Effectiveness of Invasive Plant Treatments at Mount Greylock and Westfield River, MA

FEMC Analysis and Report for the Massachusetts Department of Conservation and Recreation

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Introduction

The FEMC conducts "sprint" projects for our state partners and stakeholders annually. Proposals are submitted describing a project that may not be of relevance to partners across the region, but is of interest to an individual state. In 2025, FEMC received a proposal from the Massachusetts Department of Conservation and Recreation to conduct an analysis on the effectiveness of invasive plant treatment at several locations. Specifically, glossy buckthorn and Japanese knotweed located along the Westfield River were monitored and treated between 2013 and 2021. Additionally, honeysuckle located at a variety of sites on Mt. Greylock was treated with monitoring conducted multiple times between 2014 and 2019.

Data and Methods

Each dataset was analyzed to estimate the effectiveness of invasive species treatments over the sampling period. Data sets were cleaned and organized in R followed by evaluation of summary statistics to better understand the data. Each dataset required slightly different approaches to analysis, based on the structure of the data.

The glossy buckthorn and Japanese knotweed data includes percent cover for each plot location on three occasions. The assumption is that treatment occurred between the first and second observation point. Short-term and long-term treatment effectiveness can be analyzed with this data. To further enhance the analysis, bootstrapping was used, which is useful with small sample sizes and provides confidence intervals that can be used in interpreting the effectiveness of the treatment and providing management recommendations. Further analysis using quantile

regression was used to detect if thresholds in treatment exist (i.e., if treatment is equally effective across sites with different starting populations of the introduced plant).

The data available for Mt. Greylock honeysuckle treatment had additional information, but the full metadata was not available, so some assumptions were made. The data include population size and abundance estimates of honeysuckle at various sites along roads in Mount Greylock State Reservation for three dates between 2014 and 2019. Size of population is typically numeric, whereas abundance is indicated with descriptions. To avoid misinterpretation, abundance is not used in the analysis. Also included in the data is indication that treatment occurred on two occasions at some locations. This allowed for further analysis of the effectiveness of the treatment. Habitat type is also provided in the data, allowing for segmentation of treatment effectiveness in different habitat types. As with the buckthorn and knotweed, quantile regression was used to evaluate how different size populations responded to treatment and if there is a threshold beyond which treatment is less effective.

All R code will be made available with this report.

Results

Results for each of the invasive plants indicate treatments were effective at reducing the overall percent cover. Full results and analysis are provided below.

Westfield River – Glossy Buckthorn

Data from the Westfield River treatment of glossy buckthorn included percent cover data at 58 sites visited in 2013, 2017, 2018, and 2021. Treatment occurred in 2013. Post-treatment cover reflects the treatment effectiveness over time.

Initial review of the glossy buckthorn data indicates a decrease in the mean percent cover from the initial sampling period in 2013 compared to subsequent sampling periods following invasive plant management treatment. Pre-treatment mean percent cover was 5.83% and 2.29% post-treatment. This was demonstrated to be a significant difference ($p<0.05$) using a linear mixed model. However, it was noted that some plots had an increased percent cover following the treatment. This increase appears to have occurred several years after the treatment, and after an initial reduction (Figure 1).

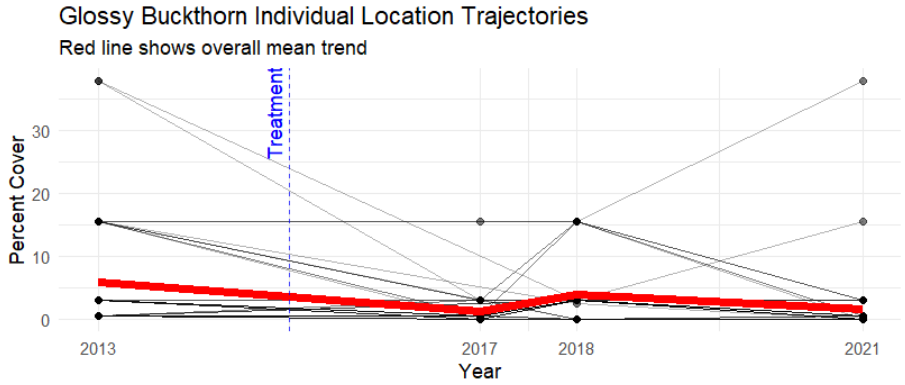

Figure 1 Changes in percent cover of glossy buckthorn at various sites along the Westfield River between 2013 and 2021.

A fixed-effects ANOVA using time as a categorical predictor was conducted to determine effectiveness of the treatment of glossy buckthorn at sites on the Westfield River (Table 1).

Table 1 Fixed effects ANOVA output evaluating treatment effectiveness on glossy buckthorn populations.

	Estimate	Std. Error	Df	T value	Pr(>|t|)
Intercept	2.4163	0.6465	62.0089	3.738	0.000407 ***
Pre-treatment	3.4204	0.7252	149.9615	4.716	5.45e-06 ***

These initial results indicate that the mean percent cover did decrease between the initial sampling period in 2013 and the final sampling period in 2021, with invasive plant treatment occurring following the initial sampling period.

Additionally, bootstrapping analysis was conducted, which allows determination of 95% confidence intervals, which indicate how likely it is for the treatment to effectively reduce glossy buckthorn cover. The results from this analysis indicate that treatment was effective (Figure 2).

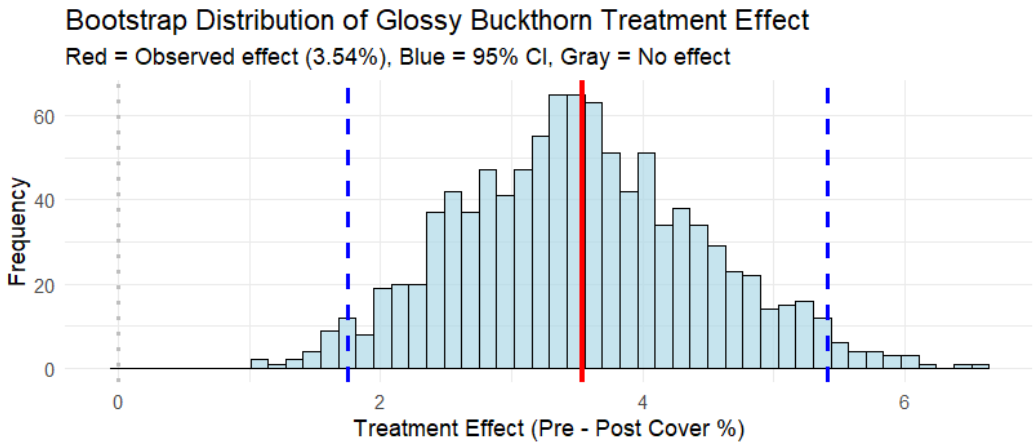

Figure 2 Bootstrap analysis of treatment effect of glossy buckthorn in the Westfield River.

While a reduction in percent cover at treated sites is significant, the data also indicated that treatment is not consistent at all sites. To further investigate this, the residuals were plotted against fitted values, which detected heteroskedasticity (Figure 3).

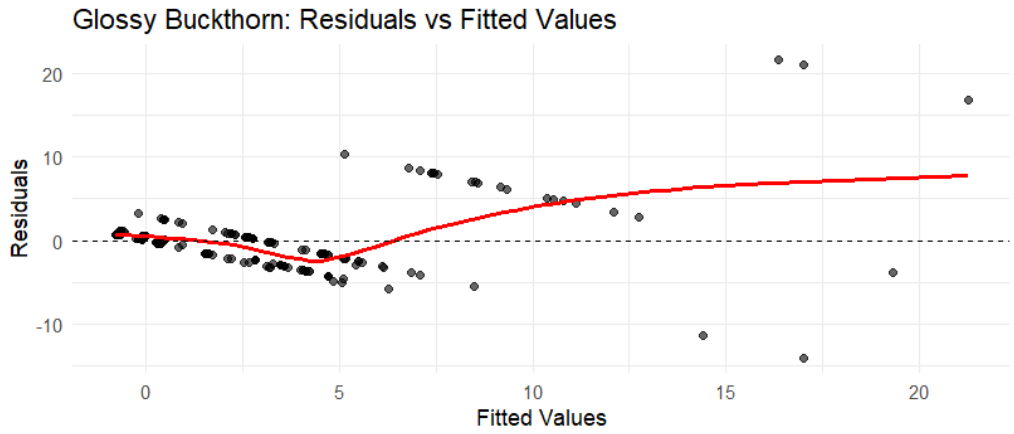

Figure 3 Residual plot to detect heteroskedasticity of the glossy buckthorn data. This plot indicates the treatment was not effective at all sites, requiring further analysis.

To address this, quantile regression was conducted to evaluate treatment on plots with differing values of starting percent cover. It is possible that starting conditions influence the effectiveness of the treatment. That is, sites starting with high cover may respond to treatment differently than sites starting with low percent cover. Larger decreases in percent cover are possible in plots with high initial cover compared to those with low initial cover.

The results from the quantile regression indicate that plots with the highest percent cover before treatment showed the greatest reduction in cover following treatment. This suggests the treatment is effective, even when the plant was not fully eradicated from the plot. Plots that started with lower percent cover did show a reduction in cover, but the decline was not as steep. There is high variability in the medium-density plots, with some increases in cover following treatment (Table 2).

Table 2 Quantile regression to evaluate treatment effectiveness of glossy buckthorn in the Westfield River.

Quantile	Treatment effect	Std Error	CI Lower	CI Upper
0.15	-0.5	0.00	-0.5	-0.5
0.25	-0.5	0.08	-0.66	-0.34
0.5	-2.5	1.00	-4.47	-0.53
0.75	0.0	6.17	-12.09	12.09
0.9	-12.5	4.76	-21.84	-3.16

The long-term effectiveness of the treatment was evaluated to determine if the treatments were sustained over time based on the pre-treatment quantile. This analysis suggests that the treatment was effective in all plots and largely sustained over time (Figure 4). Plots that started with a higher percent cover did have a reduction in cover that was sustained. Two plots showed an increase in cover over the longer period (Table 3).

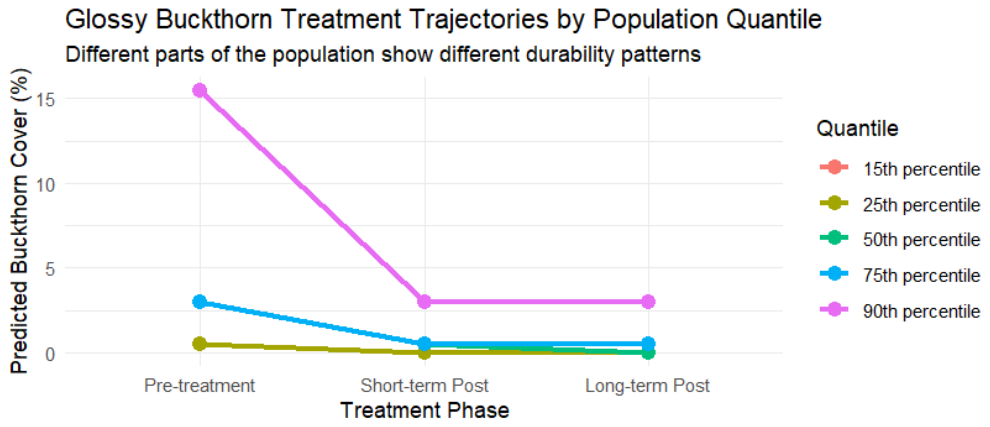

Figure 4 Sustained effectiveness of buckthorn treatment over time across different starting percent cover quantiles.

Site ID	Short-term change	Relapse Amount	Net Long-term Change
GM-183	-35.0	35.0	0.0
RL-119	-15.5	3.0	-12.5

Table 3 Treatment was not effective in two sites.

Westfield River – Japanese Knotweed

The data was cleaned and organized for analysis. An initial review of the data to identify outliers and any missing data was conducted. Some data points were identified as outliers, but were not removed because while they are outside of the expected range based on the other plots, it is not ecologically appropriate to remove the data points. The data was also reviewed for any missing data; all plots had at least two observations.

The data consists of 56 plots, with visits occurring in 2013, 2018, and 2021. Treatment occurred after the 2013 data was collected. Some sites only had two visits, but analysis was conducted for all sites.

Initial analysis of the Westfield River Japanese knotweed data was conducted to visualize the change in cover over time and the trajectory of individual plots (Figure 5). Boxes indicate the 25th – 75th percentiles with outliers outside of this range shown as points (Figure 6). Following treatment in 2013, median percent cover declined. A few sites continued to have elevated percent cover, but statistically, the treatment was effective.

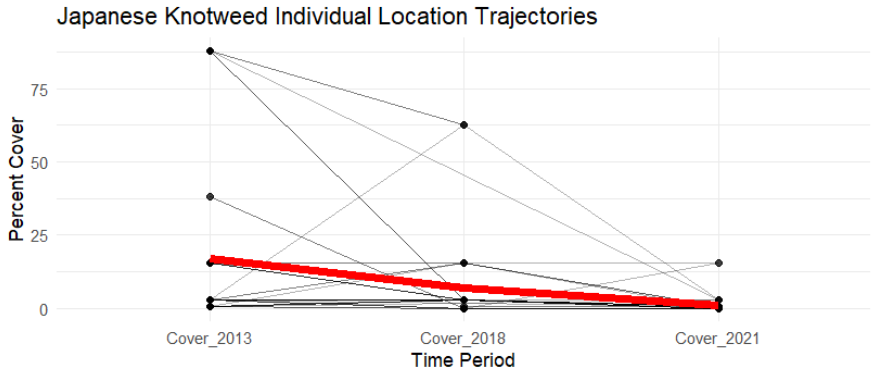

Figure 5 Individual trajectories of percent cover of Japanese knotweed over time, before and after treatment in 2013.

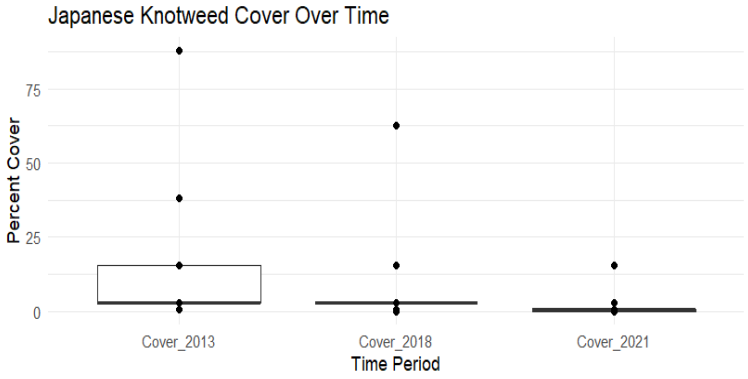

Figure 6 Japanese knotweed box plots indicating percent cover declined following treatment.

Bootstrap analysis was used to estimate confidence intervals of the treatment effect, which indicate that the treatment effect falls within the 95% confidence intervals and does not include 0, meaning that the treatment is accepted as effective (Figure 7).

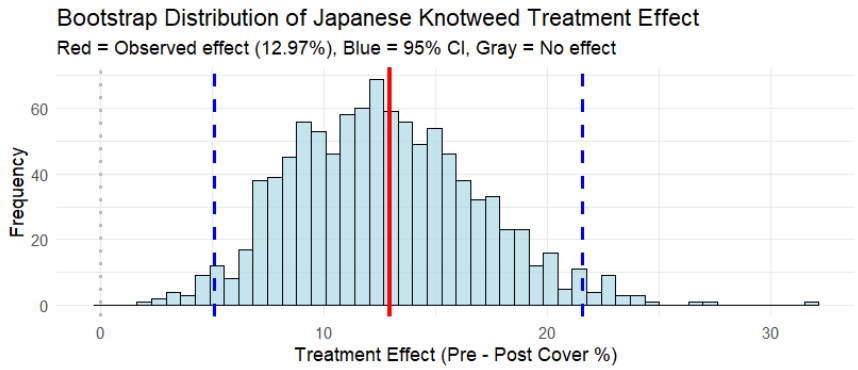

Figure 7 Bootstrap analysis of Japanese knotweed treatment, used to provide 95% confidence intervals, which indicate that treatment was effective.

Mt. Greylock - Honeysuckle

Honeysuckle was treated and monitored at 59 sites on Mt. Greylock. Observations were made two or three times between 2014 and 2018. The data available for honeysuckle plots on Mt. Greylock included information about the:

- date of observation,
- size or abundance of population,
- date of treatment,
- type of treatment (pulled, partial treatment, Y, and N)
- type of habitat (Forest, Edge, Roadbank, Roadside, or Mixed Roadside)

Analysis for the effectiveness of treatment on honeysuckle populations on Mt. Greylock was limited by a complex dataset. To provide the most reliable analysis, simple summaries of the data were used, which provides a conservative estimate of treatment effectiveness. Additional data or continued monitoring may allow for more in-depth analysis, but these options were not appropriate for the data currently available.

The Mt. Greylock data did include treatment methods and habitat type, which allowed for further investigation into effectiveness of different treatment methods and how habitat type may affect treatment. Treatment type included manual removal, cut stem herbicide treatment, and foliar treatment. Habitat was designated as forest (33) or roadside (26), simplifying the more detailed types of roadside classifications into a single category.

Forty-two sites were visited twice, receiving one treatment conducted during the first visit. These sites largely resulted in complete removal and no need for additional treatment. Sixteen sites were visited three times. Complete eradication was achieved at 31 of the sites that were treated once and at 13 of the sites that were treated twice.

Plotting the data by habitat type, the overall reduction in population is apparent over time. The treatment often did not appear effective at the second observation time, but following a second treatment application, many populations were fully removed (Figure 8).

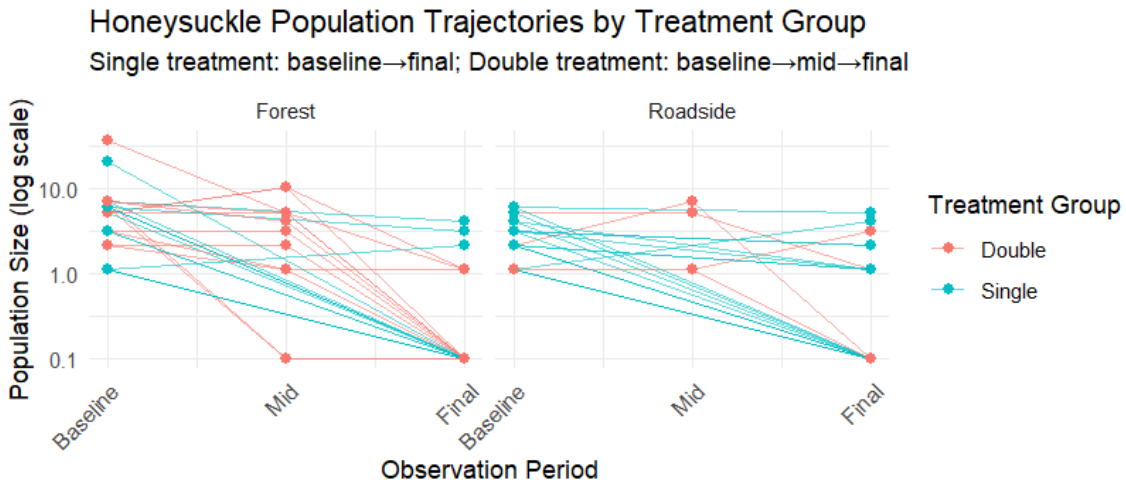

Figure 8 Honeysuckle populations following either single or double treatment applications in two habitat categories: forest and roadside.

Overall, treatment of honeysuckle populations on Mt. Greylock had some success. Populations found in forested areas had a higher eradication rate for both single and double treatments than roadside populations. Roadsides tend to have disturbed soil that is more conducive to invasive plants becoming established, so this is an expected outcome.

# Treatments	Habitat Type -	# Sites	Mean Baseline Population	Mean Final Population	Mean Response Rate (%)	Eradication Rate (%)
Double	Forest	12	7.3	0.2	94.4	75.0
Single	Forest	21	4.0	0.4	84.6	85.7
Double	Roadside	4	2.7	1.0	93.3	50.0
Single	Roadside	21	2.6	0.8	63.1	61.9

Conclusion

Invasive plant treatments are demonstrated to be effective in this analysis of glossy buckthorn, Japanese knotweed and honeysuckle at sites in Massachusetts.

While these analyses provide information to managers about effectiveness of treatment at these specific locations, this analysis should not be used broadly for management decisions. To improve the ability of using data to guide management decisions, metadata with information about how the data is collected and explanations for acronyms should be included. Additionally, while randomly selecting plots, testing different treatment methods, using control plots, or implementing more systematic monitoring may be challenging given the time constraints of many land managers, any of these improvements would increase the ability to make comparisons within the data about the effectiveness of treatments.