stability, hydrology, nutrient loading, micro-habitat conditions, and aquatic biota of adjacent lotic systems" (Urgenson, 2006). However, a 95% reduction in knotweed footprint is possible through one year of herbicide treatment, showing that it is possible to significantly reduce soil erosion and reap the benefits from controlling that invasive in riparian areas (Cygan, n.d.).

How Knotweed Will Spread with Climate Change:

Knotweed has been documented in 43 of 50 states in the United States (Minnesota Department of Agriculture, 2020). It is expected that, with warming average temperatures due to climate change, the possible range of knotweed will expand northward into areas where it was not historically present (Groeneveld, Belzile, & Lavoie, 2014). Figure 1 represents the current spread and sighted detections of knotweed throughout the United States and Canada. Figure 2 represents the current spread and sighted detections of knotweed throughout the Chesapeake Bay Watershed. Finally, Figure 3 represents the expected expansion or retraction of the knotweed throughout the US.

Figure 1. US & Canada Knotweed Detections

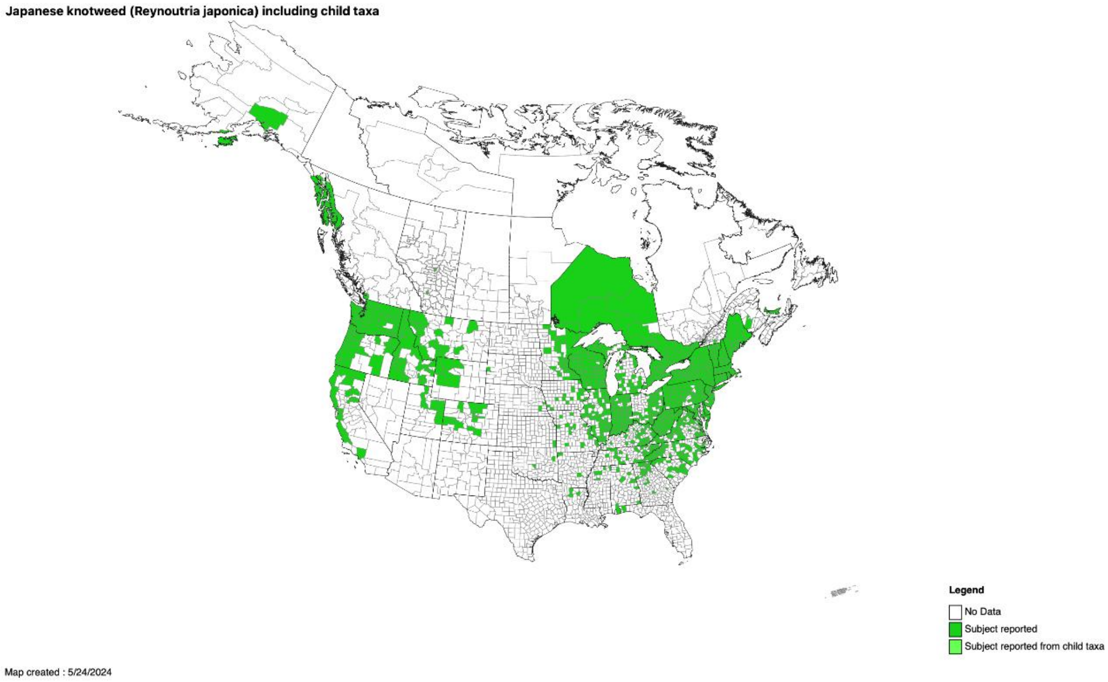


Figure 1. EDDMapS. 2024. Early Detection & Distribution Mapping System. The University of Georgia - Center for Invasive Species and Ecosystem Health. Available online at http://www.eddmaps.org/; last accessed May 24, 2024

Figure 2. Chesapeake Bay Watershed Knotweed Detections

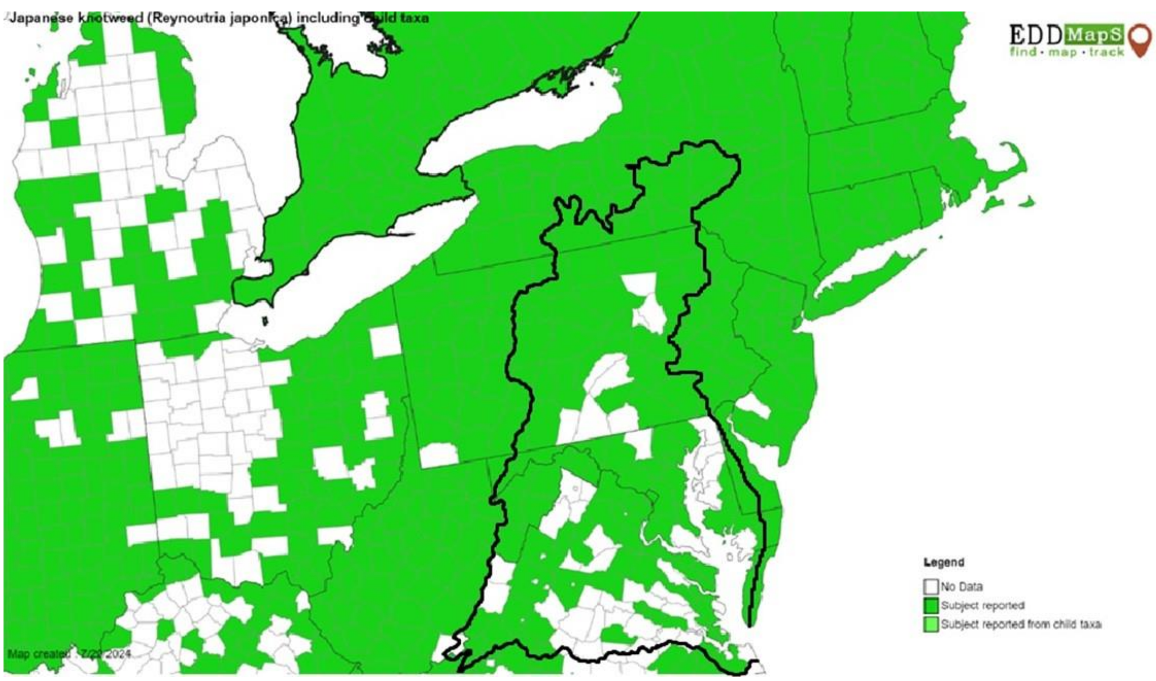


Figure 2. EDDMapS. 2024. Early Detection & Distribution Mapping System. The University of Georgia - Center for Invasive Species and Ecosystem Health. Available online at http://www.eddmaps.org/; last accessed July 21, 2024.

Figure 3. Future Range of Knotweed by 2040 - 2060

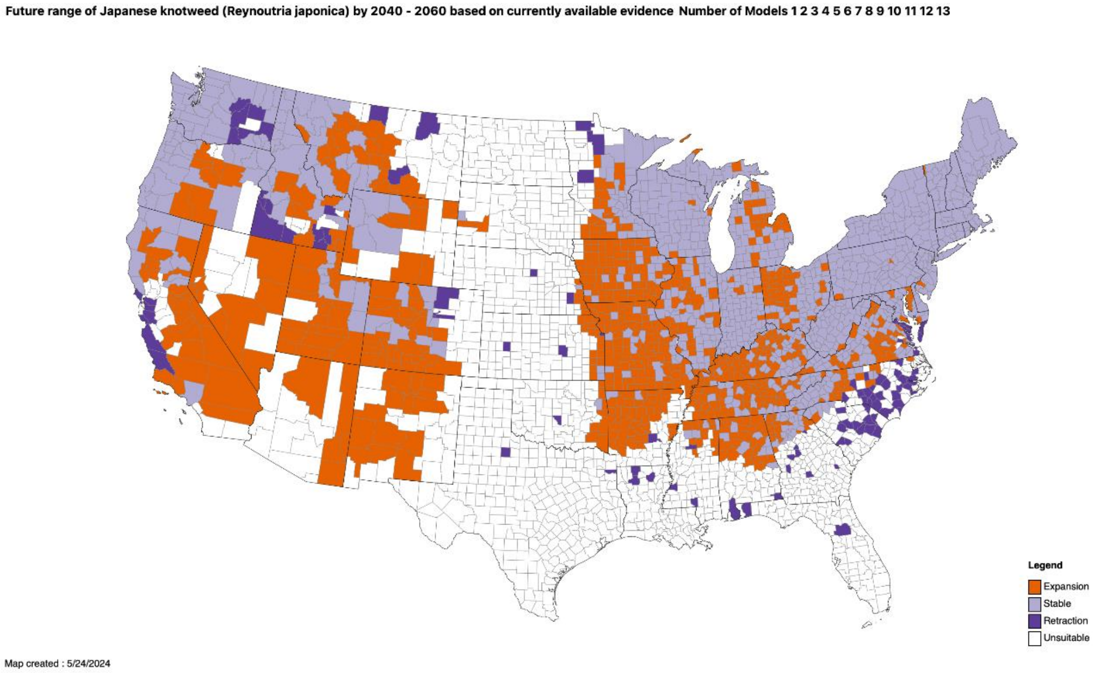


Figure 3. EDDMapS. 2024. Early Detection & Distribution Mapping System. The University of Georgia - Center for Invasive Species and Ecosystem Health. Available online at http://www.eddmaps.org/; last accessed May 24, 2024.

Results

Contact Responses

In total, nine of the twenty-seven experts contacted regarding their knowledge on knotweed management. Only three could provide a cost estimate for controlling knotweed.

Location	Control Method	Source	Price Quotes	
Cedar River, WA	Herbicide Treatment	Lorenzo Cinalli*	$1.14/linear ft.	$378.01/acre
King County, WA	Herbicide Treatment	Kieran O'Donnell***	$200-300/acre	
Quebec, Canada	Rapid Response Excavation	Claude Lavoie **	$5,800 1-yr/person, $142/aborted knotweed clone	

Table 1. Price Estimates

** Gathered from Lorenzo Cinalli, USFS, lorenzo.cinalli@usda.gov*

*** (Rouleau, Bouchard, Matte, & Lavoie, 2023)*

**** Gathered through email communication w/ Kieran O'Donnell, Kieran.odonnell@kingcd.org*

Data Collected

Table 2 represents soil loss and erosion according to the studies that compared rates in knotweed covered slopes versus those without the invasive. Metric tons per meter and centimeters were chosen as the unit of measurement, respectively. The timeframes of the studies were included. Table 3 represents the conversions of Table 2 into imperial units. Table 3 was calculated by averaging the two low estimates and the two high estimates. The average soil loss was calculated by averaging all available estimates for Soil Loss (metric ton/m). A metric ton is 2,204.62 lbs.

Soil Loss and Erosion According to Studies						
Study	**Timeframe**	**Soil Loss (metric tons/m)**		**Erosion (cm)**		
		Low	**High**	**Low**	**Average**	**High**
(Matte, Boivin, & Lavoie, 2021)	Nov. '18 – Jun. '19	1.3	2.3	x	2.808	x
(Arnold & Toran, 2018)	Jun. '15 – Apr. '16	x	x	9	x	29
(Arnold, 2016)	Jun. '15 – Apr. '16	0.1245	0.705	x	x	x
(Kaehler, 2023)	Aug. '21 – Oct. '22	x	x	x	6.8	x

Table 2. Soil Loss (metric ton/m) and Soil Erosion (cm)

Soil Loss Averages		
Average Soil Loss (metric ton/m)	**Average Soil Loss (kg/m)**	**Average Soil Loss (lbs/ft)**
1.107375	1,107.375	744.122
Average Low	**Average Low**	**Average Low**
0.71225	712.25	478.61
Average High	**Average High**	**Average High**
1.5025	1,502.5	1,009.633

Table 3. Low, Average, and High Soil Loss by Different Measurement Conversions

Field Work/Map

Knotweed was mapped in RCP along Rock Creek using ArcGIS Pro. The below figures show recorded knotweed locations along Rock Creek. Table 4 was calculated by adding up the area of the polygons, while the length was calculated by adding up the measurements of the lengths of each polygon on both sides of Rock Creek. Table 5 was calculated in various ways; the cost to treat the entirety Rock Creek in RCP was calculated by multiplying the length of Rock Creek in RCP containing knotweed by Lorenzo Cinalli's linear foot price estimate; the potential reduction was calculated by multiplying the length of Rock Creek in RCP containing knotweed by the average soil loss in lbs/ft; The reduction of pound of sediment per dollar was calculated by dividing the potential reduction of sediment by the cost of treatment.

Figure 4. Map of RCP Detailed with Spread of Knotweed

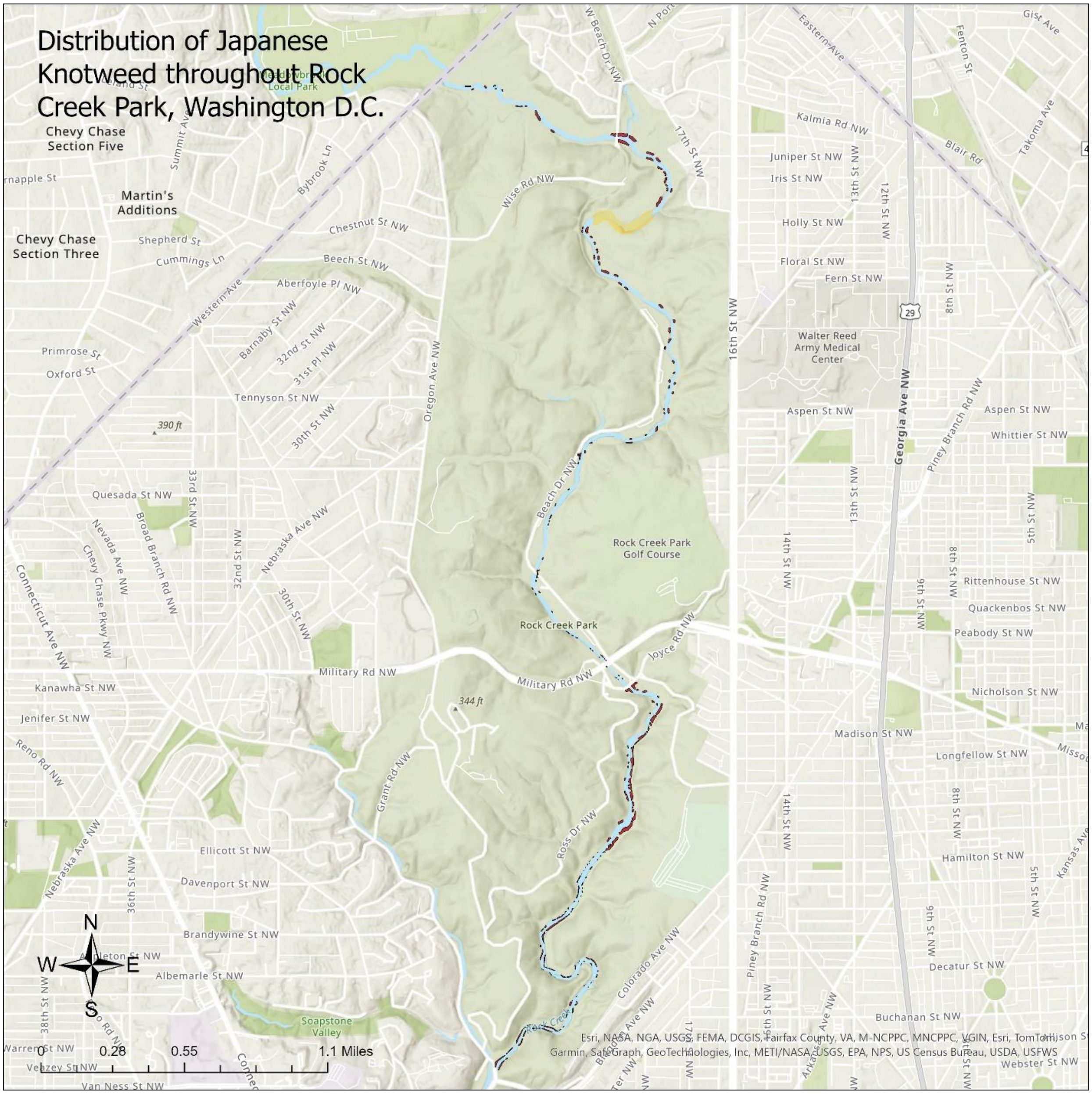


Figure 5. Zoomed in Map of Riparian Knotweed in Upper RCP

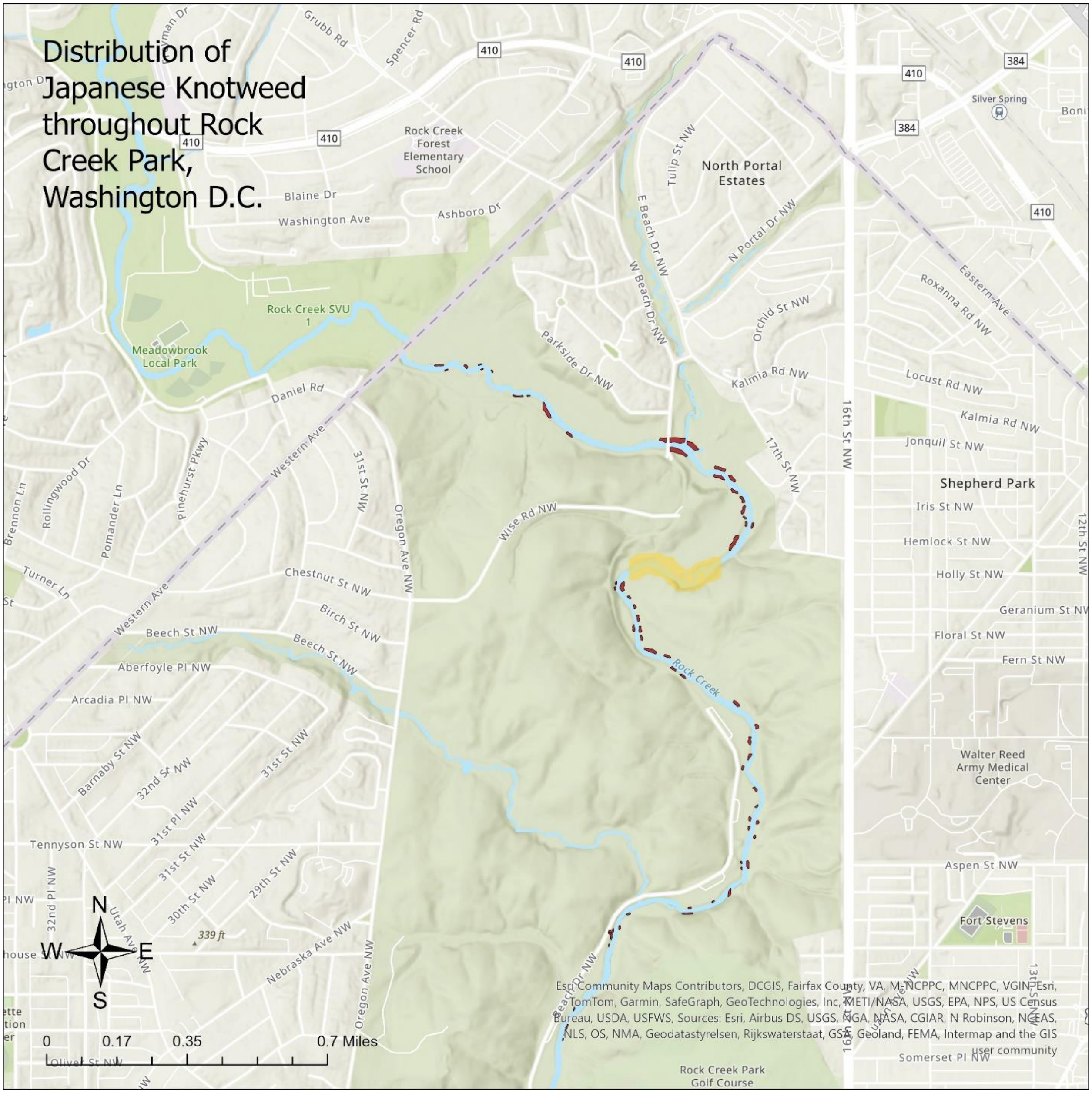


Figure 6. Zoomed in Map of Riparian Knotweed in Central RCP

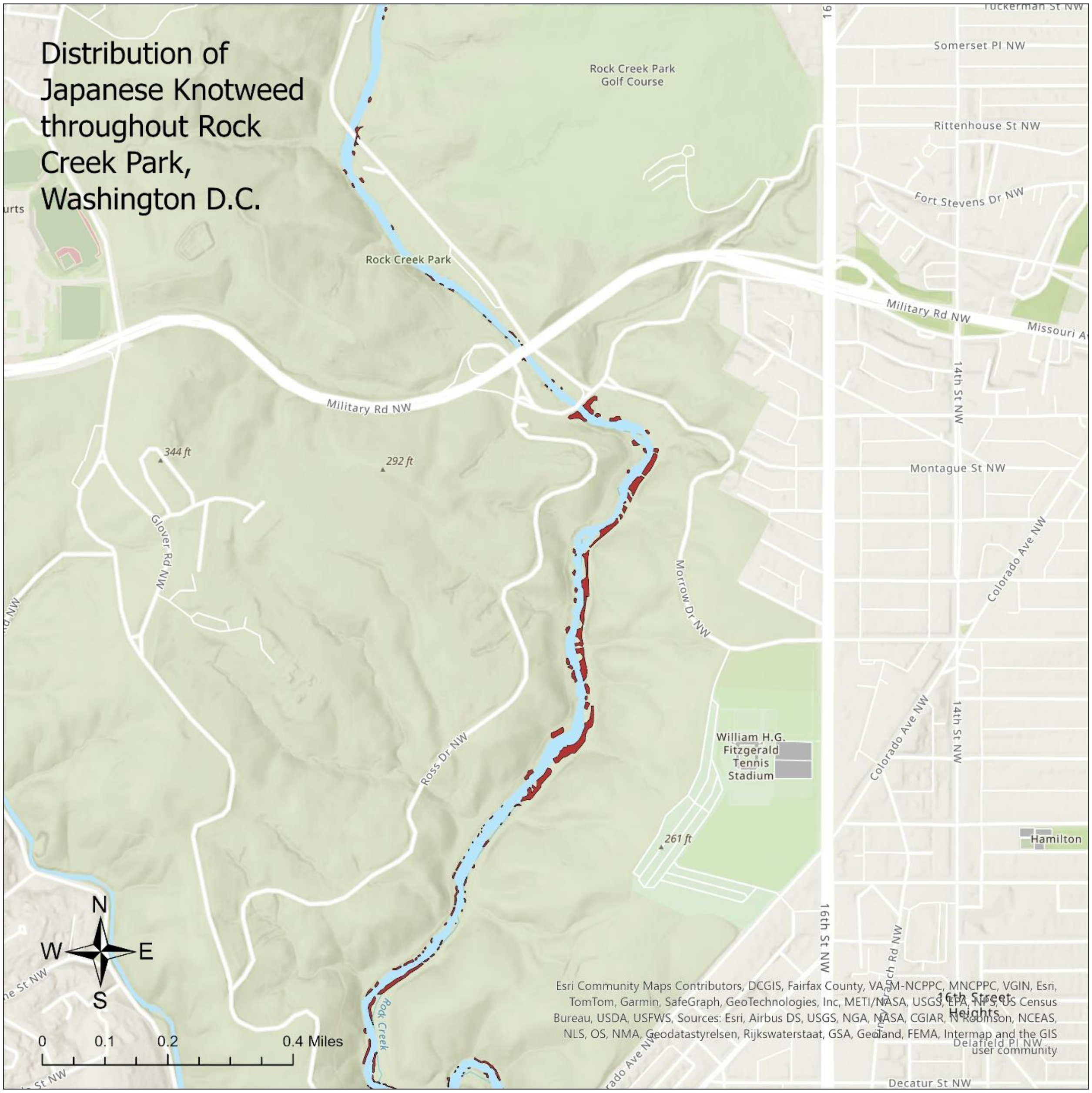
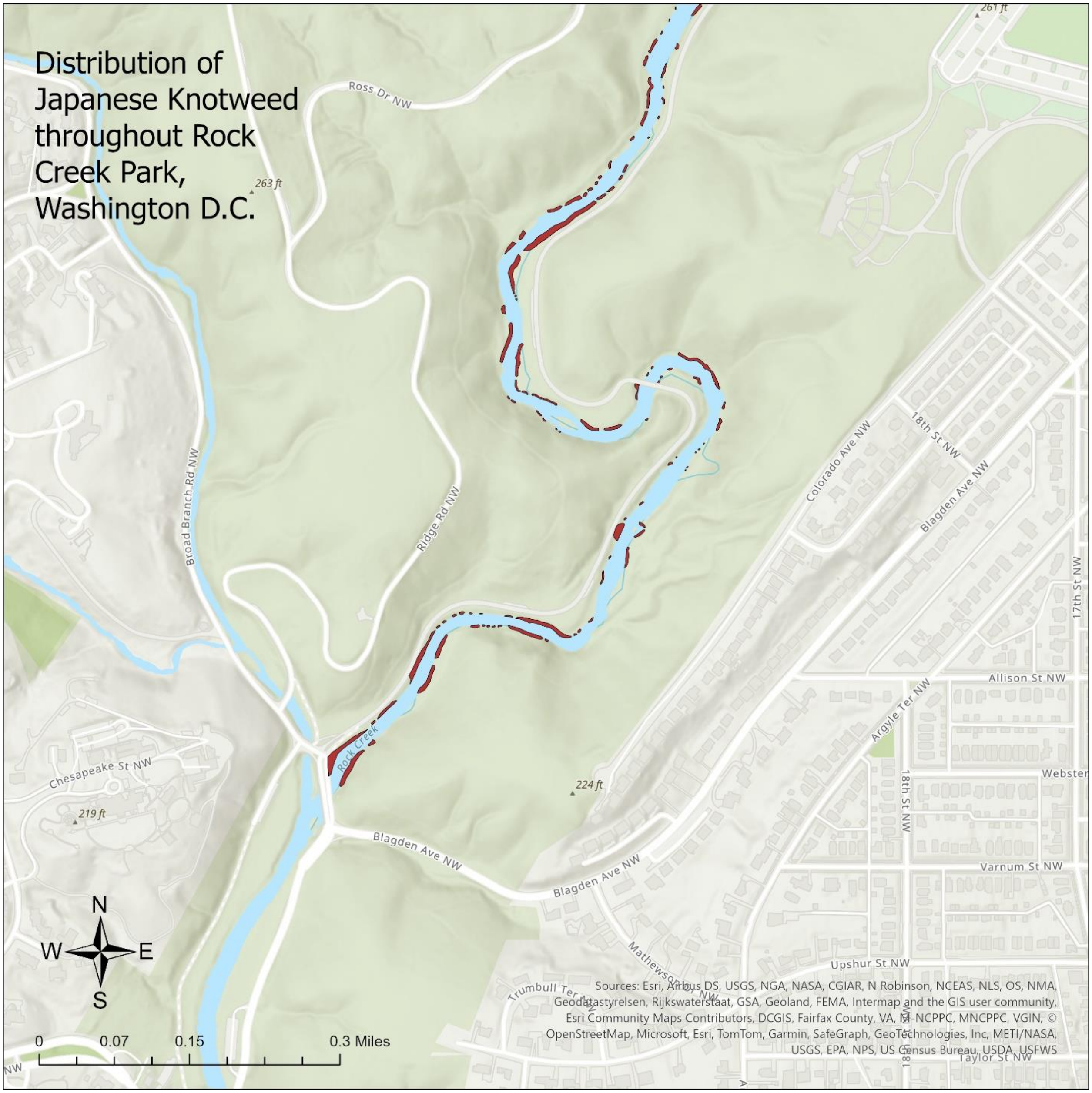


Figure 7. Zoomed in Map of Riparian Knotweed in Lower RCP



Area and Length of Rock Creek with Knotweed Presence in Metric and Imperial Units	
Area of Stream w/ Knotweed (m^2)	**Length of Stream w/ Knotweed (m)**
24,275.81	5,417.62
Area of Stream w/ Knotweed (ft^2)	**Length of Stream w/ Knotweed (ft)**
261,302.64	17,774.34

Table 4. Area and Streambank Length w/ Knotweed Presence

Total Cost and Benefit of Knotweed Removal	
Cost to Treat Area ($)	**Cost to Treat Length ($)**
1,200-2,268.06	20,262.36
Potential Reduction by Treatment (lbs)	
13,226,277.4	
Reduction of lbs/$	
652.75*	

Table 5. Total Cost and Benefit of Implementing Knotweed Management

**Calculated by dividing potential reduction by treatment by cost to treat length*

Discussion

Limitations

Determining the benefits of knotweed removal is difficult due to the lack of robust scientific literature regarding the erosive effects of the invasive and the variability of natural processes. This presents an issue in gathering concrete numbers as to how much knotweed removal would reduce sediment pollution. Research yielded four articles that focused on soil loss and erosion, and communication with the researchers of those studies revealed that there is a lack of other literature on the erosive effects of knotweed. However, two of those studies reported total streambank erosion, and not in weight, which was the unit of measurement necessary for the purpose of this report.

Furthermore, field work limitations included the fact that the tool used to visually map RCP was not a dedicated GPS unit. This presents an issue in accurately determining knotweed presence due to the fact that application had an accuracy of only 5-10 meters. This means that all knotweed stands were mapped in estimated locations and that the perimeter of knotweed was only estimated visually. Additionally, not all parts of Rock Creek were visually accessible from the trails. Approximately five hundred meters of Rock Creek were not able to be visually examined for knotweed presence due to the difficult terrain. This portion was highlighted yellow in Figure 4 and 5.

Lastly, the soil loss estimates depicted in Table 3 were taken across different timeframes, ranging from 7-12 months. Soil loss averages were calculated assuming erosion rates were applicable for a year long timeframe to allow for simpler analysis.

Cost

Cost estimates were only calculated for herbicide treatment. While herbicide treatment is not the only method to manage knotweed, for the purposes of this report, other methods were not included in calculations.

Approximately 261,302.64 ft^2, or 5.99 acres, of the riparian forest area of Rock Creek is infested with knotweed. Using Lorenzo Cinalli's price estimate—$1.14/linear ft.—it would cost $20,262.36 to treat the entirety of the knotweed presence at Rock Creek. Price estimates were also available per acre which would have yielded a lower cost estimate, however, the presence of knotweed at Rock Creek is not conglomerated in a six-acre clump. Rather, the presence of knotweed is spread throughout the entirety of the creek. The linear foot quote gives a more accurate estimate to how much it would cost to treat Rock Creek because a practitioner would have to traverse the length of the creek to treat the knotweed presence.

The knotweed presence at RCP must however be put into context. Rock Creek originates in Laytonsville, Maryland, and travels dozens of miles before reaching RCP in Washington DC. If knotweed management is to be implemented, it needs to be recognized that the source of propagative knotweed fragments remains throughout the headwaters of the creek. Knotweed will continue to enter and establish itself throughout RCP unless action is taken at the headwaters of Rock Creek. Unlike Washington DC, Maryland has yet to add knotweed to its invasive species plant list, which was last revised in February 2023 (Maryland Department of Agriculture, 2023). This is an issue because knotweed has been "widely recognized by biologists and natural resource practitioners to degrade natural resources and/or negatively impact native species" (Maryland Invasive Species Council, 2005). The failure to add invasive species to lists that encourage the control of said invasives can result in potentially destructive effects on biodiversity conservation (Ochoa-Ochoa, et al., 2019). By putting knotweed on an invasive species list, Maryland would be more capable of focusing financial and scientific efforts on the management and prevention of knotweed throughout riparian forest buffers.

Although herbicide was the treatment examined in this investigation, there has been discussion of alternatives in recent years. Numerous studies and experts have recognized that when knotweed has reached widespread and abundant status, control with cutting and herbicides becomes difficult and expensive, especially alongside hard-to-reach riverbanks (Rouleau, Bouchard, Matte, & Lavoie, 2023). This has led to an increase in interest in other control methods over the last decade or so. Particularly, there is interest in psyllids and fungi that solely predate on knotweed and could potentially become a natural management solution to large infestations.

Benefit

Approximately 17,774 feet of RCP contains knotweed. Table 4 shows the average soil loss derived from the available literature — 744 lbs/ft. Implementing the management of knotweed would lead to a reduction of 13,226,277 pounds in soil erosion, or 6,613 US tons. Using the price range per linear foot mentioned in the cost discussion, there would be a reduction of 652.75 pounds of soil per dollar spent on knotweed management implementation.

Managing knotweed presents a wide variety of benefits compared to the low cost of financing the process. It would not only reduce the amount of sediment entering the tributaries of the Chesapeake Bay, but it would also help decrease the amount of nutrients entering rivers. Knotweed not only contributes to erosion, but it also disrupts the flow of nutrients throughout the soil by decreasing biodiversity and preventing native flora from providing ecosystem services. Invasive species within riparian forest buffers present a threat to these incredibly valuable and important ecosystems around streams and rivers, and potentially contribute to the damage or destruction of these buffers.

Co-Benefits

Knotweed has been found to alter the type of allochthonous litter inputs in riparian areas. Native leaf litter inputs were significantly lower than that of knotweed in invaded forest patches—up to a 70% reduction in native litter input (Urgenson, 2006). Knotweed, prior to losing its leaves during seasonal changes, stores its nitrogen into its rhizome system to be used when weather conditions improve. This is contrasted to native species that contribute a greater share of their nutrient resources back into their riparian area and aquatic environments.

Knotweed has been found to cause significant decreases in biodiversity and total number of plant species in riparian areas (Matte, Boivin, & Lavoie, 2021). This is due to knotweed's ability to grow in great stem densities, pushing out native vegetation, and thus reducing biodiversity and food sources for terrestrial and aquatic organisms.

Implementing knotweed management will allow for better regulation of nutrient cycles within a riparian area by preventing the reduction of native litter input. It will also allow for an increase in native species by preventing knotweed from establishing monocultures in riparian areas, giving natives the opportunity to regrow.

Furthermore, in the United Kingdom, which has been dealing with knotweed for decades, the invasive has long been known to cause expensive damage to homes. Annually, the nation pays approximately £165 million ($214.10 million) combatting the plant, with the burden of costs falling onto homeowners and land developers (Shaw, et al., 2017). With rising costs of living and housing, many communities will be unable to afford the economic costs of implementing management. That is why there needs to be more studies into how knotweed impacts low income or racially diverse communities. These communities are often disproportionately neglected economically, which can result in their failure to control the spread of invasive species, including knotweed. It leads to a reduction of native, beneficial flora in their communities and reduces the ecosystem services they derive from native vegetation.

Conclusion

Knotweed disproportionately contributes to further soil loss and erosion in riparian areas and threatens sediment pollution goals in the Chesapeake Bay watershed. This report shows that managing knotweed can provide a reduction of 13.2 million pounds of sediment, a significant amount for the approximately five-mile portion of the creek examined. Rock Creek is just one of many streams and rivers throughout the Chesapeake Bay watershed that contains knotweed along their streambanks. It is unknown how many of the riparian areas in the Chesapeake Bay watershed contain knotweed, but there are massive potential benefits to mapping the watershed for knotweed, finding it, and controlling it. Based on the potential costs and benefits outlined above, municipalities and other local governments may want to consider the implementation of knotweed management strategies. Where there is a will there is a way!

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