

Analyzing the Effect of Japanese Barberry on Lyme Disease Using Geographical and Epidemiological Analysis

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ABSTRACT: Japanese barberry (*Berberis thunbergii*) is an invasive shrub widely distributed in the northeastern United States and has been linked to increased risk of Lyme disease through its effects on blacklegged tick (*Ixodes scapularis*) habitat. This study investigates the geographic relationship between Japanese barberry abundance, tick populations, and Lyme disease incidence across the United States, with a focused county-level analysis in New Jersey. Publicly available datasets from environmental surveys and public health records were analyzed and visualized using choropleth maps and time-series graphs. Results show a strong geographic overlap between high barberry occurrence reports, established tick populations, and elevated Lyme disease cases, particularly in forested regions of the Northeast. In New Jersey, counties with extensive forest cover and higher reported barberry presence, including Morris and Hunterdon counties, exhibited the highest Lyme disease rates, while counties with documented control efforts showed comparatively lower incidence. Analysis of statewide regulations revealed no immediate reduction in Lyme disease cases following barberry bans, suggesting that existing infestations and ecological lag effects limit short-term policy impact. These findings indicate that Japanese barberry contributes to Lyme disease risk by supporting favorable tick habitat and highlight the need for long-term invasive species management strategies that integrate environmental and public health policy.

KEYWORDS: Environmental Science, Ecology, Japanese Barberry, Lyme Disease, Invasive Species.

■ Introduction

Invasive Species:

The intersection of environmental science and public health is rarely considered, yet invasive species pose a distinct threat that impacts both. Invasive species are non-native plants that cause environmental or economic harm. Common types include shrubs like the Japanese Barberry, vines and creepers like Kudzu and English Ivy, and perennials like garlic mustard and giant hogweed. Common tick sources include the invasive species, tall grass, and suburban backyards with moist shaded areas and leaf litter. This study focuses on one such connection: the relationship between the invasive Japanese barberry and the prevalence of Lyme disease. Invasive species are non-native organisms that cause significant harm to the environment, economy, and human and animal health.¹ These species can include plants, insects, fungi, or animals, and their presence has become a growing problem around the world and particularly, it is a local problem in New Jersey.¹⁻³ Invasive species often spread quickly because they lack natural predators in their new environments, which gives them an advantage over native species.⁴ The presence of invasive species has a widespread impact on nature, as they outcompete native plants and animals, disrupting ecosystems.¹ This, in turn, affects businesses and individuals, specifically homeowners, park workers, and even recreational industries like fishing and boating, which are burdened by the extra costs and labor of managing invasive species, costing them billions of dollars globally.⁵ In fact, New Jersey alone loses over \$290 million annually in agricultural damage due to invasive species.³ Despite all this, New Jersey is one of only two states in the country that doesn't ban the sale of

some of the worst invasive plants, making the issue even harder to control.⁶ This paper focuses on one such species, Japanese barberry (*Berberis thunbergii*), and explores its relationship to Lyme disease prevalence in New Jersey to better understand how environmental and public health concerns intersect. These facts make it clear that invasive species are a serious issue, and understanding their spread and consequences is crucial for protecting biodiversity, economic well-being, and public health.

Basic Description of Barberry:

One particularly harmful invasive plant in the U.S. is Japanese barberry (*Berberis thunbergii*), a deciduous shrub native to Japan and eastern Asia.⁷ The plant is easily recognizable by its red berries and ability to form dense thickets that crowd out native species and alter ecosystems.⁸ It was first introduced to the United States in the late 1800s, when seeds were sent from Russia to Boston for ornamental purposes.⁷ It later became popular in landscaping, and its seeds were also dispersed by birds, allowing the plant to spread rapidly.⁹ Japanese barberry thrives in a wide range of conditions, including sun, shade, drought, and warmer temperatures.¹⁰ It's also unaffected by other species, including deer, which tend to avoid it and eat only native plants.¹¹ As a result of its persistence and damage to the environment, it is now banned in several northeastern states, including Maine, Massachusetts, New York, and Pennsylvania.¹²

Ecological Impacts:

Ecologically, Japanese barberry creates serious damage. Its ability to spread deep into forest interiors means it replac-

es native plants that would otherwise feed and support local wildlife.¹³ As barberry spreads, native plant populations decline, leading to fewer insects, fewer food sources for animals, and a breakdown of entire food webs.^{13,14} In particular, deer contribute to the spread of barberry as well, since they only eat native plants; they end up over-browsing those while completely ignoring barberry.¹⁵ This type of trophic downgrading reduces biodiversity and makes ecosystems more fragile.¹⁶ Japanese barberry has also been found to affect soil chemistry, changing nutrient cycling and further hindering the growth of native plants.¹³ These changes don't stay localized—they cascade through the entire ecosystem, affecting everything from microbes to large mammals.

Control:

Controlling Japanese barberry is possible but difficult.¹⁷ Physical methods like pulling or digging up the roots can work, especially in cases of small infestations, but are labor-intensive and time-consuming.¹⁸ Herbicides offer a chemical solution, but they come with environmental concerns such as soil contamination, damage to non-target plants, and the plants could develop resistance to the herbicide over time.¹⁹ Prevention can be more effective than removal, which is why planting native alternatives, like the Red chokeberry and Dwarf Fothergilla, is recommended by experts.²⁰ Increasing public awareness and legislation is also an effective control measure, especially in states like New Jersey that don't currently ban its sale.^{6,21} To sum up, barberry control is possible through commitment and collaboration, which is not happening in most parts of New Jersey.²²

Lyme Disease:

Japanese barberry is linked to public health concerns related to Lyme disease, which makes control even more critical.²³ Barberry creates a humid, protected environment that is ideal for black-legged ticks (*Ixodes scapularis*) and is unique to barberry, as other native plants don't provide the same habitat.⁷ These ticks carry *Borrelia burgdorferi*, the bacteria that cause Lyme disease.²⁴ Lyme disease was first recognized in 1975 in Lyme, Connecticut, after many children were diagnosed with rheumatoid arthritis.²⁴ Today, almost half a million Americans get Lyme disease each year.²⁵ Symptoms include fever, fatigue, joint pain, and the hallmark bullseye rash at the location of the bite, though not all patients develop the rash, which makes diagnosis more difficult.²⁶ Lyme disease can usually be treated early with antibiotics, with patients recovering in a few weeks. However, if left untreated, it can lead to long-term neurological and heart problems such as facial palsy, meningitis, myocarditis, and more.²⁶ Japanese barberry fostering the growth of Lyme disease highlights the urgent need to consider public health when managing invasive species.

Purpose of this Study:

The first goal of this study was to establish the geographical correlation between Japanese barberry occurrence reports, blacklegged tick populations, and Lyme disease cases across the United States. Understanding this US-wide trend, I next

investigated further the connection between Japanese barberry (*Berberis thunbergii*) and Lyme disease, specifically in New Jersey. Finally, this research explores whether removing or restricting barberry might be linked to a change in Lyme disease incidence by analyzing the timing of statewide bans or regulations.

■ Methods

Data Collection: Japanese barberry USA Abundance Dataset:

Japanese barberry distribution data from EDDMapS was used, which provided the number of plant sites per state.²⁷ The data were downloaded as a CSV file and were further processed on Datawrapper, a map-making website. When the Datawrapper map was created, the color assignment was adjusted to include values from 0 to 5,000 for Barberry abundance to best represent differences in the plants' presence across states. Further, natural interpolation for color was used because it followed the natural distribution of the data without creating artificial divisions, unlike deciles or quartiles, which distorted the results. The FOHVOS dataset consists of recorded occurrences of invasive plant species, where each entry represents a confirmed observation of Japanese barberry at a specific location. Each record includes a geographic location (county), observation status (Detected or Positive), and a reporting source. It does not include tick population density. Because the dataset is based on reported observations rather than systematic sampling, it serves as an estimate for relative presence rather than true population density.

Occurrence records were filtered for Japanese Barberry and organized by county. The total number of reports per county was used to estimate relative barberry presence. Higher report counts were interpreted as a greater presence of Japanese barberry.

Data Collection: Lyme Disease Prevalence and Tick Datasets:

For Lyme disease prevalence, the state and locality-level surveillance data were downloaded from the Centers for Disease Control and Prevention (CDC) as an XLS file.²⁸ All cases from the last 20 years for each state were aggregated in Excel to obtain a cumulative picture of Lyme distribution. This dataset was then imported into Datawrapper, where natural interpolation for color assignment was again used, this time with a range from 0 to 130,000 cases, to show which states had the fewest cases (light green) and which had the most (dark blue). This color scale allowed direct comparisons to the barberry map.

The black-legged tick distribution data were used to make the tick table by inserting a pivot table in Excel. The pivot table used state for rows and state for columns, with the count of status per state as the values. Another column was created for the percentage of counties with an established tick population, which was calculated as the number of established counties divided by the total number of counties with data. It should be noted that Alaska and Hawaii did not have any data, and counties that had "no records" do not necessarily mean that there are no ticks, but rather that they have not been reported.

Data Collection and Analysis: New Jersey County Correlation:

First, an interactive species distribution map in NJ provided by FOHVOS (Friends of Hopewell Valley Open Space) was used.²⁹ On the webpage with the map, "All" was selected for county, property, and eradication status, Japanese barberry was chosen for species, and the data was then exported as an XLS file. This data was used for the analysis of New Jersey counties below. Separately, Excel was used to create graphs showing the total case numbers over time for each New Jersey county from 2000 to 2022, as well as the percentage of the population affected in each county. During the chart design phase, data were selectively included or not included to ensure clarity in the presentation of the time-series and comparative incidence data.

Data Collection: Statewide Policy Reference Table:

Official state invasive species lists, agriculture department pages, and university extension websites were used to find the policies implemented in states that had implemented a statewide ban or regulation on Japanese barberry. In particular, Connecticut, Maine, Delaware, Massachusetts, New York, New Hampshire, Vermont, and West Virginia have banned Japanese barberry, while Wisconsin and Minnesota have regulations. The timing of those bans or regulations was then recorded and compiled in the table below to facilitate comparison with Lyme disease trends.

■ Results and Discussion

Geographical Correlations in Distributions of Lyme Disease, Blacklegged Ticks, and Japanese Barberry Across the US:

The distribution maps reveal a clear geographic correlation: areas with higher prevalence of Japanese barberry also tend to align with higher populations of blacklegged ticks, which in turn parallels reported Lyme disease cases. In Figure 1A, it is shown that Lyme disease cases per capita are the most concentrated in the Northeast. There are also some other states not in the Northeast that have slightly higher cases per capita, such as Wisconsin and Oregon. Figure 1B shows the percentage of counties in each state that have an established tick population, which is prevalent mostly in the eastern part of the United States (there's no data for Alaska and Hawaii). All states have data for Lyme disease, but not for Japanese barberry (Figure 1C); this may be because Japanese barberry isn't as much of a problem in the West, so there's less research and documentation of the plant in that region. The same correlation with Figure 1C is with Figure 1A; there's a relatively high concentration of Japanese barberry plant sites and Lyme disease cases.

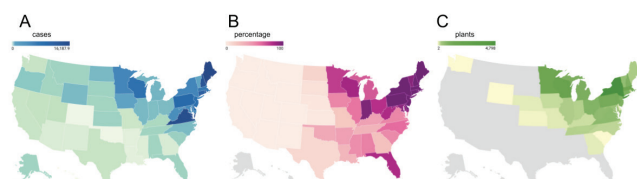


Figure 1: Lyme disease cases per capita- cases per 100,000 people (A), percentage of counties per state that have an established tick population (B), and number of Japanese barberry plant reports per state (C).

A distinct geographic overlap exists between the three variables, particularly clustered in the northeastern quadrant of the United States.

Hunterdon County had the third-highest number of reports of Japanese Barberry, with 97 reports (groupings of Japanese Barberry plants), and it had the highest amount of Lyme disease cases per capita (457 per 100,000 people). Meanwhile, Bergen County had one of the smallest numbers of reports, with only 2 reports, and it had the third-lowest amount of Lyme disease cases per capita, with 42 cases per 100,000 people. Interestingly, Essex County had the lowest number of Lyme disease cases per capita (18) and was the only county to initiate plans to mitigate the spread of Lyme disease. This overlap supports a geographic association between reported barberry presence and Lyme disease risk."

Although it's important to note that correlation does not equal causation, and there may be other factors influencing Lyme disease cases - such as deer populations, which also carry blacklegged ticks - the observed overlap supports existing research on habitat-level ecology. Dense barberry thickets create humid microhabitats ideal for tick survival and reproduction. States shaded gray on the Japanese barberry and blacklegged tick maps represent either regions with no presence of the species or insufficient data. There is a clear east-west divide in prevalence, with higher barberry and Lyme disease levels concentrated in the Northeast and Midwest. This could be explained by poleward expansion due to climate change.³⁰ Since Japanese barberry (and ticks) thrive in warmer conditions, northern states that are now hotter for longer periods of the year can sustain more growth, contributing to the rise in Lyme disease cases. Taken together, these patterns show that the spread of Japanese barberry indirectly influences the risk of Lyme disease by fostering favorable conditions for blacklegged tick populations.

Analysis of Lyme Disease Charts:

Over the past two decades, Lyme disease cases have steadily increased, with a particularly sharp rise in the last five years, reaching 70.7 cases per 100,000 people in New Jersey.³¹ Although there was a dip in 2020 due to COVID-19, when people were less likely to be outdoors and exposed to ticks, the trend has since rebounded and continued upward. Ten counties account for nearly 80% of Lyme disease cases, with Morris County (12.6%), Hunterdon County (9.6%), and Monmouth County (9.3%) being the highest contributors.

The specific counties in Figure 2A were chosen to show a variety of different counties, showing the counties that had the least amount and the highest amount of Lyme disease cases, had a plan for controlling Japanese barberry, and had the most amount of Lyme disease cases. It is important to note that in Figure 2B, the percentages add up to 100%, which shows how much each county contributes to the total Lyme disease cases in New Jersey, but is not weighted, unlike in the first graph.

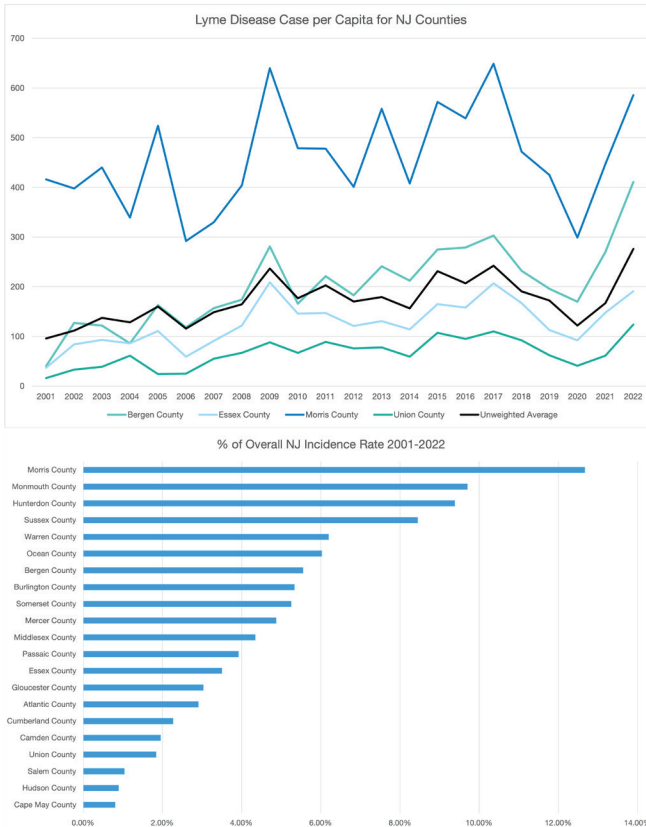


Figure 2: Lyme disease cases per 100,000 people from 2005-2022 in select NJ counties (A) and the percentage of Lyme disease cases in NJ that came from each county from 2001-2022 (B).

The data show that Lyme disease is heavily concentrated in specific areas, led by Hunterdon County's high per capita rates and Morris County's top share of overall state cases. These sharp geographic disparities highlight the specific high-risk forest and barberry habitats driving New Jersey's incidence.

Data from FOHVOS shows that Morris County has the highest incidence of Japanese barberry, which also has the highest net number of Lyme disease cases, as shown in Figure 2B (12.6%). This clearly demonstrates how higher Japanese barberry abundance contributes to more Lyme disease cases. Morris County is very wooded, and Japanese barberry is very widespread in the county. Overall, counties with more forested land and dense vegetation showed higher Lyme disease rates, reinforcing the connection between habitat characteristics and disease prevalence. These geographic and ecological patterns provide a strong foundation for analyzing how management efforts and environmental changes may influence Lyme risk, which will be explored further in the discussion section. Hunterdon County is an example of this, as the population is relatively small, with about 130,000 people; however, it has 280,000 acres of forest and, as a result, has the highest number of Lyme disease cases per capita. This same pattern matches up with the rest of the United States; for example, Maine has the highest percentage of forest area, with almost 90%, and also has the highest number of Lyme disease cases per capita at 16187.90. Wisconsin and New Jersey have the same percentage of forest area (42%) and have about the same number of Lyme disease cases per capita (around 8,300 cases); however,

Wisconsin has a large deer population, with it being in the top 5 states in the US, which also spreads ticks.³² This helped me explore whether removing or restricting barberry might be linked to a change in Lyme disease incidence, while keeping in mind that many other factors, like the climate and tick populations, can influence Lyme risk.

Analysis of Statewide Policies on Japanese Barberry and Lyme Disease Cases:

Several northeastern states have implemented policies to regulate or prohibit Japanese barberry, while others have limited measures or pending legislation (Table 1). In New Hampshire, the state's invasive species regulations (Agr 3800) prohibit the sale, transport, propagation, or distribution of species listed on its Prohibited Invasive Plant List, which includes Japanese barberry (New Hampshire Department of Agriculture, Markets & Food). In New York, 6 NYCRR Part 575, enacted in March 2015, made it illegal to possess, import, sell, or introduce Japanese barberry, with a one-year grace period allowing the sale of existing nursery stock (New York Department of Environmental Conservation; Cary Institute of Ecosystem Studies). By contrast, New Jersey currently has no statewide ban or comprehensive invasive species law regulating barberry. The proposed Invasive Species Management Act (S1029), introduced in 2025, would prohibit its sale, distribution, and propagation without a permit and establish a state Invasive Species Council (New Jersey Conservation Foundation). Although it's not a law yet, barberry appears on New Jersey's "Do Not Plant" lists, such as those published by the New Jersey Invasive Species Strike Team (FOHVOS).

Table 1: States with regulations or bans on Japanese barberry. Legislative bans and restrictions on Japanese barberry have steadily expanded across the Northeast and Midwest over the past two decades. However, because these policies primarily target future nursery sales, they have a limited immediate impact on reducing local Lyme disease rates without active removal of already established wild populations.

State	Year Regulation Measure Introduced	Measure
Connecticut	Public Act 24-11 (2024) adds species; CT Invasive Plant Council notes barberry to be prohibited from sale by Oct 1, 2028, after phase-out	BANNED (still phasing in) ³³
Delaware	July 1, 2022	BANNED (Invasive Plant List, nursery/retail sales prohibited) ³⁴
Maine	January 14, 2017	BANNED (DACF "Do Not Sell" list) ³⁵
Massachusetts	January 1, 2009, phase out completed 2009-2012	BANNED (MDAR Prohibited Plant List) ³⁶
New Hampshire	January 1, 2007	BANNED (Agr 3800 Prohibited Invasive Plants) ³⁷
New York	March 10, 2015, later allowed limited sterile cultivars via permits/research	BANNED (6 NYCRR Part 575 "Prohibited Invasive Species") ³⁸
Pennsylvania	October 8, 2021	BANNED (Noxious Weed Control - List B) ³⁹
Vermont	In 2008, on the current prohibited list	REGULATED (On Vermont's Noxious Weed Quarantine) ⁴⁰
West Virginia	July 1, 2020	BANNED (state noxious/invasive list - sale prohibited) ⁴¹
Wisconsin	May 1, 2015, sales and distribution are controlled	REGULATED (NR 40 Invasive Species Rule) ⁴²
Minnesota	January 1, 2015, sale and distribution are prohibited, though cultivars are legal.	REGULATED ("Specially Regulated" terrestrial invasive - sterile cultivars may be permitted) ⁴³

The comparison of state-level policies with Lyme disease trends suggests that while implementing bans and regulations

is a necessary first step, their immediate impact on disease incidence may be limited due to the large existing presence of Japanese barberry. Many states, especially in the Northeast, that have banned or regulated the plant (such as Massachusetts and New Hampshire) still report some of the highest case numbers in the country. For example, New York implemented its ban in 2015, and while it had a one-year grace period, cases have generally not gotten significantly worse or better. The CDC's revised surveillance case definition in 2022, which led to a large increase in reported cases, also complicates pre- and post-ban comparisons.⁴⁴ Nevertheless, policies like those in New York, which allow limited sterile cultivars via permits, show a proactive approach to managing the introduction of new barberry plants. Additionally, in January 2026, New Jersey enacted the Invasive Species Management Act, which designates Japanese barberry as a prohibited invasive species and establishes a statewide framework for its regulation. Because the law's restrictions are being phased in, its effects on barberry prevalence and Lyme disease incidence cannot yet be evaluated.

The primary challenge remains the removal and control of established barberry thickets across vast areas, a slow process that requires sustained public awareness and commitment, especially in states like New Jersey, where there are currently no statewide bans. While banning invasive plants is helpful, it doesn't reduce the amount already present, and they will continue to reproduce without active management. New Jersey provides a clear example: every county besides Essex lacks control plans for barberry, even though it's widespread across the state. States should not only ban invasive species but also make it publicly aware of the dangers of planting them, as many people do not even know what invasive plants are, and that plants in their garden may even be banned in their state. For example, the public-led campaign to squash invasive lanternflies in New Jersey shows how widespread awareness, even through small actions, can help control ecological threats.

■ Conclusion

Japanese barberry is more than just an invasive plant—it is an environmental and public health threat that contributes to higher Lyme disease risk. I explored three main questions: how barberry distribution correlates with blacklegged tick populations and Lyme disease cases, whether this connection is visible in New Jersey, and how state policies impact the problem. My findings revealed clear geographic overlap between barberry abundance, tick presence, and Lyme disease cases, especially in forested regions like northern New Jersey. States with bans on barberry still report high disease rates, showing that regulation alone isn't enough without long-term removal and prevention efforts. These results highlight the urgent need for stronger management strategies and public awareness to limit both ecological and health impacts of invasive species like Japanese barberry. States with high invasive species need a multi-prong approach to minimize the impact on public health. A grass-roots volunteer effort could play an important role in helping to eradicate these plants in forested areas. Community members may also consider writing to local representatives. New

Jersey could benefit from passing the pending Invasive Species Management Act. In addition, detecting and eradicating the shrubs from growing in the wild is an important strategy that could be achieved through partnerships among local communities, foundations, environmental agencies, and forest land conservation departments. These results reinforce previous ecological findings that invasive plant management is directly tied to public health outcomes, highlighting the urgent need for stronger management strategies and public awareness to limit both ecological and health impacts of invasive species like Japanese barberry. Future studies should include other invasive vegetative species like the herbaceous plants and perennials (e.g., giant hogweed), and vines (e.g., English Ivy).

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