Slope Restoration on Urban Freeways

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TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. SPR-1767	2. Government Accession No. N/A	3. Recipient's Catalog No.
4. Title and Subtitle Slope Restoration on Urban Freeways		5. Report Date Sept. 30, 2025 6. Performing Organization Code N/A
7. Author(s) Bert M. Cregg, Ph.D. https://orcid.org/0000-0001-7271-5003		8. Performing Organization Report No. N/A
9. Performing Organization Name and Address Michigan State University Contract and Grant Administration 426 Auditorium Road Room 2 Hannah Administration East Lansing, Michigan 48824		10. Work Unit No. N/A 11. Contract or Grant No. Contract #2013-0066 Z10
12. Sponsoring Agency Name and Address Michigan Department of Transportation (MDOT) Research Administration 8885 Ricks Road P.O. Box 33049 Lansing, Michigan 48909		13. Type of Report and Period Covered Final Report, 4/1/2017 – 12/31/2025 14. Sponsoring Agency Code N/A
15. Supplementary Notes Conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. MDOT research reports are available at www.michigan.gov/mdotresearch. Report from previous phase of the project https://mdotjboss.state.mi.us/TSSD/tssdResearchAdminDetails.htm?keyword=Cregg&checkBox=undefined Previous Research Spotlight: https://www.michigan.gov/mdot/-/media/Project/Websites/MDOT/Programs/Research-Administration/Research-Spotlights/SPR-1701-Spotlight.pdf Article in Urban Forestry and Urban Greening https://www.sciencedirect.com/science/article/abs/pii/S161886672200231X?via%3Dihub		

16. Abstract

Improving the diversity of roadside plantings can provide an array of benefits including improved aesthetics, improved driver safety, and increased biodiversity. However, establishing landscape plants along roadsides can often be difficult due to a variety of soil related and other environmental factors. In an earlier trial, researchers from Michigan State University conducted a large-scale field planting along Interstate 696 in the Detroit metro area in order to identify site preparation practices and identify plant materials that were suited for roadside conditions. From the initial phase of this project MSU researchers determined that compost addition was important to aid in the establishment of landscape plants both from the perspective of improved survival as well as improved plant growth. MSU personnel also identified plant species that were well suited for highway plantings based on initial survival and growth. Here we report the continuation of this project focusing on characterizing the highway roadside environment and examining long-term (years 3-6) responses of the plant materials based on their cover and survival. We found that shrubs generally performed better along the roadside environment than herbaceous perennials or grasses. Shrubs that survived well and provided excellent cover included Diervilla, Physocarpus, contoneaster, and Cornus. Herbaceous perennials that provided excellent cover were Amsonia and hemerocallis. An examination of weather data from weather stations established along the Interstate roadside indicated that air temperatures were 3 to 4°F higher along the roadside compared to regional temperatures. There was little difference in ambient temperatures between north-facing and south-facing slopes along the freeway. A major challenge in maintaining plants along the highway roadside was weed control. In the study, chemical weed control was complicated because the plots were relatively small and contained a mixture of both grasses as well as broad-leaf plants, limiting the ability to control weeds using selective

17. Key Words	**18. Distribution Statement**
Site preparation, compost, mulch, tillage, shrubs, herbaceous perennials, grasses	No restrictions. This document is also available to the public through the Michigan Department of Transportation.

19. Security Classif. (of this report)	**20. Security Classif. (of this page)**	**21. No. of Pages**	**22. Price**
Unclassified	Unclassified	35	N/A

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Executive Summary

This report summarizes the continuation of a research project by personnel from the Michigan State University Department of Horticulture to investigate the establishment of roadside plants along urban freeways. The initial study was initiated in 2018, and assessments were conducted through 2020. The project was installed in two phases. In the Site Preparation study, the Research team installed replicated plots of 16 landscape plant selections with four levels of site preparation, which included combinations of compost and tillage. In addition, the researchers installed supplemental plots in order to evaluate sixteen additional landscape plant selections. The results of the initial trials indicated that compost addition rather than tillage was the principle factor in improving initial growth and performance of landscape plants along the roadside. In the current project, the investigators continued evaluations of the plants in order to determine long term survival and site occupancy. The research team also installed an automated weather station at the two locations in order to document conditions along the freeway roadsides that might impact plant performance. The results of the current investigation indicate that plant performance of several selections that grew relatively well in the initial trial declined over time. However certain selections, in particular Amsonia, cotoneaster, Diervilla, and Hemerocallis continued to survive and perform well on the freeway roadside. Long-term management challenges in maintaining plants along the roadside were largely related to managing competing vegetation, particularly Canada thistle. A need for further research is the development of effective and reliable protocols for managing weeds within landscape plantings along roadsides. In particular, the use of pre-emergent herbicides will be essential in order to allow landscape plants to become fully established. In addition, selective post emergent herbicides used judiciously can further aid in maintaining self-sustaining roadside plantings. Further investigations should also examine additional plant selections, particularly shrubs and fast-spreading herbaceous perennials. Another key factor for investigation is plant density as certain plants had good survival but because of their small stature did not achieve full site occupancy.

Introduction

Roadside plantings have numerous benefits to the urban landscape, including filtering out airborne particulate matter, providing habitat to urban wildlife, and dissipation of the urban heat island effect (Baldaulf, 2017; Edmondson et al., 2016; Hopwood, 2008). In addition, well-landscaped roadsides can reduce crash rates, possibly due to reduced driver stress (Mok et al., 2006; Van Treese et al.,2017). Incorporating minimal maintenance plantings can also reduce maintenance costs when compared to turf plantings due to the reduced need for mowing. Unfortunately, establishing roadside plants can be challenging because of the effects of poor urban soils and pollution (Craul, 1985; Mills et al., 2020; Muthu et al., 2021), which can cause municipalities to be hesitant to fund these projects. Proper site preparation and plant selection can drastically improve the success of these roadside plantings (Cregg et al., 2021; Haan et al., 2012). The addition of compost can improve soil nutrition and reduce the bulk density of urban soils, which allows for better root growth and improved plant nutrition (Bary et al., 2016; Dubelko et al., 2022; McGrath et al., 2020). The bulk density of urban soils can be further reduced by tillage (McGrath and Henry, 2016). When selecting plants for roadside sites one should not only consider aesthetics (Fathi and Masnavi, 2014; Guneroglu et al., 2019), but also a plant's tolerance for urban conditions and pollution (Kour and Adak, 2023; Lauki et al., 2022). Incorporating proper plant selection and site preparation into municipal planting manuals may result in better outcomes for future roadside planting projects.

Methodology

Note: A complete description of the sites and study installation can be found in the original project report.

Location

Site description

The study was installed in 2018 on two sites along Interstate 696 (I-696), an east-west running highway located near Detroit, Michigan, USA (Fig. 1-3). Two sloped roadsides along I-696 were selected for this experiment near Roseville, MI and Warren, MI. The Roseville site was on a south facing slope (south aspect) and the Warren site was on a north aspect.

Experimental Design

This study was installed as a split-plot in a randomized complete block design with site preparation treatment (site prep) as the main plot factor and plant selection as the sub-plot factor (Figure 4-5).

Main plot: Site Prep

We installed three complete blocks with four main plots within each block at each location. Each main plot measured 20 ft wide and 56 feet long. We randomly assigned one of four site preparation treatments to each main plot: control, compost only, tillage only, and compost + tillage. Before construction of each block, existing plant material, mulch and compost were cleared from the site down to mineral soil. Plots assigned to the *compost only* treatment were top-dressed with a 4 in deep layer of compost. Plots assigned the *tillage only* treatment were mechanically tilled to a 8 in depth using a rotary tiller attached to a skid-steer tractor. Plots assigned the *compost + tillage* had a 4 in deep layer of compost applied, which was then mechanically tilled into the soil to a 8 in depth. All plots were subsequently top-dressed with a top layer of 3 in of twice-ground hardwood mulch.

Sub-plot: Plant Selection

Each main plot was divided into 16 sub-plots. The subplots were arranged in two rows with larger sub-plots located at the top of the slope measuring 8 ft wide and 12 ft long, and contained 6 individual plants each (Figure 5). Smaller sub-plots were located at the bottom of each main plot and measured 8 ft by 6 ft, and contained 9 plants (Figure 7).

Within each sub-plot, contract crews planted one of 16 selections of ornamental plants; these included 7 shrubs, 5 herbaceous perennials and 4 ornamental grasses (Table 1).

Plant Evaluation Study

Adjacent to each block, one additional Plant Evaluation plot was constructed to allow evaluation of additional plant selections without replicating the entire site preparation study. These evaluation plots were the same size and layout of the main plots and contain 16 additional plant selections. Within each evaluation plot, contract crews planted 16 selections of ornamental plants; this included 7 shrubs, 6 herbaceous perennials and 3 ornamental grasses (Table 2).

<u>Site Management</u>

Weed Control

To reduce competition from weeds, each planting site was treated with a pre-emergent herbicide (Snapshot 2.5 TG Dow Agrosciences, Indianapolis, IN) at 100 lb/acre after compost application and before mulching according to MDOT 2012 Standard Specifications for Construction. This application was repeated in the spring of 2019. We were unable to apply pre-emergent herbicide in spring 2020 due to Covid-19 travel restrictions. During the growing seasons, weeds were removed from each site by hand or by spray application of glyphosate (Prosecutor, Lesco, INC. Cleveland, OH) as a 2% a.i. solution.

<u>Current study</u>

MSU Enviroweather Station

During the summer of 2020 we installed two weather stations with the assistance of the MSU Enviroweather Team. One station was installed close to block one at the Roseville location approximately 15 feet from the roadside. The other station was installed between blocks five and six at the Warren location approximately 15 feet from the roadside. Each station was outfitted with a wind sentry set (model 03002-L, Campbell Scientific, Logan, UT), solar radiation sensor (model LI200x, LI-COR INC. 4647 Lincoln, NE), HygroVUE10 Temp/Rh sensor (model HygroVUE10, Campbell Scientific, Logan, UT), and datalogger (model CR1000, Campbell Scientific, Logan, UT). Air temperature, relative humidity, and total precipitation were logged every hour. Wind speed and temperature were logged every five minutes.

Plant Evaluation

Growth and Mortality

In fall of 2020, 2021, 2022, and 2023, we assessed plant survival and plant cover on each plot. Individual plant growth measurements were discontinued in 2020 as plants on many of the plots had grown together, making it difficult to identify individual plants. Plant cover was evaluated by visual estimation of percentage of plant cover within each sub-plot (Figure 7). Within a block, the same observer estimated plant cover.

Findings

Site Prep Experiment

Several herbaceous perennials that had excellent survival (80% survival or greater) at the end of the initial evaluation period in 2020, had significant mortality in the subsequent years (Fig. 8). Chelone and Deutzia 'Nikko', suffered nearly complete mortality between 2020 and 2022. All Chelone plants appeared dead at the 2022 evaluation, but a few plants had re-sprouted by the 2023 evaluation. Survival of Hemerocallis 'Happy returns', nepeta, Schizachyrium 'the Blues', and Panicum decreased by at least 30% from 2020 to 2023. In contrast, Amsonia Halfway to Arkansas maintained approximately 100% survival throughout the study (Fig.9). Overall. shrubs had much better survival than herbaceous perennials and grasses (Fig. 10 and 11). Five shrubs; 'Kodiak black' diervilla, 'Summer Wine' ninebark, Arctic sun dogwood, 'Sugar shack' buttonbush and 'Michigan sunset' diervilla had 80% or better survival by the end of the study. Forsythia had nearly 100% survival in 2020 but had only 75% survival by 2023. Baptisia, in contrast, had less than 40% survival by the end of the study.

Trends in ground cover were similar to those for survival. Among the herbaceous perennials, only Amsonia 'Halfway to Arkansas' maintained greater than 60% ground cover and maintained 100% ground cover from 2021 onward. If we assume that 75% ground cover is necessary for successful maintenance, none of the other perennials in the trial meet this criteria. Percent ground cover increased for several shrubs during the study. These included 'Summer wine' ninebark, 'Kodiak black' diervilla ,'Michigan sunset' deirvilla, and 'Arctic sun' dogwood, all of which maintained 75% or more cover by 2023, suggesting that these shrubs are good candidates and can maintain adequate cover to suppress competing vegetation.

Plant Evaluation plots

In the Plant Evaluation plots, growth and survival of the herbaceous perennials varied more widely than that of the shrubs (Fig. 12-13). Hemerocallis Stella de Oro and Amsonia maintained over 85% survival throughout the study. Deutzia 'Chardonnay pearls' and Allium 'Summer beauty', which had excellent survival in 2020, suffered significant mortality between 2020 and 2023 and had less than 50% survival. By the end of the study, all the Deschampsia 'Goldstaub', Schizachyrum 'Little arrow', and Carex had died. Among the shrubs, Cotoneaster 'Coral beauty', Yuki cherry blossom Deutzia, and Tiny wine Physocarpus maintained 75% or more survival. Survival of Diervilla 'Butterfly', Kodiak red, and Kodiak orange decreased steadily during the trial, and all had less than 70% by 2023. Overall, percent ground cover for the herbaceous perennials and grasses was poor. By 2023 only Amsonia had greater than 75% ground cover, increasing from approximately 45% in 2020. Percent cover for all other perennials and grasses remained steady or decreased from 2020 to 2023. Among the shrubs in the plant evaluation plots, cotoneaster 'Coral beauty' consistently maintained the highest percent ground cover. Cotoneaster had nearly 100% ground cover throughout the study and in some cases began to invade adjoining plots. All other shrubs in the plant evaluation plots had 65% ground cover or less.

<u>Summary</u>

Combining results from the site preparation plots and the plant evaluation plots several trends become clear (Table 5 & 6) . First, ornamental grasses generally performed very poorly. Panicum was the best performer among the grasses but only maintained 43% ground cover and had less than 50% survival. All other grasses had approximately 25% survival or less and 20% ground cover or less. Among herbaceous perennials, both Amsonia's were excellent and had 80% or better survival and ground cover. Hemerocallis Stella de Oro had particularly good survival (94%) but because of its relatively small stature only had 68% ground cover. Selections of Hemerocallis also performed well in roadside trials in Europe (Laukli et al., 2022). This suggests the plant is a good choice for roadsides but may be more effective if planted at slightly higher densities. Nepeta had mediocre performance in this trial, with approximately 50% survival and 50% ground cover. This is somewhat surprising given this plant often does very well on comparable sites along I-696 as well as in other published studies (Eom, 2005). Performance of nepeta was variable from plot to plot suggesting that stock type or differences in stock type may have played a role in the variable performance.

Several shrubs trialed in this project had good survival and provided excellent ground cover, suggesting they can become self-sustaining. In particular, Diervilla Kodiak black, Physocarpus, cotoneaster, and Cornus all maintained 75% or more ground cover. Baptisia, which is actually an herbaceous perennial but was included in the shrub plots because of its size, performed poorly in both the site preparation and the plant evaluation plots and resulted in less than 40% ground cover and had less than 45% survival.

The changes in plant cover and survival between 2020 and 2023 point out the importance of longer term valuations in assessing plants for roadside projects. In particular, several shrubs that did well early on faded and had poor survival by the end of the study. Given the high weed pressure faced on the site especially after the heavy infestation of Canada thistle and other weeds in 2020 (Fig. 14), the survival and ground cover assessments included in this study should be viewed as worst-case scenarios.

Discussion

Implementation and recomendations

We evaluated plant coverage and survival for 32 plant selections in this study. Fifteen selections had both high rates of survival and high amounts of average plant coverage. Shrubs that were most successful in this study based on plant coverage and survival were *Physocarpus opulifolius* 'Seward', *Physocarpus opulifolius* 'SMPOTW', *Diervilla lonicera* 'Copper', Diervilla rivularis 'SMNDRSF', *Diervilla* 'G2X885411', *Diervilla* 'G2X88544', *Diervilla sessilifolia* 'Butterfly', and *Cephalanthus occidentalis* 'SMCOSS'. Perennials that were successful in this study were *Nepeta* x *faassenii* 'Six Hills Giant', *Hemerocallis* 'Happy Returns', *Hemerocallis* 'Stella De Oro', *Amsonia hubrichtii* 'Halfway to Arkansas', *Panicum virgatum* 'Rotstrahlbush', *Allium tanguticum* 'Noneuq', *Allium tanguticum* 'Summer Beauty'. All the plant selections mentioned would be good choices for roadside plantings in Michigan.

Knowledge gaps for potential future research directions A key finding from this project is the interaction between successful establishment and successful weed control. For plants that maintained excellent cover (e.g., 80% cover or better), little weed competition was present in the plots. In contrast, on plots where plants survival and cover was poor, weeds were a consistent problem throughout the study and required continual attention either through the application of pre and post emergent herbicides or through hand weeding. A logical next step in this research area would be the development of larger scale plots with an emphasis on identifying efficient and effective management strategies to ensure high density plantings and minimal inputs, particularly herbicides. We suggest a project utilizing some of the better selections from this project (e.g., Diervilla and Amsonia) planted on larger scales (e.g., quarter acre plots or larger) and the development of pre-emergent and post emergent weed control strategies. In particular, identifyomh pre-emergent herbicides that could be applied either in late fall or early spring when plants are dormant and maintain weed control well into the growing season, would be greatly improve landscape plant establishment. In conjunction with this, would be the identification of selective post emergent herbicides that could be applied effectively and efficiently to control any weeds that were not managed through the pre-emergent applications. Based on our experience with the initial project it seems reasonable that self-sustaining landscape plantings could be achieved within two years utilizing plants that quickly develop full canopy closure and full occupancy of the site along with a judicious pre and post emergent herbicide program.

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Appendices

Table 1. Plant selections planted in Site Preparation Experiment

Scientific name	Common name	Plant Type	Plants per subplot	Container size
Cephalanthus occidentalis 'SMCOSS'	Sugar Shack® Buttonbush	Shrub	6	#3
Cornus sanguinea 'Cato'	Arctic Sun® Red Twig Dogwood	Shrub	6	#3
Deutzia gracilis 'Nikko'	Slender Deutzia	Shrub	9	#3
Diervilla lonicera 'Michigan Sunset'	Dwarf Bush Honeysuckle	Shrub	6	#3
Diervilla rivularis 'SMNDRF'	Kodiak® Black Diervilla	Shrub	6	#3
Forsythia x 'Minfor6'	Show Off® Starlet Forsythia	Shrub	6	#3
Physocarpus opulifolius 'Seward'	Summer Wine® Ninebark	Shrub	6	#3
Carex pensylvanica	Pennsylvania Sedge	Grass	9	#1
Deschampsia cespitosa 'Bronzeschleier'	Bronze Veil Tufted Hair Grass	Grass	9	#1
Panicum virgatum 'Rotstrahlbush'	Red Switch Grass	Grass	9	#1
Schizachyrium scoparium 'The Blues'	Little Blue Stem	Grass	9	#1
Baptisia australis	Blue False Indigo	Perennial	6	#1
Chelone lyonii 'Hotlips'	Hot Lips Turtle Head	Perennial	9	#1
Hemerocallis 'Happy Returns'	Happy Returns Daylily	Perennial	9	#1
Nepeta x *faassenii* 'Six Hills Giant'	Six Hills Giant Nepeta	Perennial	9	#1
Amsonia hubrichtii 'Halfway to Arkansas'	Halfway to Arkansas Narrow Leaf Blue Star	Perennial	9	#1

Table 2. Plant selections planted in plant evaluation experiment.

Scientific name	Common name	Plant Type	Plants per subplot	Container size
Cotoneaster dammeri 'Coral Beauty'	Bearberry Cotoneaster	Shrub	6	#3
Deutzia gracilis 'Duncan'	Chardonnay Pearls® Deutzia	Shrub	6	#3
Deutzia 'NCDX2'	Yuki Cherry Blossom® Deutzia	Shrub	6	#3
Diervilla sessilifolia ‘Butterfly’	Southern Bush-honeysuckle	Shrub	9	#3
Diervilla 'G288544'	Kodiak® Orange Diervilla	Shrub	6	#3
Diervilla 'G2X885411'	Kodiak® Red Diervilla	Shrub	6	#3
Physocarpus opulifolius 'SMPOTW'	Tiny Wine® Ninebark	Shrub	6	#3
Carex vulpinoidea	Fox Sedge	Grass	9	#1
Deschampsia cespitosa 'Goldstaub'	Goldstaub Tufted Hair Grass	Grass	9	#1
Panicum virgatum 'Shenandoah'	Shenandoah Switch Grass	Grass	9	#1
Schizachyrium scoparium 'Little Arrow'	Little Arrow® Little Blue Stem	Grass	9	#1
Allium tanguticum 'Balloon Bouquet'	Balloon Bouquet Ornamental Chive	Perennial	9	#1
Allium tanguticum 'Summer Beauty'	Summer Beauty Ornamental Chive	Perennial	9	#1
Baptisia ‘Solar Flare’	Solar Flare Prairieblues™ Indigo	Perennial	6	#1
Hemerocallis 'Stella de Oro'	Stella de Oro Daylily	Perennial	9	#1
Amsonia tabemontana	Blue Star	Perennial	9	#1

Table 3. Mean daily air temperatures two site along I-696 roadside in Warren-Roseville area 2022 and 2023 relative to regional temperatures.

	Average daily maximum temperature (deg. F)			
	Annual		Summer[1]	
Site	2022	2023	2022	2023
South aspect	60.6	62.4	84.4	81.4
North aspect	60.6	62.2	84.9	81.7
Regional[2]	57.4	59.1	80.8	78.2

	Average daily minimum temperature (deg. F)			
	Annual		Summer	
Site	2022	2023	2022	2023
South aspect	42.7	45.6	63.7	62.1
North aspect	42.9	45.8	64.0	62.4
Regional	37.8	40.6	58.6	57.2

1. Average of daily temperatures for June, July, August
2. Data from Michigan State University Enviroweather station in Commerce township, MI

Table 4. A comparison of the survival rates of perennial selections from the site preparation experiment, and the supplemental plant evaluation experiment. Survival rates of selections from the site preparation experiment were calculated from the compost and tillage treatment only.

Survival Rate			
Species	Experiment group	Survival	Ground Cover
A. hubrichtii	Site Preparation	100.0	100.0
A. tabernaemontana	Plant Evaluation	83.3	78.3
H. 'Stella de Oro'	Plant Evaluation	94.4	68.3
Nepeta	Site Preparation	51.9	55.0
H. 'Happy Returns'	Site Preparation	63.0	48.3
P. 'Rotstrahlbush'	Site Preparation	46.3	43.3
A. 'Balloon Bouquet'	Plant Evaluation	61.1	38.3
D. 'Duncan'	Plant Evaluation	44.4	38.3
S. 'The Blues'	Site Preparation	25.9	21.7
P. 'Shenandoah'	Plant Evaluation	24.1	21.7
A. 'Summer Beauty'	Plant Evaluation	22.2	15.0
Chelone	Site Preparation	11.1	6.7
D. 'Bronzeschleier'	Site Preparation	13.0	0.0
C. pensylvanica	Site Preparation	0.0	0.0
D. 'Nikko'	Site Preparation	0.0	0.0
C. vulpinoidea	Plant Evaluation	0.0	0.0
D. 'Goldstaub'	Plant Evaluation	0.0	0.0
S. 'Jazz'	Plant Evaluation	0.0	0.0

Table 5. A comparison of the survival rates of shrub selections from the site preparation experiment, and the supplemental plant evaluation experiment. Survival rates of selections from the site preparation experiment were calculated from the compost and tillage treatment only.

	Survival Rate		
Species	Experiment group	2019	2020
D. Kodiak Black	Site Preparation	91.7	95.0
P. 'Summer Wine'	Site Preparation	91.7	91.7
Cotoneaster	Plant Evaluation	94.4	90.0
D. lonicera	Site Preparation	75.0	78.3
Cornus	Site Preparation	80.6	73.3
P. 'Tiny Wine'	Plant Evaluation	75.0	61.7
D. 'Butterfly'	Plant Evaluation	63.9	56.7
Deutzia	Plant Evaluation	80.6	55.0
Forsythia	Site Preparation	63.9	55.0
Cephalanthus	Site Preparation	77.8	53.3
D. Kodiak Red	Plant Evaluation	58.3	48.3
B. 'Solar Flare'	Plant Evaluation	44.4	35.0
D. Kodiak Orange	Plant Evaluation	38.9	26.7
Baptisia	Site Preparation	33.3	21.7

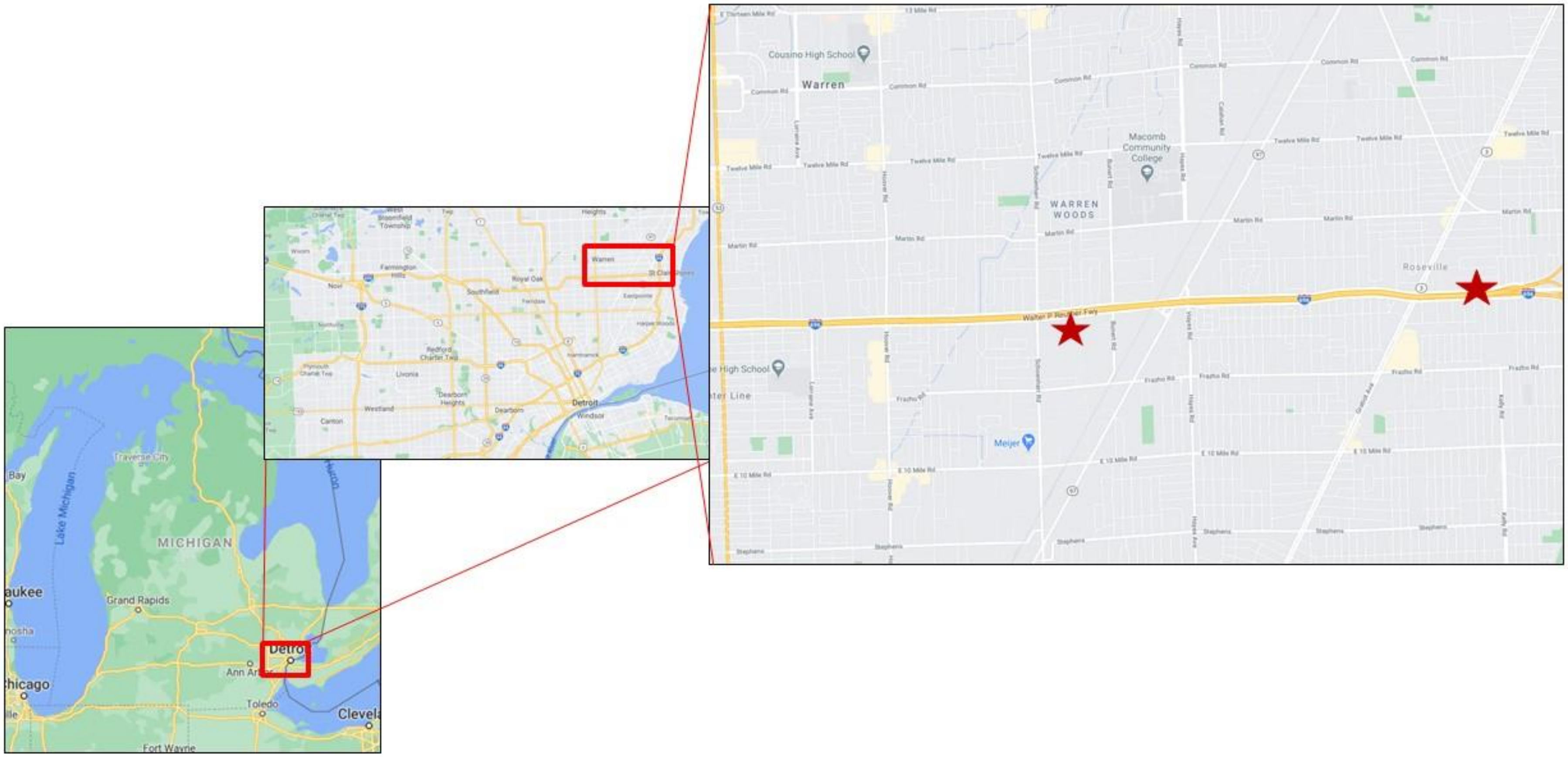


Figure 1. Location of the two studies sites is suburban Detroit, MI USA.

Figure 2. Photo indicating location of blocks at the Roseville site along I-696. Blocks with an “A” are the plant evaluation plots.

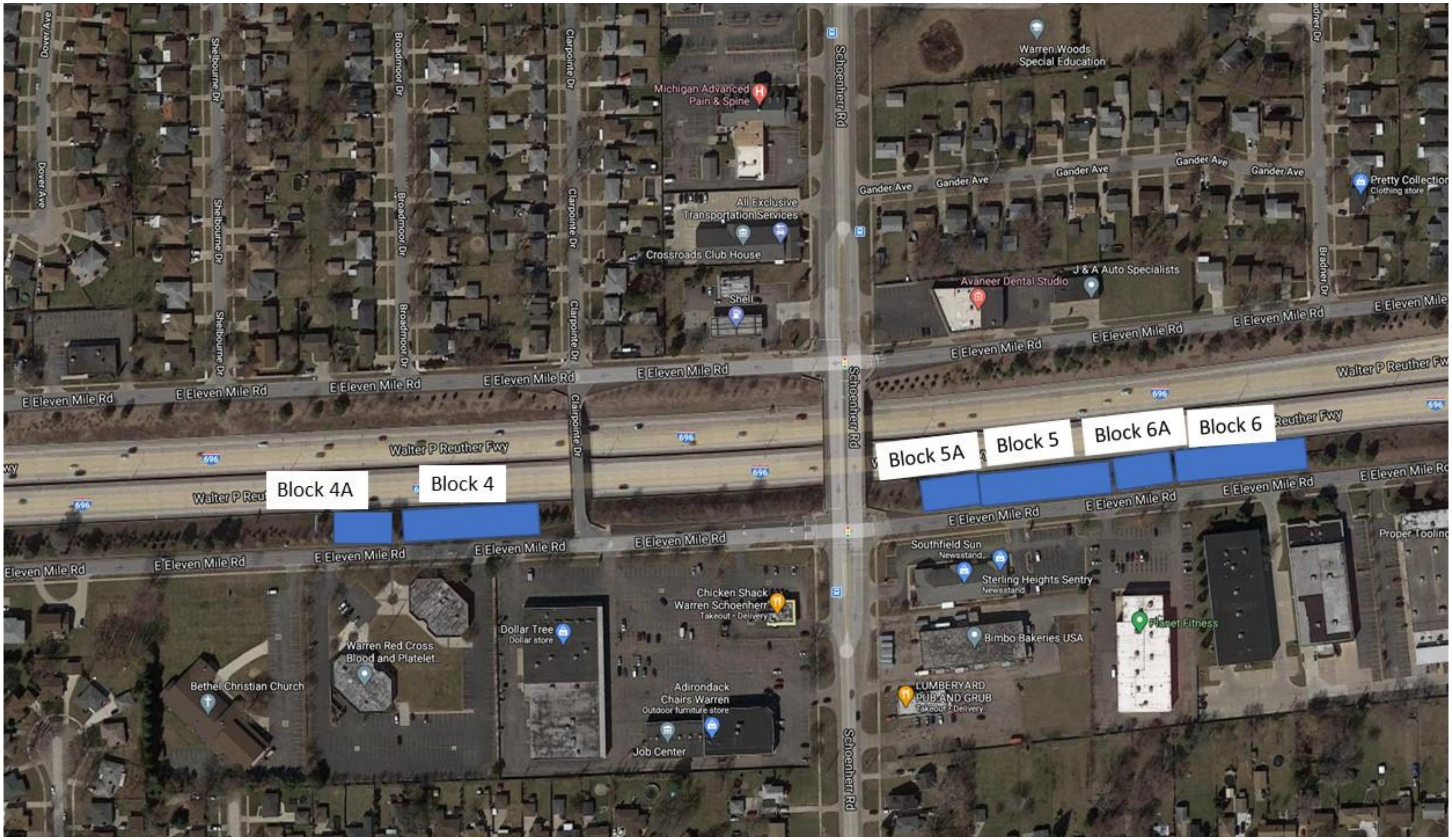


Figure 3. Photo indicating location of blocks at the Warren site along I-696. Blocks with an “A” are the plant evaluation plots.

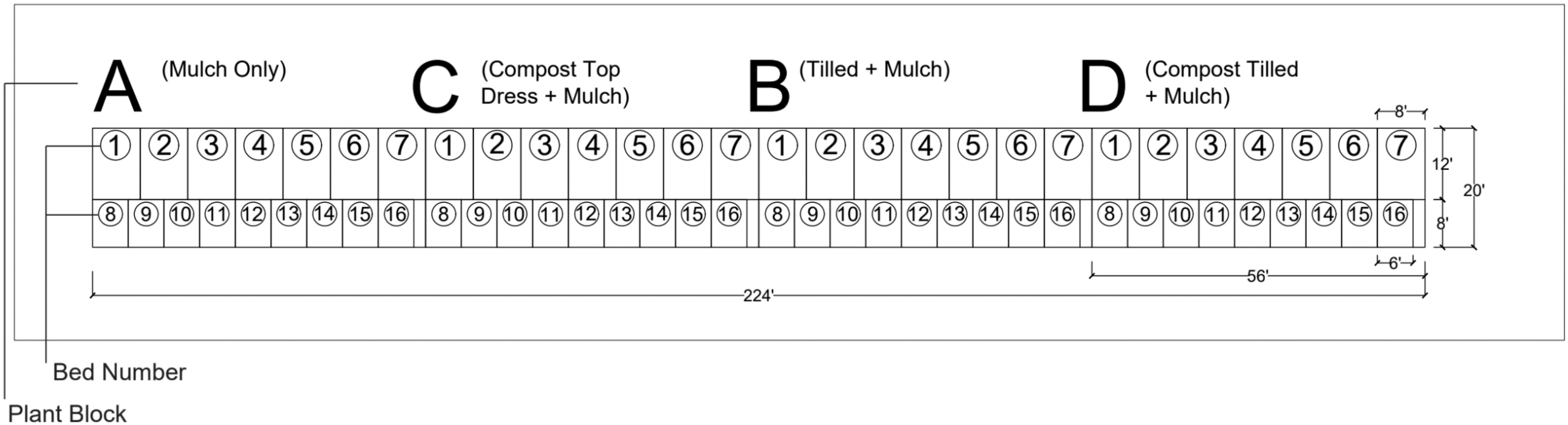


Figure 4. Schematic illustration of a single block indicating layout of main plots and subplots

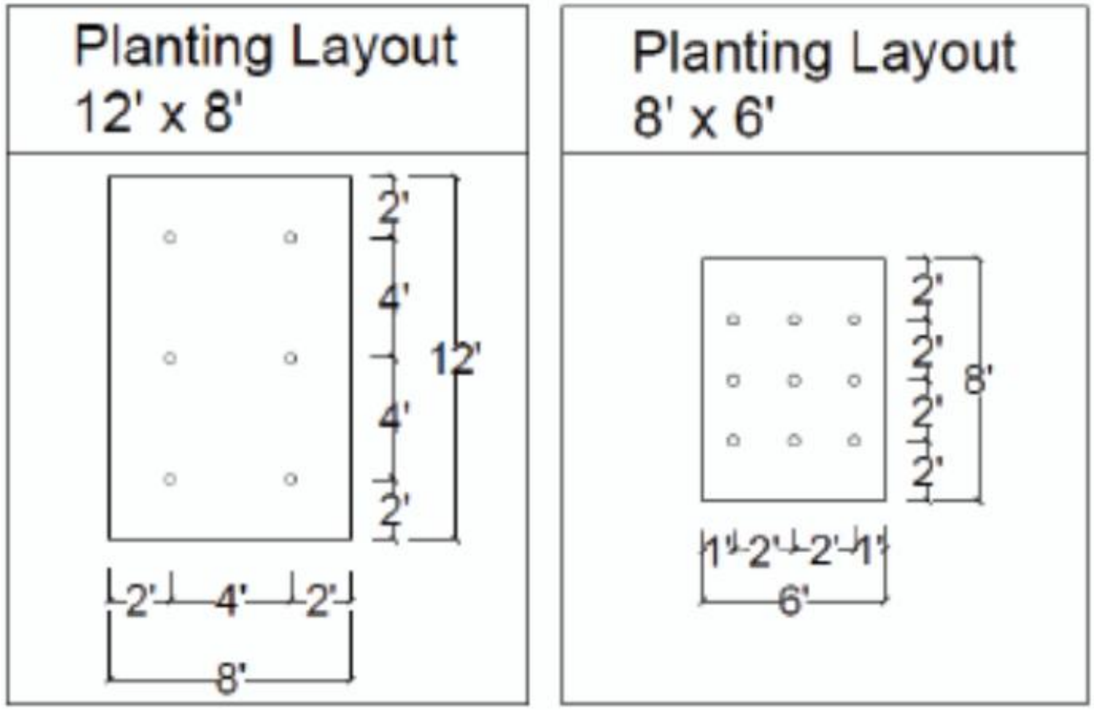
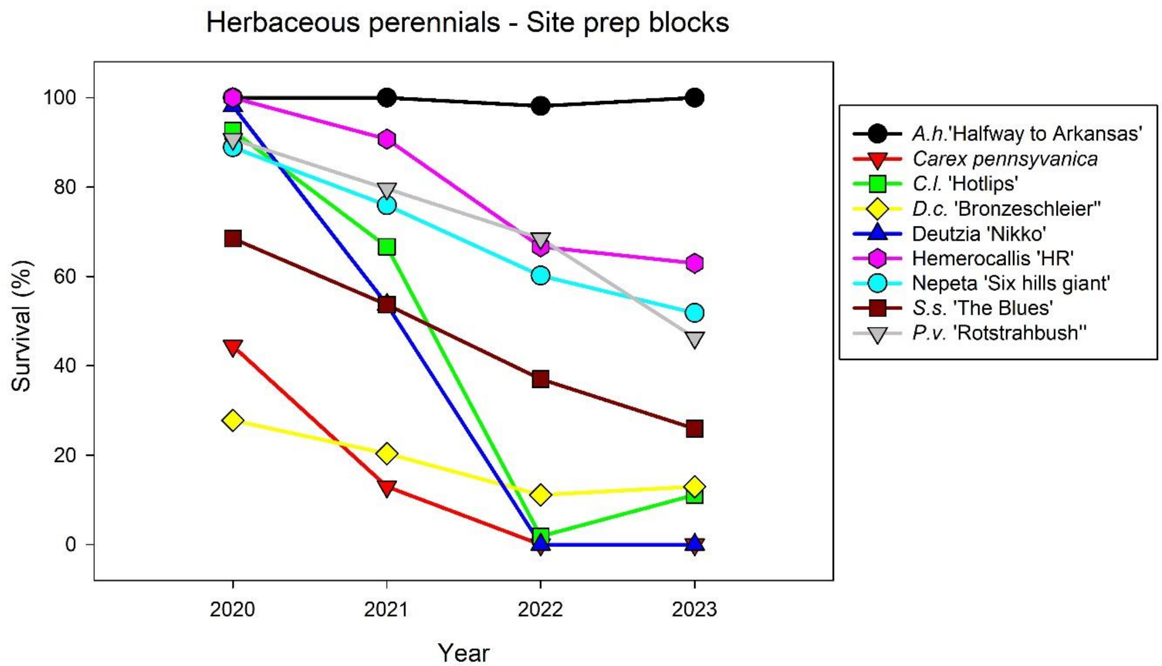


Figure 5. Schematic illustration of the two subplot sizes

Figure 6. A single treatment plot after plant installation in 2019 (top) and 2024 (bottom).

Figure 7. Example of assessing survival and plant cover for an herbaceous perennial (Hemerocallis). All 9 plants are present (survival =100%). Plant cover is visually estimated as 80%.



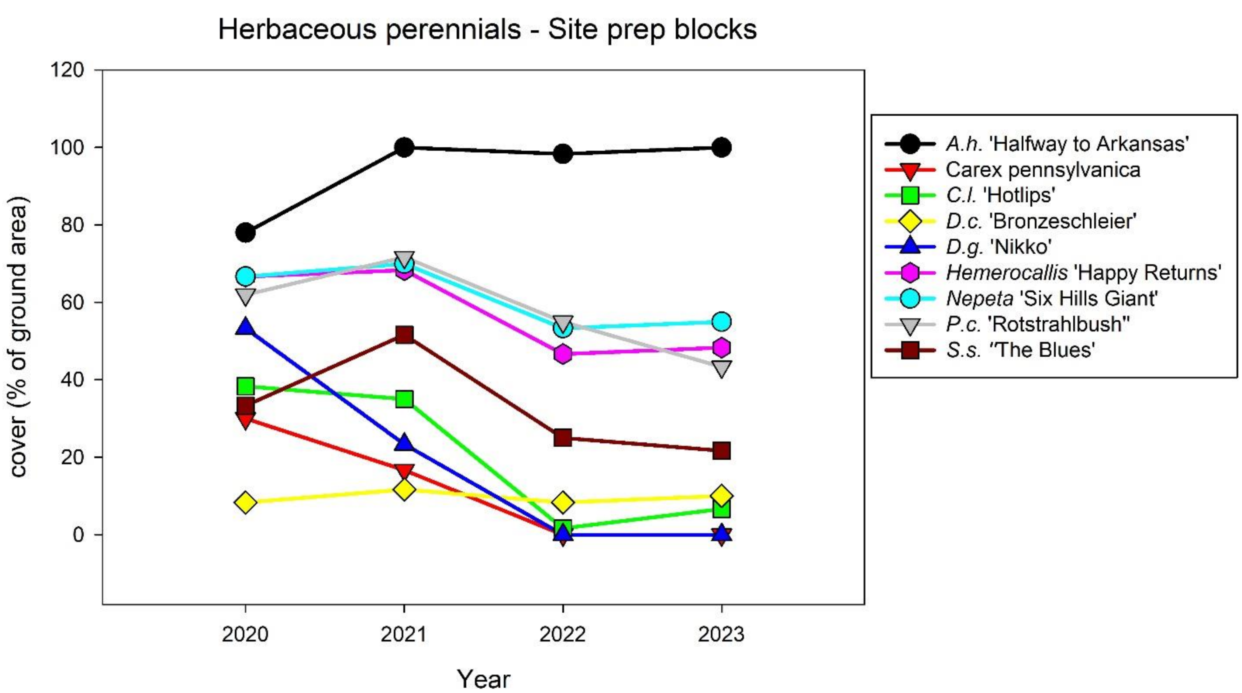
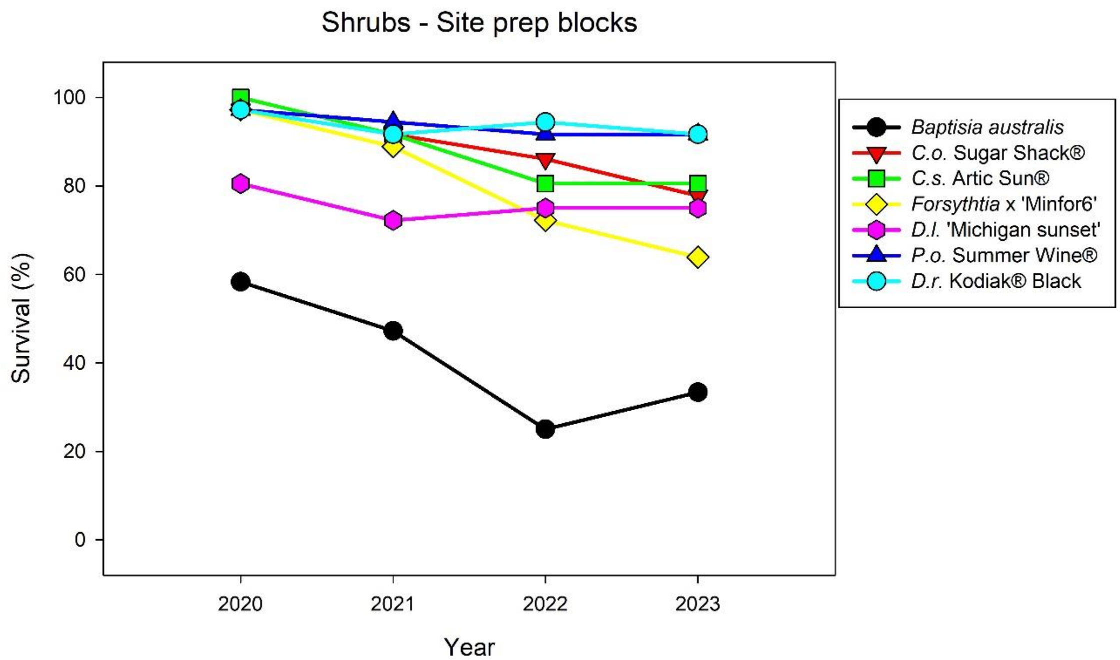


Figure 8. Survival (top) and plant cover (bottom) of herbaceous perennials and grasses the Site Preparation plots .

Figure 9 . Amsonia had excellent survival and formed dense, self-sustaining stands.



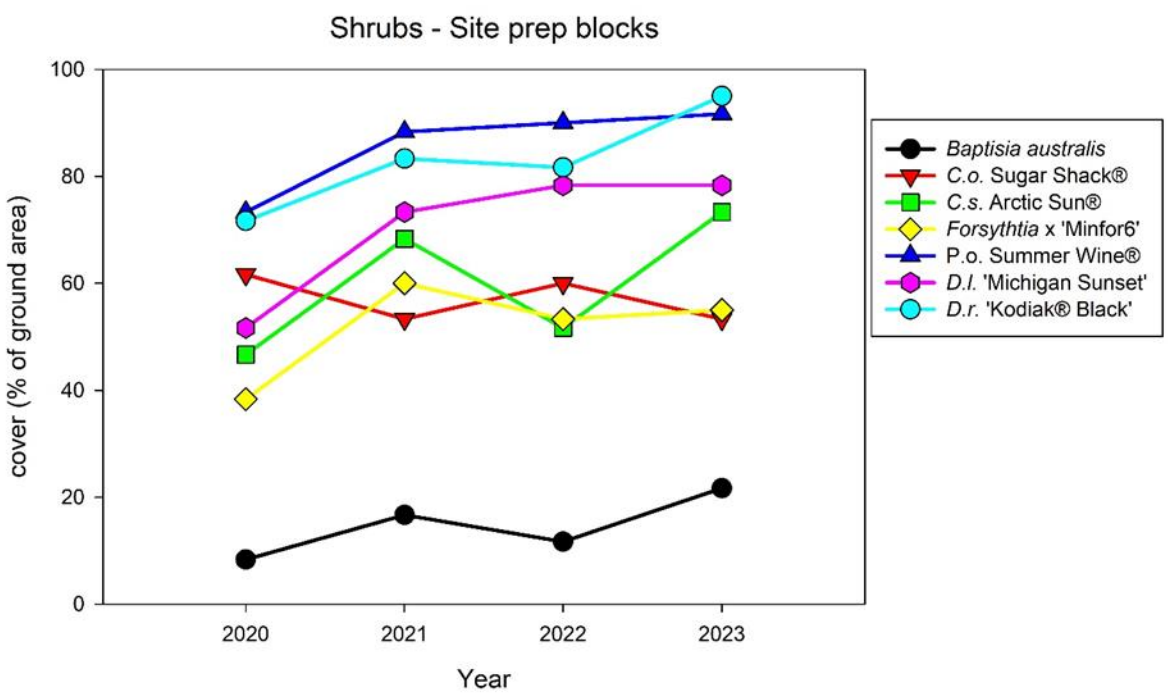


Figure 10. Survival (top) and plant cover (bottom) of shrubs in the Site Preparation plots
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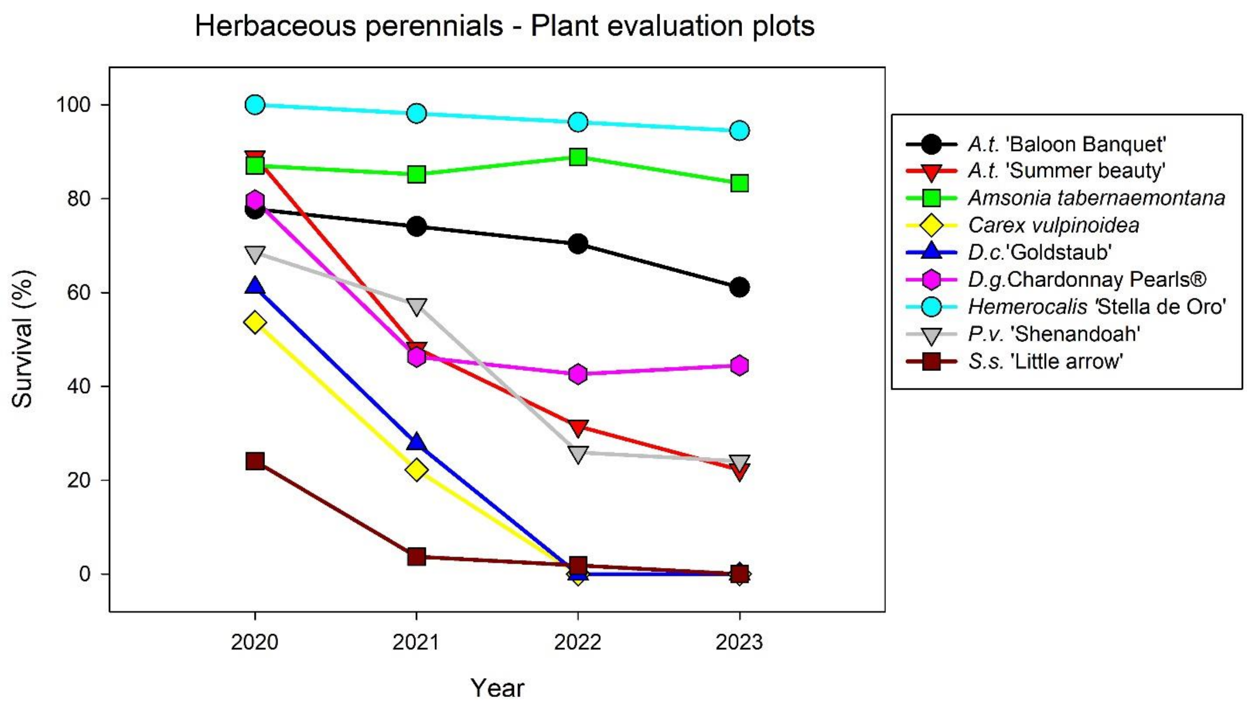
Figure 11. Diervilla often formed complete, dense stands.



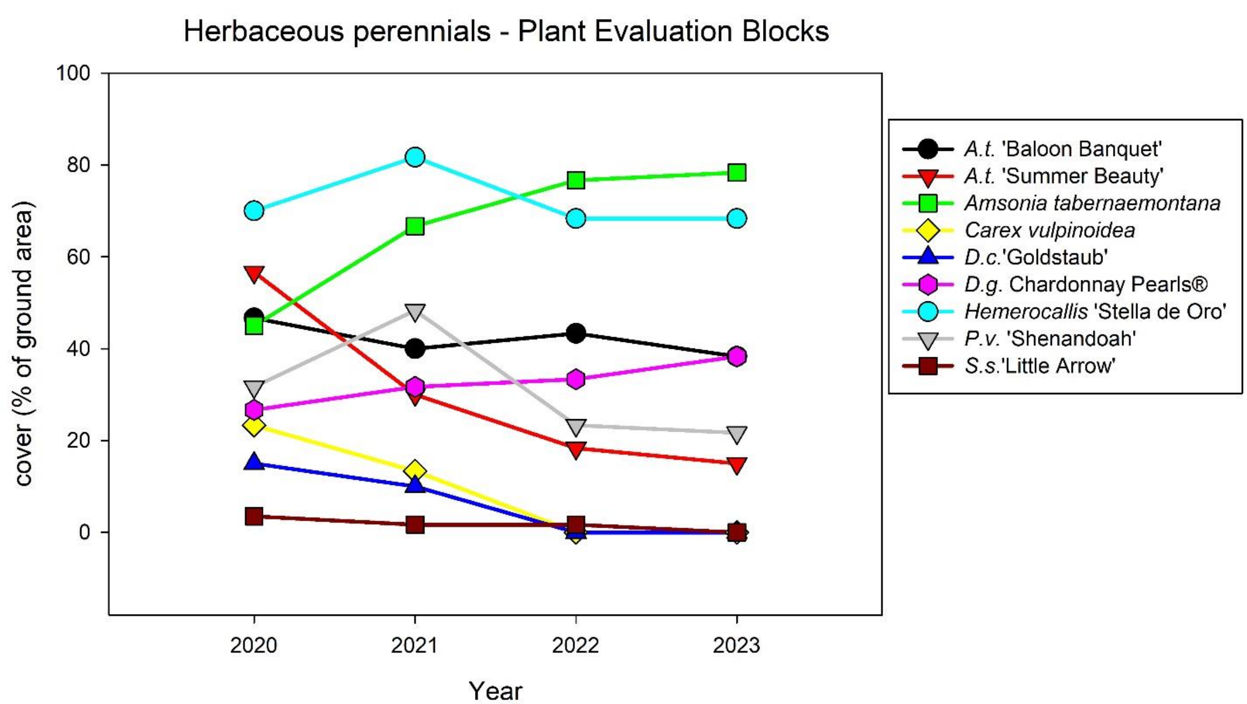


Figure 12. Survival (top) and plant cover (bottom) of shrubs in the Plant Evaluation plots.

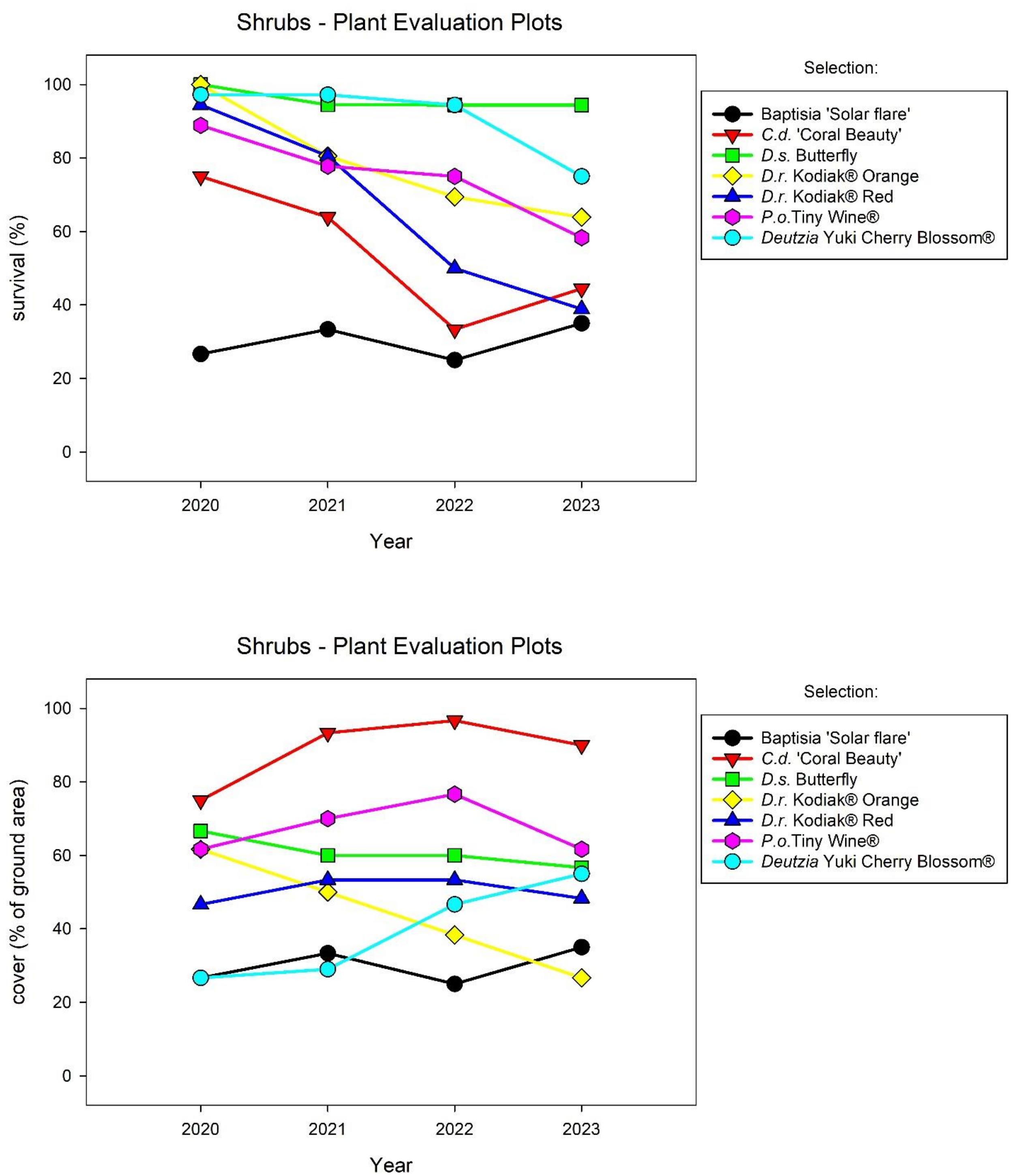


Figure 13. Survival (top) and plant cover (bottom) of shrubs in the Plant Evaluation plots
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Figure 14. Widespread establishment of Canada thistle (*Cirsium arvense*) during the 2020 Covid19 shutdown required extensive hand-weeding to remove.