DEPARTMENT OF TRANSPORTATION

Regional Roadside Turfgrass Testing Program

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University of Minnesota

August 2019

Research Project
Final Report 2019-38

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16. Abstract (Limit: 250 words)

Roadsides are a challenging environment for successfully establishing turfgrass. Site-specific stresses demand multi-site testing of grasses and grass mixtures. This study evaluated 60 entries that varied by cultivar, species, or mixture by establishing on-site trials in MI, MN, NE, NJ, and WI. The entries tested included 50 individual cultivars and 10 standard mixtures, two from each participating state based on their current specifications. One location in each state was along an urban or suburban street with a curb, while the second location was along a rural highway without a curb having a ditch that slopes away from the road with a daily traffic volume of at least 30,000 vehicles. Plots were seeded at most sites in late summer 2016, and data were collected through spring 2018. Turfgrass performance was assessed by counting living turf cover, weed cover, and bare soil using the grid intersect method in the spring and fall of each year. Species and cultivar performance varied among locations. Several species showed potential for inclusion in effective mixtures. Other species performed well at some locations and poorly at others. Performance of standard mixtures was also inconsistent across locations. This research demonstrates the need for locally generated data on roadside turfgrass performance.

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Regional Roadside Turfgrass Testing Program

FINAL REPORT

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LIST OF ABBREVIATIONS

AL – alkaligrass (*Puccinellia distans*)
AM – seaside alkaligrass (*Puccinellia maritima*)
CH – Chewings fescue (*Festuca rubra* ssp. *fallax*)
DOT – Department of Transportation
HD – hard fescue (*Festuca brevipila*)
KB – Kentucky bluegrass (*Poa pratensis*)
MnDOT – Minnesota Department of Transportation
MX – DOT-specified mixtures
PR – perennial ryegrass (*Lolium perenne*)
SB – smooth bromegrass (*Bromus inermis*)
SL – slender creeping red fescue (*Festuca rubra* ssp. *littoralis*)
ST – strong creeping red fescue (*Festuca rubra* ssp. *rubra*)
TF – tall fescue (*Schedonorus arundinaceus*)
VNS – Variety Not Stated

EXECUTIVE SUMMARY

Survival of turf along roadsides is a significant challenge, particularly in cold climates where salt is applied to roads in the winter. Over the past decade, the University of Minnesota has led a series of projects to address this problem. These projects have included the identification of best management practices for roadside establishment along with new species and cultivar recommendations. One of the challenges of this type of work is year-to-year variability in winter conditions, which reduces the usefulness of single-site testing of turfgrass performance. One approach to this problem is a coordinated, multi-state, multi-location cultivar testing effort that would allow for simultaneous evaluation of various stresses common to roadsides. In this project, we developed a five-state roadside turfgrass cultivar trial and seeded it at two locations within each state (10 total). Turfgrass performance was assessed by counting living turf cover, weed cover, and bare soil, which allowed for the determination of percent living cover calculations for each rating date. Species and cultivar performance for change in living cover from season to season varied among locations. Several species showed potential for inclusion in effective mixtures. Other species performed well at some locations and poorly at others. Performance of standard mixtures was also inconsistent across locations. This research demonstrates the need for locally generated data on roadside turfgrass performance.

CHAPTER 1: MULTI-STATE ROADSIDE TESTING

1.1 INTRODUCTION

Survival of turf along roadsides is a challenge in many states in the central and northern U.S. Grasses growing along roadsides experience a number of stresses including high levels of salt from deicing operations, drought stress from lack of irrigation, and heat stress. State departments of transportation recommend mixtures for various roadside environments; however, many of these mixture recommendations are either outdated or developed without supporting research data collected by an unbiased source. Failed grass installation projects have both economic (labor and materials) and environmental (soil erosion, invasive weed establishment, etc.) impacts.

Failed installations can happen for a number of reasons, and it is our contention based on observation and previous research, that failures often are due to using the wrong species for a given site. These failed installations most often result in needing to reseed or even re-sod. The most basic method for reestablishment of a failed site would be to kill the existing vegetation and reseed, which will still have a cost of $150 to $530 per acre when using the most popular roadside seed mixtures plus the added cost of labor and resources needed to rectify a failed installation. Sod can cost nearly $20,000 per acre. The additional cost of re-grading, installation, and water can also be significant. Using the right turfgrass species for a specific area will provide the best option for a successful establishment.

The primary stress of roadside turfgrass areas in the northern U.S. is often salt stress. There have been only a few recent examples of grasses being tested for salt-tolerance in a roadside environment in the northern states (Biesboer et al., 1998; Brown and Gorres, 2011; Friell et al., 2012). Turfgrass breeders, both public and private, have increasingly focused on research and development of salt-tolerant and low-input turfgrasses (Friell et al., 2012; Koch and Bonos, 2011; Koch and Bonos, 2011; Rose-Fricker and Wipff, 2001; Watkins et al., 2011). New cultivars of numerous species possessing better heat, drought, and salt tolerance are being released that likely are better adapted to the harsh roadside conditions found in the northern U.S. As these cultivars have become available, many states have not updated seed mixes with these new cultivars. This indicates that the current system is not nimble enough to utilize the newest genetic resources for these environmentally sensitive areas along roadsides.

The University of Minnesota previously identified species and cultivars that can be utilized on roadsides in Minnesota. However, today there is a need for additional testing on roadsides so that more recently-developed cultivars and previously unexplored grass species can be identified for inclusion in DOT-recommended mixtures in the northern U.S. In previous studies, multiple sites in a single state (Minnesota) were utilized for this type of research; however, year-to-year variability in weather does not allow for sites in a single state to provide information on the tolerances of these grasses to the many stresses found on roadsides. A multi-state approach, whereby roadside turfgrass trials are planted throughout the northern U.S., would greatly improve the chance that during any given year we will be collecting data on important stress tolerances. Results from a multi-state, multi-site study would improve our knowledge on roadside turfgrass stress tolerances resulting in better recommendations for state DOTs and ultimately financial benefit to public agencies.

The objective of this study is to assess potential roadside turfgrasses across multiple states in the northern U.S. to generate unbiased data for use by public agencies.

CHAPTER 2: METHODS

2.1 PLANT MATERIAL

A total of 60 entries were included in this trial; this includes 50 individual cultivars and 10 standard mixtures (Table 2.1), two from each participating state based on current specifications for that state. Individually-tested cultivars were chosen based on recommendations from turfgrass breeders along with publicly-available data suggesting that the cultivar had some potential as a roadside turfgrass.

2.2 TRIAL LOCATIONS

Trials were seeded at two locations in each of five states – Michigan, Minnesota, Nebraska, New Jersey, and Wisconsin (Figure 2.1; Table 2.2). One of the two locations was along an urban or suburban street with a curb, having a daily traffic volume of between 10,000 and 15,000 vehicles, while the second location was along a rural highway without a curb having a ditch that sloped away from the road with a daily traffic volume of at least 30,000 vehicles. The curbed locations were those that would be maintained regularly (mowed as needed to maintain turfgrass aesthetics) while the rural sites would typically be mowed between 1-3 times per year. Soil tests were taken at each site prior to seeding (Table 2.3). Precipitation was measured at each site and local temperature data was collected by a nearby weather station (Table 2.4).

2.3 TRIAL ESTABLISHMENT

Each trial was planted as a randomized complete block design with 3 replications. Individual plots were 5 feet long (parallel to the road) and 3 feet wide (perpendicular to the road; Figure 2.2). Seeding rate was 2.0 pure live seeds cm^{-2}. At seeding, a granular starter fertilizer was applied providing approximately 1 lb. P_2O_5 per 1000 ft^2. Plots were covered with a germination blanket (Futerra Environet [Profile] blankets) after seeding. Plots at the urban site in MN were irrigated using a drip irrigation system supplied by a fire hydrant during establishment at a rate of 0.14 in of water per day and both the rural MN and urban WI sites were watered with a water truck during establishment. All other sites were established with natural precipitation. All plots were mowed as needed to a height appropriate for the site, generally between 3 and 4 inches. The rural site in MN was damaged due to a construction crane and had to be re-seeded in fall 2017. The urban WI site was also seeded in fall 2017. Neither site in NE established in 2016 due to lack of rainfall after seeding. Soil samples were collected and homogenized to form a composite sample for each replication at each site after soil preparation but before seeding (Table 2.3). Soil samples were analyzed by a soil testing laboratory for soil cation exchange capacity, electrical conductivity, pH, and concentrations of soil phosphorus and soil organic matter. Similarly, intact cores were collected to obtain bulk density samples for each location.

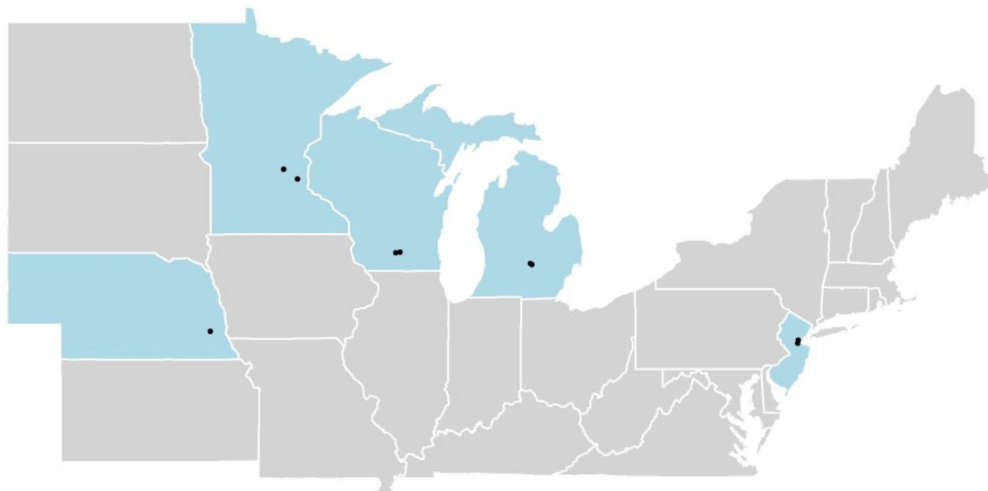

Figure 2.1 Locations of research sites in Michigan, Minnesota, Nebraska, New Jersey, and Wisconsin.

Figure 2.2 Plots at urban site in Michigan.

Table 2.1 Mixture compositions for commonly used DOT mixtures from each testing state that were included at all 10 testing locations.

Mixture name	Cultivar[1]	Species	Percent
MI DOT THV Mixture	Pennlawn	Creeping red fescue	44
	Pennant	Perennial ryegrass	29
	Baron	Kentucky bluegrass	15
	Fults	Salt grass	10
MI DOT TUF Mixture	Dawson	Creeping red fescue	40
	Pennant III	Perennial ryegrass	19
	Reliant IV	Hard fescue	20
	Baron	Kentucky bluegrass	10
	Fults	Salt grass	10
MN 25-131 Low Maintenance Turf	Park	Kentucky bluegrass	16
	VNS	Sheep fescue	11
	Boreal	Creeping red fescue	29
	Radar	Chewings fescue	20
	Chariot	Hard fescue	14
	VNS	Perennial ryegrass	9
Salt Tolerant Sod (MNST-12)	Seabreeze GT	Slender creeping red fescue	20
	Celestial	Strong creeping red fescue	20
	Moonlight SLT	Kentucky bluegrass	20
	Bighorn GT	Hard Fescue	10
	Radar	Chewings fescue	30
NE Rural MX-5077	Overland	Winter wheat	31
	Linn	Perennial ryegrass	16
	Barton	Western wheatgrass	13
	Texoka	Buffalograss	11
	First Strike	Slender wheatgrass	11
	Butte	Sideoats grama	9
	KY-31	Tall fescue	7
	VNS	Sand dropseed	1
NE Urban Roadside and Lawns	Titanium	Tall fescue	88
	Park	Kentucky bluegrass	7
	Evening Shade	Perennial ryegrass	5
NJ DOT A-4 Mixture	VNS	Creeping red fescue	29
	VNS	Chewings fescue	29
	VNS	Kentucky bluegrass	29
	VNS	Perennial ryegrass	10
NJ Type B Mixture	VNS	Creeping red fescue	44
	KY-31	Tall Fescue	15
	Blackwell	Switchgrass	15
	VNS	Weeping lovegrass	10
	VNS	Redtop	9

	VNS	Perennial ryegrass	5
WI DOT #20	3rd Millennium	Tall fescue	40
	VNS	Perennial ryegrass	29
	VNS	Chewings fescue	24
	VNS	Kentucky bluegrass	6
WI DOT #40	Park	Kentucky bluegrass	34
	VNS	Perennial ryegrass	25
	VNS	Creeping red fescue	19
	VNS	Hard fescue	19

[1] VNS = Variety not stated

Table 2.2 Site information for location, seeding, and rating dates for each of the 10 testing sites.

State	*Type*	*Location description*	*Latitude, Longitude*	*Seeding date*	*Fall '16 rating date*	*Spring '17 rating date*	*Fall '17 rating date*	*Spring '18 rating date*
MI	Rural	Interstate 96 (I96) - westbound adjacent to the Williamston rest-stop	42.677271, -84.410884	9/21/2016	12/1/2016	4/26/2017	10/9/2017	5/23/2018
	Urban	Hagadorn road in East Lansing	42.716271, -84.462398	9/16/2016	11/18/2016	4/25/2017	9/15/2017	5/22/2018
MN	Rural	MnROAD research facility, Albertville, MN	45.258063, -93.702909	8/24/2017	NA	NA	11/6/2017	5/21/2018
	Urban	East side of Cleveland Ave, Falcon Heights, MN	44.994210, -93.187045	8/26/2016	12/7/2016	5/8/2017	11/3/2017	5/22/2018
NE	Rural	HWY 34 East of Lincoln, 200' West of 202nd St. to 100' East of 202nd Street	40.813014, -96.446318	10/15/2016	NA	5/15/2017	10/21/2017	4/21/2018
	Urban	Lincoln, south side of Normal BLVD, 0-300 feet west of 70th Street	40.782382, -96.627521	10/15/2016	NA	5/15/2017	10/21/2017	4/21/2018
NJ	Rural	I-287 North; near exits 4 and 5, South Plainfield, NJ	40.557921, -74.425622	10/4/2016	12/13/2016	5/10/2017	10/3/2017	6/1/2018
	Urban	US Rt. 1 South; Between Technology Way and Milltown Road Interchanges; North Brunswick, NJ	40.465826, -74.444616	10/5/2016	12/1/2016	4/27/2017	10/18/2017	6/1/2018
WI	Rural	Wisconsin State Highway 151 in Madison, WI, approximately 1 km northeast of Exit 81	42.999603, -89.495880	10/6/2016	11/22/2016	4/17/2017	10/17/2017	NA
	Urban	Median on McCoy Rd, in Fitchburg WI between Wisconsin State Highway 14 and Herman Road	43.022149, -89.384437	9/8/2017	NA	NA	10/17/2017	4/28/2018

Table 2.3 Site-specific soil information for each testing location.

Location	Site	Soil CEC	Soil pH	Soil P mg kg^{-1}	Soil EC Mmhos cm^{-1}	Soil B.D. g cm^3	Soil O.M. (%)	Soil Texture
Michigan	Rural	-	7.9	4.0	0.14	1.25	1.9	Gilford sandy loam
	Urban	-	8.1	7.3	0.29	1.49	3.5	Metea loamy sand
Minnesota	Rural	32.67	7.7	14.3	0.61	1.58	3.5	Cordova loam
	Urban	17.33	7.6	5.7	0.56	1.44	4.4	Kingsley sandy loam
Nebraska	Rural	28.60	8.1	41.0	-	-	2.4	Wymore silty clay loam
	Urban	22.70	8.2	20.0	-	-	2.8	Aksarben silty clay loam
New Jersey	Rural	-	8.0	7.3	8.7	1.54	3.7	Klinesville channery loam
	Urban	-	6.8	36.3	1.8	1.48	3.8	Matapeake silt loam
Wisconsin	Rural	21.69	7.6	11.1	0.58	-	4.1	Orion silt loam
	Urban	30.32	7.3	31.0	0.63	1.33	3.9	McHenry silt loam

Table 2.4 Site-specific weather information for each testing location.

Location	Site	Duration of experiment[1]	Average monthly maximum air temperature	Average monthly minimum air temperature	Total Precipitation	Total snowfall	Total accumulated growing degree days[2]	Relative accumulated growing degree days[3]
		Days	°F	°F	in	in	GDDs	GDDs
Michigan	Rural	392	54.0	36.5	44.3	47.2	3764.4	9.6
	Urban	392	54.0	36.5	46.7	56.8	3829.7	9.8
Minnesota	Rural	267	53.2	35.2	37.8	80.6	1053.0	3.9
	Urban	379	51.3	34.3	51.2	72.7	3525.7	9.3
Nebraska	Rural	355	62.8	38.3	36.8	26.6	3669.3	10.3
	Urban	355	63.5	39.6	14.7	21.4	3849.0	10.8
New Jersey	Rural	219	60.1	40.7	43.1	24.9	4911.5	22.4
	Urban	205	59.7	40.3	45.8	33.1	4479.2	21.9
Wisconsin	Rural	375	50.4	32.0	30.1	36.3	2943.2	7.9
	Urban	233	44.4	26.6	12.8	37.3	646.7	2.8

[1] Duration of experiment = number of days between planting date and final collection date.

[2] Total accumulated growing degree days = total summation of daily average temperature (°F) - 40°F for the duration of the experiment.

[3] Relative accumulated growing degree days = total accumulated growing degree days divided by the number of days for the experiment.

CHAPTER 3: ANALYSIS AND RESULTS

3.1 ANALYSIS

Turfgrass performance was assessed using the grid-intersect method whereby a 3 x 5 ft. grid of 60 intersections overlaid each plot (Figure 3.3). An observation was made at each intersection as either living turf, weed, or bare soil/germination blanket. Observations were recorded such that the location of each data point within the grid was known. Most plots were assessed four times: late fall 2016, spring 2017 (after snowmelt and prior to turf green-up), fall 2017, and spring 2018 (Tables 3.1 and 3.2).

Mean analyses for turf, weed, or bare soil coverage were analyzed in SAS (SAS Institute Inc., 2014, ver. 9.4, Cary, NC, USA) using PROC GLM. When treatment F tests were significant ($p \leq 0.05$), the Fisher's Protected Least Significant Difference Test ($\alpha = 0.05$) was used to separate means. Negative values for change in turf coverage indicate a reduction in turf coverage of desired species, whereas a positive value means the turf coverage of the plot increased.

3.2 RESULTS

Turfgrass coverage varied greatly by entry, species, state, and whether the site was urban or rural (Tables 3.1 and 3.2). Several seed treatment or turfgrass species by state by location interactions existed, so data are presented within location and state for both cultivar (Tables 3.3 to 3.12) and species (Tables 3.13 to 3.22).

Perennial ryegrass entries were often initially in the top statistical grouping at sites in MI, WI, and NJ (urban only) but did poorly in both locations in MN after a harsh winter in 2016-2017. Alkaligrasses were top performers at rural sites in MN and NJ, but did not do well in MI, primarily due to poor establishment. At the rural site in NJ (Tables 3.9 and 3.19), only alkaligrasses survived through two winters, along with the two state DOT-specified mixtures that contained alkaligrass (Table 2.1). Strong creeping red fescue and slender creeping red fescue performed better than other species at urban sites in MN and WI (Tables 3.6, 3.12, 3.16, and 3.22). The smooth bromegrass entry consistently had the lowest turf coverage at the final rating date across all locations.

At several sites, turfgrass entry differences were not significant for turf cover or change in turf cover (Tables 3.4, 3.7, 3.8, 3.10, 3.11, 3.14, 3.17, and 3.21). Urban sites generally had higher turf coverage across all seed mixture treatments compared to rural sites within a state (Tables 3.1 and 3.2).

Figure 3.1 Grid overlaid on a plot in New Jersey. Each grid intersection was logged as being on top of the turfgrass that was originally seeded, a weed, or bare soil.

Table 3.1 Analysis of variance for the effect of seeding mixture treatment, state, and site on mean turf coverage.

Source	Fall turf cover		Spring turf cover		Change turf cover	
	F-value	P-value	F-value	P-value	F-value	P-value
Rep	20.71	<0.0001	2.84	0.0589	7.85	0.0004
Treatment (TRT)	11.10	<0.0001	6.46	<0.0001	3.96	<0.0001
State (ST)	577.46	<0.0001	633.23	<0.0001	566.23	<0.0001
Site (SI)	214.24	<0.0001	907.25	<0.0001	178.73	<0.0001
TRT*ST	1.08	0.3224	2.95	<0.0001	1.30	0.0640
TRT*SI	1.88	<0.0001	3.37	<0.0001	1.57	<0.0001
TRT*ST*SI	1.95	<0.0001	3.41	<0.0001	2.11	<0.0001

Table 3.2 Analysis of variance for the effect of turfgrass species, state, and site on mean turf coverage.

Source	Fall turf cover		Spring turf cover		Change turf cover	
	F-value	P-value	F-value	P-value	F-value	P-value
Rep	21.14	<0.0001	2.75	0.0641	8.40	0.0002
Species (SP)	47.57	<0.0001	20.22	<0.0001	0.23	0.6280
State (ST)	341.62	<0.0001	408.22	<0.0001	330.91	<0.0001
Site (SI)	111.93	<0.0001	475.92	<0.0001	109.46	<0.0001
SP*ST	2.44	<0.0001	10.99	<0.0001	4.49	<0.0001
SP*SI	5.80	<0.0001	11.87	<0.0001	5.77	<0.0001
SP*ST*SI	7.30	<0.0001	12.81	<0.0001	8.27	<0.0001

Table 3.3 Michigan Rural – Total living turf cover [Total Cover (TC)] for Fall 2016, Spring 2017, Fall 2017 and Spring 2018; and percent total cover change from 2016 to 2017 (2016-2017 % TC Change) and percent total cover change from 2017 to 2018 (2017-2018 % TC Change).

		Fall 2016[1]	Spring 2017	2016-2017	Fall 2017	Spring 2018	2017-2018
Turfgrass Entry	Species[2]	Total Cover (TC)		% TC Change	Total Cover (TC)		% TC Change
BAR PD06N17	AL	42.8	42.8	0.0	1.7	7.8	6.1
BAR PD9032	AL	15.0	15.6	0.6	27.2	22.8	-4.4
Fults	AL	73.3	70.5	-2.8	2.8	12.2	9.4
Salton Sea	AL	36.1	38.3	2.2	20.6	15.0	-5.6
SeaSalt	AL	25.6	33.3	7.8	3.3	7.2	3.9
Oceania Maritima	AM	59.5	53.9	-5.6	2.2	7.8	5.6
Castle	CH	95.0	83.9	-11.1	43.3	63.9	20.6
Compass II	CH	90.0	84.4	-5.6	46.1	66.7	20.6
FRC 43 M2	CH	96.1	89.4	-6.7	52.8	74.4	21.7
Heathland	CH	95.0	88.4	-6.6	57.8	70.6	12.8
Beacon	HD	92.8	85.6	-7.2	71.1	91.7	20.6
Gladiator	HD	90.0	87.8	-2.2	72.8	88.3	15.6
Nanook	HD	88.3	92.8	4.5	71.7	85.6	13.9
Soil Guard	HD	91.1	89.4	-1.7	68.9	85.0	16.1
Sword	HD	86.1	91.1	5.0	75.0	92.2	17.2
Barduke	KB	60.6	51.7	-8.9	41.1	43.3	2.2
J-525	KB	68.9	70.5	1.6	47.8	72.2	24.4
J-793	KB	75.6	77.2	1.7	65.6	76.7	11.1
J-920	KB	64.5	62.8	-1.7	46.7	70.0	23.3
Milagro	KB	56.7	56.1	-0.6	68.3	65.0	-3.3
Morocco	KB	62.8	68.3	5.6	81.1	82.2	1.1
Tirem	KB	59.4	65.0	5.6	37.8	58.9	21.1
Volt	KB	63.9	67.8	3.9	56.7	58.3	1.7
16-14-Lp 145	PR	96.1	90.5	-5.6	82.2	76.1	-6.1
BAR Lp 10970	PR	97.8	91.7	-6.1	63.9	66.1	2.2
Gray Fox	PR	97.8	93.9	-3.9	75.0	78.9	3.9
Premium	PR	97.8	97.2	-0.5	75.6	76.1	0.6
Replicator[3]	PR	95.0	91.1	-3.9	65.0	77.2	12.2
Stellar	PR	96.7	93.9	-2.8	74.4	75.6	1.1
BAR BIF 1GRL	SB	85.6	84.4	-1.1	97.8	90.6	-7.2
Blue Mesa	SH	90.0	90.6	0.6	68.9	84.4	15.6
J-248	SH	91.1	86.1	-5.0	67.2	82.2	15.0
Quatro	SH	93.3	90.6	-2.8	70.0	85.0	15.0
10RT DE	SL	96.7	90.0	-6.7	57.2	71.7	14.4
Sea Mist	SL	92.2	90.6	-1.7	65.0	71.7	6.7
Seabreeze GT	SL	93.9	86.1	-7.7	62.2	70.6	8.3
Shoreline	SL	91.1	91.1	0.0	50.0	76.1	26.1
FRR 72 M2	ST	92.2	91.1	-1.1	55.0	69.4	14.4
Kent	ST	92.8	82.2	-10.6	77.2	87.2	10.0
Navigator II	ST	88.3	87.2	-1.1	65.6	82.8	17.2

Ruddy	ST	91.6	91.7	**0.0**	62.2	77.2	**15.0**
Xeric	ST	92.8	88.3	**-4.4**	52.2	72.2	**20.0**
Avenger II	TF	98.9	92.2	**-6.6**	90.6	90.6	**0.0**
Birmingham	TF	95.0	88.9	**-6.1**	94.4	97.8	**3.3**
Black Tail	TF	98.3	93.3	**-5.0**	92.2	95.6	**3.3**
Fayette	TF	95.0	90.6	**-4.5**	86.7	93.3	**6.7**
JT-621	TF	93.3	87.2	**-6.1**	88.9	97.2	**8.3**
MNKY	TF	89.5	79.4	**-10.0**	58.3	56.7	**-1.7**
Saltillo	TF	95.0	87.2	**-7.8**	85.0	88.9	**3.9**
Thunderstruck	TF	93.9	93.3	**-0.6**	71.1	77.8	**6.7**
MI DOT THV	MX	93.9	88.9	**-5.0**	63.9	75.6	**11.7**
MI DOT TUF	MX	91.1	81.7	**-9.5**	75.0	78.9	**3.9**
MN DOT 25-131	MX	93.9	84.4	**-9.5**	61.1	84.4	**23.3**
MN DOT MNST-12	MX	89.5	90.6	**1.1**	67.2	87.2	**20.0**
NE DOT Rural Region 2	MX	38.3	46.7	**8.4**	62.2	61.7	**-0.6**
NE DOT Urban and Turf	MX	97.2	91.1	**-6.1**	85.0	90.0	**5.0**
NJ DOT A-4	MX	83.3	82.2	**-1.1**	62.2	70.6	**8.3**
NJ DOT Type B	MX	80.0	81.7	**1.7**	82.2	95.6	**13.3**
WI DOT #20	MX	90.0	83.9	**-6.1**	77.8	87.8	**10.0**
WI DOT #40	MX	78.9	73.9	**-5.0**	39.4	57.8	**18.3**
LSD (0.05)		11.9	12.9	10.8	30.5	25.8	20.9

1. When treatment F tests were significant (p≤0.05), the Fisher's Protected Least Significant Difference Test (LSD) (α=0.05) was used to separate means. NS = not significant. For % TC Change (when significant), the most positive value within a column is shaded blue, while the most negative value within a column is shaded red. Remaining cells are shaded in a blue-purple-red gradient with zero shaded purple. Negative values indicate a reduction in turf coverage of desired species, whereas a positive value means the turf coverage of the plot increased.
2. Species tested include: AL = alkaligrass (*Puccinellia distans*); AM = seaside alkaligrass (*Puccinellia maritima*); CH = Chewings fescue (*Festuca rubra* ssp. *fallax*); HD = hard fescue (*Festuca brevipila*); KB = Kentucky bluegrass (*Poa pratensis*); PR = perennial ryegrass (*Lolium perenne*); SB = smooth bromegrass (*Bromus inermis*); SL = slender creeping red fescue (*Festuca rubra* ssp. *littoralis*); ST = strong creeping red fescue (*Festuca rubra* ssp. *rubra*); TF = tall fescue (*Schedonorus arundinaceus*); MX = DOT-specified mixtures.
3. Tetraploid perennial ryegrass

Table 3.4 Michigan Urban – Total living turf cover [Total Cover (TC)] for Fall 2016, Spring 2017, Fall 2017 and Spring 2018; and percent total cover change from 2016 to 2017 (2016-2017 % TC Change) and percent total cover change from 2017 to 2018 (2017-2018 % TC Change).

		Fall 2016[1]	Spring 2017	2016-2017	Fall 2017	Spring 2018	2017-2018
Turfgrass Entry	Species[2]	Total Cover (TC)		% TC Change	Total Cover (TC)		% TC Change
BAR PD06N17	AL	63.9	42.2	-21.7	56.1	66.1	10.0
BAR PD9032	AL	33.9	15.0	-18.9	58.3	67.2	8.9
Fults	AL	77.8	46.7	-31.1	57.8	70.6	12.8
Salton Sea	AL	56.7	35.0	-21.7	56.7	67.8	11.1
SeaSalt	AL	31.1	20.6	-10.5	52.2	66.1	13.9
Oceania Maritima	AM	78.4	55.0	-23.4	57.2	71.1	13.9
Castle	CH	86.1	82.2	-3.9	50.6	66.7	16.1
Compass II	CH	91.1	85.0	-6.1	56.1	67.8	11.7
FRC 43 M2	CH	96.7	81.6	-15.0	56.7	68.3	11.7
Heathland	CH	90.0	81.1	-8.9	57.8	66.7	8.9
Beacon	HD	92.8	85.0	-7.8	50.6	68.9	18.3
Gladiator	HD	94.4	88.3	-6.1	52.2	60.6	8.3
Nanook	HD	92.8	90.5	-2.7	59.4	71.7	12.2
Soil Guard	HD	90.6	85.5	-5.0	58.3	70.6	12.2
Sword	HD	93.9	86.1	-7.8	48.3	66.7	18.3
Barduke	KB	60.6	13.9	-46.7	50.6	61.7	11.1
J-525	KB	56.1	26.1	-30.0	54.4	66.7	12.2
J-793	KB	72.2	32.2	-40.0	58.9	73.3	14.4
J-920	KB	57.2	28.3	-28.9	53.3	62.2	8.9
Milagro	KB	47.8	8.3	-39.4	51.7	67.8	16.1
Morocco	KB	57.2	28.3	-28.9	57.2	68.9	11.7
Tirem	KB	57.2	29.5	-27.8	56.7	67.8	11.1
Volt	KB	65.0	29.4	-35.6	58.3	72.8	14.4
16-14-Lp 145	PR	98.9	94.4	-4.5	56.7	67.8	11.1
BAR Lp 10970	PR	98.3	95.0	-3.3	59.4	71.7	12.2
Gray Fox	PR	99.4	98.3	-1.1	57.2	63.9	6.7
Premium	PR	100.0	97.8	-2.2	55.0	67.8	12.8
Replicator[3]	PR	100.0	97.8	-2.2	61.1	70.0	8.9
Stellar	PR	98.9	96.7	-2.2	52.2	68.3	16.1
BAR BIF 1GRL	SB	97.8	92.8	-5.0	53.9	68.3	14.4
Blue Mesa	SH	87.2	92.2	5.0	50.0	64.4	14.4
J-248	SH	95.5	90.0	-5.5	54.4	68.3	13.9
Quatro	SH	90.0	85.0	-5.0	52.8	67.8	15.0
10RT DE	SL	93.9	89.5	-4.4	55.6	60.0	4.4
Sea Mist	SL	96.1	87.8	-8.3	56.1	65.0	8.9
Seabreeze GT	SL	97.8	87.2	-10.5	58.9	70.6	11.7
Shoreline	SL	96.7	92.8	-3.9	56.7	71.7	15.0
FRR 72 M2	ST	95.0	79.4	-15.6	56.1	68.9	12.8
Kent	ST	90.0	86.1	-3.9	57.8	70.6	12.8
Navigator II	ST	93.3	84.4	-8.9	52.8	62.8	10.0

Ruddy	ST	88.9	83.3	**-5.5**	50.6	69.4	18.9
Xeric	ST	92.2	85.5	**-6.7**	52.8	62.2	9.4
Avenger II	TF	98.3	96.7	**-1.7**	55.6	62.2	6.7
Birmingham	TF	100.0	91.1	**-8.9**	52.8	62.8	10.0
Black Tail	TF	97.8	92.8	**-5.0**	55.6	61.7	6.1
Fayette	TF	96.7	88.9	**-7.8**	57.2	66.7	9.4
JT-621	TF	96.1	93.3	**-2.8**	56.7	63.9	7.2
MNKY	TF	93.9	85.6	**-8.3**	53.3	62.8	9.4
Saltillo	TF	96.7	93.9	**-2.8**	53.9	68.9	15.0
Thunderstruck	TF	97.8	88.9	**-8.9**	55.0	70.0	15.0
MI DOT THV	MX	96.1	90.6	**-5.5**	48.9	65.6	16.7
MI DOT TUF	MX	97.8	93.3	**-4.4**	48.3	65.0	16.7
MN DOT 25-131	MX	97.2	88.9	**-8.3**	50.0	62.8	12.8
MN DOT MNST-12	MX	96.1	86.1	**-10.0**	57.8	68.9	11.1
NE DOT Rural Region 2	MX	90.0	80.0	**-10.0**	56.7	66.1	9.4
NE DOT Urban and Turf	MX	98.9	97.8	**-1.1**	59.4	68.9	9.4
NJ DOT A-4	MX	83.9	75.0	**-8.9**	57.8	70.6	12.8
NJ DOT Type B	MX	92.8	97.2	**4.4**	55.6	63.9	8.3
WI DOT #20	MX	96.1	85.0	**-11.1**	53.9	62.2	8.3
WI DOT #40	MX	86.7	75.5	**-11.2**	56.7	67.2	10.6
LSD (0.05)		12.4	13.5	11.5	NS	NS	NS

1. When treatment F tests were significant (p≤0.05), the Fisher's Protected Least Significant Difference Test (LSD) (α=0.05) was used to separate means. NS = not significant. For % TC Change (when significant), the most positive value within a column is shaded blue, while the most negative value within a column is shaded red. Remaining cells are shaded in a blue-purple-red gradient with zero shaded purple. Negative values indicate a reduction in turf coverage of desired species, whereas a positive value means the turf coverage of the plot increased.
2. Species tested include: AL = alkaligrass (*Puccinellia distans*); AM = seaside alkaligrass (*Puccinellia maritima*); CH = Chewings fescue (*Festuca rubra* ssp. *fallax*); HD = hard fescue (*Festuca brevipila*); KB = Kentucky bluegrass (*Poa pratensis*); PR = perennial ryegrass (*Lolium perenne*); SB = smooth bromegrass (*Bromus inermis*); SL = slender creeping red fescue (*Festuca rubra* ssp. *littoralis*); ST = strong creeping red fescue (*Festuca rubra* ssp. *rubra*); TF = tall fescue (*Schedonorus arundinaceus*); MX = DOT-specified mixtures.
3. Tetraploid perennial ryegrass

Table 3.5 Minnesota Rural – Total living turf cover [Total Cover (TC)] for Fall 2017 and Spring 2018; and percent total cover change from 2017 to 2018 (2017-2018 % TC Change).

		Fall 2017[1]	Spring 2018	2017-2018
Turfgrass Entry	**Species[2]**	**Total Cover (TC)**		**% TC Change**
BAR PD06N17	AL	76.1	46.7	-29.4
BAR PD9032	AL	65.0	25.6	-39.4
Fults	AL	30.6	20.0	-10.6
Salton Sea	AL	61.7	11.7	-50.0
SeaSalt	AL	26.7	12.2	-14.4
Oceania Maritima	AM	63.9	41.1	-22.8
Castle	CH	78.9	8.9	-70.0
Compass II	CH	67.2	13.9	-53.3
FRC 43 M2	CH	81.1	8.3	-72.8
Heathland	CH	70.0	13.9	-56.1
Beacon	HD	92.2	28.9	-63.3
Gladiator	HD	84.4	25.6	-58.9
Nanook	HD	51.1	17.2	-33.9
Soil Guard	HD	71.7	7.2	-64.4
Sword	HD	77.2	12.2	-65.0
Barduke	KB	56.7	7.8	-48.9
J-525	KB	52.8	4.4	-48.3
J-793	KB	37.8	2.2	-35.6
J-920	KB	27.2	2.2	-25.0
Milagro	KB	57.2	1.1	-56.1
Morocco	KB	69.4	8.3	-61.1
Tirem	KB	56.1	11.7	-44.4
Volt	KB	72.8	0.6	-72.2
16-14-Lp 145	PR	90.6	1.1	-89.4
BAR Lp 10970	PR	77.8	2.8	-75.0
Gray Fox	PR	83.9	0.6	-83.3
Premium	PR	88.3	0.6	-87.8
Replicator[3]	PR	90.6	1.7	-88.9
Stellar	PR	93.9	0.6	-93.3
BAR BIF 1GRL	SB	40.6	1.1	-39.4
Blue Mesa	SH	82.2	35.6	-46.7
J-248	SH	68.9	18.9	-50.0
Quatro	SH	81.7	23.9	-57.8
10RT DE	SL	90.0	29.4	-60.6
Sea Mist	SL	91.1	25.6	-65.6
Seabreeze GT	SL	84.4	12.8	-71.7
Shoreline	SL	87.8	37.2	-50.6
FRR 72 M2	ST	70.0	13.9	-56.1
Kent	ST	85.0	21.1	-63.9
Navigator II	ST	70.0	23.9	-46.1
Ruddy	ST	64.4	18.9	-45.6
Xeric	ST	81.1	18.9	-62.2

Avenger II	TF	87.2	3.9	**-83.3**
Birmingham	TF	86.1	10.6	**-75.6**
Black Tail	TF	68.9	5.0	**-63.9**
Fayette	TF	80.6	3.3	**-77.2**
JT-621	TF	73.9	1.1	**-72.8**
MNKY	TF	88.9	11.7	**-77.2**
Saltillo	TF	79.4	7.8	**-71.7**
Thunderstruck	TF	78.9	1.7	**-77.2**
MI DOT THV	MX	73.3	21.7	**-51.7**
MI DOT TUF	MX	71.1	34.4	**-36.7**
MN DOT 25-131	MX	83.9	31.7	**-52.2**
MN DOT MNST-12	MX	92.8	17.8	**-75.0**
NE DOT Rural Region 2	MX	81.7	9.4	**-72.2**
NE DOT Urban and Turf	MX	98.3	11.1	**-87.2**
NJ DOT A-4	MX	84.4	18.9	**-65.6**
NJ DOT Type B	MX	80.6	11.7	**-68.9**
WI DOT #20	MX	78.3	6.7	**-71.7**
WI DOT #40	MX	43.9	4.4	**-39.4**
LSD (0.05)		30.8	18.6	27.4

1. When treatment F tests were significant ($p \leq 0.05$), the Fisher's Protected Least Significant Difference Test (LSD) ($\alpha=0.05$) was used to separate means. NS = not significant. For % TC Change (when significant), the most positive value within a column is shaded blue, while the most negative value within a column is shaded red. Remaining cells are shaded in a blue-purple-red gradient with zero shaded purple. Negative values indicate a reduction in turf coverage of desired species, whereas a positive value means the turf coverage of the plot increased.
2. Species tested include: AL = alkaligrass (*Puccinellia distans*); AM = seaside alkaligrass (*Puccinellia maritima*); CH = Chewings fescue (*Festuca rubra* ssp. *fallax*); HD = hard fescue (*Festuca brevipila*); KB = Kentucky bluegrass (*Poa pratensis*); PR = perennial ryegrass (*Lolium perenne*); SB = smooth bromegrass (*Bromus inermis*); SL = slender creeping red fescue (*Festuca rubra* ssp. *littoralis*); ST = strong creeping red fescue (*Festuca rubra* ssp. *rubra*); TF = tall fescue (*Schedonorus arundinaceus*); MX = DOT-specified mixtures.
3. Tetraploid perennial ryegrass

Table 3.6 Minnesota Urban – Total living turf cover [Total Cover (TC)] for Fall 2016, Spring 2017, Fall 2017 and Spring 2018; and percent total cover change from 2016 to 2017 (2016-2017 % TC Change) and percent total cover change from 2017 to 2018 (2017-2018 % TC Change).

		Fall 2016	Spring 2017	2016-2017[1]	Fall 2017	Spring 2018	2017-2018
Turfgrass Entry	Species[2]	Total Cover (TC)		% TC Change	Total Cover (TC)		% TC Change
BAR PD06N17	AL	98.3	85.6	-12.8	7.8	1.1	-6.7
BAR PD9032	AL	89.5	83.9	-5.6	7.8	12.2	4.4
Fults	AL	97.8	85.0	-12.8	33.3	7.2	-26.1
Salton Sea	AL	89.4	71.7	-17.8	19.4	5.6	-13.9
SeaSalt	AL	86.7	90.0	3.3	12.8	5.0	-7.8
Oceania Maritima	AM	91.6	76.1	-15.5	23.3	11.7	-11.7
Castle	CH	98.9	82.2	-16.7	96.1	1.1	-95.0
Compass II	CH	96.1	91.1	-5.0	84.4	3.3	-81.1
FRC 43 M2	CH	97.2	95.0	-2.2	92.2	6.7	-85.6
Heathland	CH	99.4	90.0	-9.5	86.1	29.4	-56.7
Beacon	HD	98.9	95.0	-3.9	96.7	5.0	-91.7
Gladiator	HD	97.8	92.2	-5.6	63.9	8.3	-55.6
Nanook	HD	97.2	94.5	-2.8	75.0	13.9	-61.1
Soil Guard	HD	93.3	90.6	-2.8	92.8	9.4	-83.3
Sword	HD	96.7	94.5	-2.2	85.0	26.1	-58.9
Barduke	KB	93.9	18.9	-75.0	65.6	2.8	-62.8
J-525	KB	98.3	47.8	-50.6	65.0	7.8	-57.2
J-793	KB	98.3	82.8	-15.5	80.6	28.9	-51.7
J-920	KB	97.8	32.2	-65.6	80.6	5.6	-75.0
Milagro	KB	96.7	36.7	-60.0	58.9	0.6	-58.3
Morocco	KB	100.0	56.1	-43.9	90.0	21.1	-68.9
Tirem	KB	90.6	46.1	-44.4	70.0	0.0	-70.0
Volt	KB	97.2	11.7	-85.6	50.6	6.7	-43.9
16-14-Lp 145	PR	96.7	21.1	-75.5	66.7	0.0	-66.7
BAR Lp 10970	PR	100.0	25.6	-74.4	57.8	0.6	-57.2
Gray Fox	PR	100.0	20.0	-80.0	40.0	0.0	-40.0
Premium	PR	91.1	47.8	-43.3	89.4	0.6	-88.9
Replicator[3]	PR	98.3	1.1	-97.2	25.0	0.6	-24.4
Stellar	PR	100.0	22.8	-77.2	59.4	0.0	-59.4
BAR BIF 1GRL	SB	100.0	94.4	-5.6	37.2	0.0	-37.2
Blue Mesa	SH	98.3	93.3	-5.0	83.3	1.1	-82.2
J-248	SH	97.2	96.1	-1.1	91.7	22.8	-68.9
Quatro	SH	96.1	88.9	-7.2	73.9	7.8	-66.1
10RT DE	SL	100.0	96.1	-3.9	86.7	30.0	-56.7
Sea Mist	SL	98.9	97.2	-1.7	91.1	21.1	-70.0
Seabreeze GT	SL	98.9	96.1	-2.8	89.4	40.6	-48.9
Shoreline	SL	99.4	92.2	-7.2	92.2	46.7	-45.6
FRR 72 M2	ST	95.6	97.2	1.6	95.0	28.9	-66.1
Kent	ST	98.9	97.2	-1.6	96.1	52.8	-43.3
Navigator II	ST	96.7	95.6	-1.1	86.7	46.1	-40.6

Ruddy	ST	96.7	97.8	**1.1**	97.8	35.0	**-62.8**
Xeric	ST	98.3	93.4	**-5.0**	94.4	30.0	**-64.4**
Avenger II	TF	100.0	89.4	**-10.6**	80.0	1.1	**-78.9**
Birmingham	TF	99.4	91.1	**-8.3**	88.3	2.2	**-86.1**
Black Tail	TF	99.4	82.8	**-16.7**	94.4	0.6	**-93.9**
Fayette	TF	90.5	86.7	**-3.9**	78.9	0.0	**-78.9**
JT-621	TF	99.4	93.9	**-5.5**	85.6	0.0	**-85.6**
MNKY	TF	97.8	82.2	**-15.5**	77.8	0.0	**-77.8**
Saltillo	TF	100.0	93.9	**-6.1**	93.3	0.0	**-93.3**
Thunderstruck	TF	98.3	80.5	**-17.8**	89.4	0.0	**-89.4**
MI DOT THV	MX	99.4	97.8	**-1.7**	95.0	35.0	**-60.0**
MI DOT TUF	MX	100.0	98.3	**-1.7**	88.9	35.6	**-53.3**
MN DOT 25-131	MX	99.4	96.7	**-2.8**	92.8	34.4	**-58.3**
MN DOT MNST-12	MX	89.4	96.7	**7.2**	93.3	27.8	**-65.6**
NE DOT Rural Region 2	MX	98.9	33.9	**-65.0**	55.0	0.0	**-55.0**
NE DOT Urban and Turf	MX	97.8	83.3	**-14.4**	99.4	5.6	**-93.9**
NJ DOT A-4	MX	98.9	91.7	**-7.2**	95.6	41.7	**-53.9**
NJ DOT Type B	MX	100.0	89.5	**-10.5**	97.8	11.1	**-86.7**
WI DOT #20	MX	100.0	86.7	**-13.3**	96.1	2.8	**-93.3**
WI DOT #40	MX	97.2	86.1	**-11.1**	97.2	47.8	**-49.4**
LSD (0.05)		7.2	21.3	22.5	30.8	14.4	32.2

1. When treatment F tests were significant ($p \leq 0.05$), the Fisher's Protected Least Significant Difference Test (LSD) ($\alpha=0.05$) was used to separate means. NS = not significant. For % TC Change (when significant), the most positive value within a column is shaded blue, while the most negative value within a column is shaded red. Remaining cells are shaded in a blue-purple-red gradient with zero shaded purple. Negative values indicate a reduction in turf coverage of desired species, whereas a positive value means the turf coverage of the plot increased.
2. Species tested include: AL = alkaligrass (*Puccinellia distans*); AM = seaside alkaligrass (*Puccinellia maritima*); CH = Chewings fescue (*Festuca rubra* ssp. *fallax*); HD = hard fescue (*Festuca brevipila*); KB = Kentucky bluegrass (*Poa pratensis*); PR = perennial ryegrass (*Lolium perenne*); SB = smooth bromegrass (*Bromus inermis*); SL = slender creeping red fescue (*Festuca rubra* ssp. *littoralis*); ST = strong creeping red fescue (*Festuca rubra* ssp. *rubra*); TF = tall fescue (*Schedonorus arundinaceus*); MX = DOT-specified mixtures.
3. Tetraploid perennial ryegrass

Table 3.7 Nebraska Rural – Total living turf cover [Total Cover (TC)] for Fall 2017 and Spring 2018; and percent total cover change from 2017 to 2018 (2017-2018 % TC Change).

		Fall 2017	Spring 2018[1]	2017-2018
Turfgrass Entry	Species[2]	Total Cover (TC)		% TC Change
BAR PD06N17	AL	0.0	16.7	16.7
BAR PD9032	AL	0.0	32.8	32.8
Fults	AL	0.0	12.8	12.8
Salton Sea	AL	0.0	17.8	17.8
SeaSalt	AL	0.0	27.2	27.2
Oceania Maritima	AM	0.0	12.2	12.2
Castle	CH	0.0	26.1	26.1
Compass II	CH	0.0	7.8	7.8
FRC 43 M2	CH	0.0	0.0	0.0
Heathland	CH	0.0	15.0	15.0
Beacon	HD	0.0	4.4	4.4
Gladiator	HD	0.0	5.6	5.6
Nanook	HD	0.0	40.6	40.6
Soil Guard	HD	0.0	16.7	16.7
Sword	HD	0.0	39.4	39.4
Barduke	KB	0.0	16.1	16.1
J-525	KB	0.0	9.4	9.4
J-793	KB	0.0	30.0	30.0
J-920	KB	0.0	25.6	25.6
Milagro	KB	0.0	6.1	6.1
Morocco	KB	0.0	5.6	5.6
Tirem	KB	0.0	5.6	5.6
Volt	KB	0.0	12.2	12.2
16-14-Lp 145	PR	0.0	13.9	13.9
BAR Lp 10970	PR	0.0	32.2	32.2
Gray Fox	PR	0.0	16.7	16.7
Premium	PR	0.0	15.0	15.0
Replicator[3]	PR	0.0	15.6	15.6
Stellar	PR	0.0	5.6	5.6
BAR BIF 1GRL	SB	0.0	0.0	0.0
Blue Mesa	SH	0.0	27.8	27.8
J-248	SH	0.0	49.4	49.4
Quatro	SH	0.0	6.1	6.1
10RT DE	SL	0.0	34.4	34.4
Sea Mist	SL	0.0	24.4	24.4
Seabreeze GT	SL	1.1	20.0	18.9
Shoreline	SL	0.0	22.8	22.8
FRR 72 M2	ST	0.0	28.9	28.9
Kent	ST	0.0	29.4	29.4
Navigator II	ST	0.0	4.4	4.4
Ruddy	ST	0.0	13.3	13.3
Xeric	ST	0.0	0.0	0.0
Avenger II	TF	0.0	18.9	18.9
Birmingham	TF	0.0	4.4	4.4
Black Tail	TF	0.0	26.1	26.1
Fayette	TF	0.0	8.9	8.9

JT-621	TF	0.0	26.7	26.7
MNKY	TF	0.0	7.2	7.2
Saltillo	TF	0.0	0.0	0.0
Thunderstruck	TF	0.0	14.4	14.4
MI DOT THV	MX	0.0	2.2	2.2
MI DOT TUF	MX	0.0	4.4	4.4
MN DOT 25-131	MX	0.0	20.0	20.0
MN DOT MNST-12	MX	0.0	39.4	39.4
NE DOT Rural Region 2	MX	0.0	42.2	42.2
NE DOT Urban and Turf	MX	0.0	8.3	8.3
NJ DOT A-4	MX	0.0	26.1	26.1
NJ DOT Type B	MX	0.0	21.1	21.1
WI DOT #20	MX	0.0	8.3	8.3
WI DOT #40	MX	0.0	2.2	2.2
LSD (0.05)		NS	44.2	NS

1. When treatment F tests were significant (p≤0.05), the Fisher's Protected Least Significant Difference Test (LSD) (α=0.05) was used to separate means. NS = not significant.
2. Species tested include: AL = alkaligrass (*Puccinellia distans*); AM = seaside alkaligrass (*Puccinellia maritima*); CH = Chewings fescue (*Festuca rubra* ssp. *fallax*); HD = hard fescue (*Festuca brevipila*); KB = Kentucky bluegrass (*Poa pratensis*); PR = perennial ryegrass (*Lolium perenne*); SB = smooth bromegrass (*Bromus inermis*); SL = slender creeping red fescue (*Festuca rubra* ssp. *littoralis*); ST = strong creeping red fescue (*Festuca rubra* ssp. *rubra*); TF = tall fescue (*Schedonorus arundinaceus*); MX = DOT-specified mixtures.
3. Tetraploid perennial ryegrass

Table 3.8 Nebraska Urban – Total living turf cover [Total Cover (TC)] for Fall 2017 and Spring 2018; and percent total cover change from 2017 to 2018 (2017-2018 % TC Change).

		Fall 2017[1]	Spring 2018	2017-2018
Turfgrass Entry	Species[2]	Total Cover (TC)		% TC Change
BAR PD06N17	AL	10.0	3.3	-6.7
BAR PD9032	AL	9.1	16.7	7.6
Fults	AL	13.3	36.1	22.8
Salton Sea	AL	5.0	7.2	2.2
SeaSalt	AL	4.8	7.8	3.0
Oceania Maritima	AM	9.8	21.1	11.3
Castle	CH	3.9	0.0	-3.9
Compass II	CH	18.0	25.6	7.6
FRC 43 M2	CH	24.1	18.3	-5.7
Heathland	CH	23.3	25.0	1.7
Beacon	HD	16.9	44.4	27.6
Gladiator	HD	52.0	47.2	-4.8
Nanook	HD	19.6	29.4	9.8
Soil Guard	HD	4.4	12.8	8.3
Sword	HD	12.2	20.6	8.3
Barduke	KB	19.1	51.1	32.0
J-525	KB	25.9	28.3	2.4
J-793	KB	68.5	70.6	2.0
J-920	KB	25.4	36.7	11.3
Milagro	KB	37.8	28.9	-8.9
Morocco	KB	23.0	29.4	6.5
Tirem	KB	47.8	29.4	-18.3
Volt	KB	16.9	7.2	-9.6
16-14-Lp 145	PR	71.5	79.4	8.0
BAR Lp 10970	PR	78.0	69.4	-8.5
Gray Fox	PR	57.0	85.0	28.0
Premium	PR	65.7	77.2	11.5
Replicator[3]	PR	45.7	68.3	22.6
Stellar	PR	68.5	80.6	12.0
BAR BIF 1GRL	SB	49.6	1.1	-48.5
Blue Mesa	SH	9.6	26.7	17.0
J-248	SH	24.6	38.9	14.3
Quatro	SH	6.5	21.7	15.2
10RT DE	SL	11.9	25.0	13.2
Sea Mist	SL	35.4	49.4	14.1
Seabreeze GT	SL	17.0	16.7	-0.4
Shoreline	SL	26.9	50.0	23.2
FRR 72 M2	ST	30.2	33.9	3.7
Kent	ST	30.2	25.0	-5.2
Navigator II	ST	25.9	33.3	7.4
Ruddy	ST	33.7	33.3	-0.4
Xeric	ST	10.6	15.0	4.4
Avenger II	TF	79.3	85.6	6.3
Birmingham	TF	65.4	83.3	18.0
Black Tail	TF	65.0	55.6	-9.4
Fayette	TF	65.6	81.7	16.1

JT-621	TF	66.3	74.4	8.2
MNKY	TF	58.5	61.7	3.2
Saltillo	TF	63.2	84.4	21.3
Thunderstruck	TF	81.3	87.2	5.9
MI DOT THV	MX	30.4	58.9	28.5
MI DOT TUF	MX	15.6	58.9	43.3
MN DOT 25-131	MX	47.4	42.2	-5.2
MN DOT MNST-12	MX	17.8	17.8	0.0
NE DOT Rural Region 2	MX	47.6	48.3	0.7
NE DOT Urban and Turf	MX	80.0	81.1	1.1
NJ DOT A-4	MX	35.9	42.2	6.3
NJ DOT Type B	MX	51.1	60.6	9.4
WI DOT #20	MX	55.0	46.1	-8.9
WI DOT #40	MX	52.8	65.6	12.8
LSD (0.05)		36.7	37.9	NS

1. When treatment F tests were significant ($p \leq 0.05$), the Fisher's Protected Least Significant Difference Test (LSD) ($\alpha = 0.05$) was used to separate means. NS = not significant.
2. Species tested include: AL = alkaligrass (*Puccinellia distans*); AM = seaside alkaligrass (*Puccinellia maritima*); CH = Chewings fescue (*Festuca rubra* ssp. *fallax*); HD = hard fescue (*Festuca brevipila*); KB = Kentucky bluegrass (*Poa pratensis*); PR = perennial ryegrass (*Lolium perenne*); SB = smooth bromegrass (*Bromus inermis*); SL = slender creeping red fescue (*Festuca rubra* ssp. *littoralis*); ST = strong creeping red fescue (*Festuca rubra* ssp. *rubra*); TF = tall fescue (*Schedonorus arundinaceus*); MX = DOT-specified mixtures.
3. Tetraploid perennial ryegrass

Table 3.9 New Jersey Rural – Total living turf cover [Total Cover (TC)] for Fall 2016, Spring 2017, Fall 2017 and Spring 2018; and percent total cover change from 2016 to 2017 (2016-2017 % TC Change) and percent total cover change from 2017 to 2018 (2017-2018 % TC Change).

		Fall 2016[1]	Spring 2017	2016-2017	Fall 2017	Spring 2018	2017-2018
Turfgrass Entry	Species[2]	Total Cover (TC)		% TC Change	Total Cover (TC)		% TC Change
BAR PD06N17	AL	81.7	73.9	-7.8	16.7	41.7	25.0
BAR PD9032	AL	36.6	22.8	-13.9	35.0	34.4	-0.6
Fults	AL	87.8	80.0	-7.8	63.9	75.6	11.7
Salton Sea	AL	55.0	56.7	1.7	30.0	38.9	8.9
SeaSalt	AL	49.4	79.5	30.0	10.6	35.0	24.4
Oceania Maritima	AM	67.2	70.5	3.3	31.1	46.7	15.6
Castle	CH	46.7	0.0	-46.7	0.0	0.0	0.0
Compass II	CH	46.7	0.0	-46.7	0.0	0.0	0.0
FRC 43 M2	CH	49.4	0.0	-49.4	0.0	0.0	0.0
Heathland	CH	39.4	0.0	-39.4	0.6	0.0	-0.6
Beacon	HD	49.5	0.0	-49.5	2.8	0.0	-2.8
Gladiator	HD	43.9	0.0	-43.9	0.0	0.0	0.0
Nanook	HD	59.4	0.0	-59.4	0.0	0.0	0.0
Soil Guard	HD	36.7	0.0	-36.7	0.0	0.0	0.0
Sword	HD	67.2	0.0	-67.2	0.6	0.0	-0.6
Barduke	KB	28.3	0.0	-28.3	0.0	0.0	0.0
J-525	KB	21.1	0.0	-21.1	0.6	0.0	-0.6
J-793	KB	43.4	0.0	-43.4	0.0	0.0	0.0
J-920	KB	22.2	0.0	-22.2	0.0	0.0	0.0
Milagro	KB	20.5	0.0	-20.5	1.1	0.0	-1.1
Morocco	KB	25.6	0.0	-25.6	0.0	0.0	0.0
Tirem	KB	28.3	0.0	-28.3	0.0	0.0	0.0
Volt	KB	10.6	0.0	-10.6	0.0	0.0	0.0
16-14-Lp 145	PR	70.5	0.0	-70.5	0.0	0.0	0.0
BAR Lp 10970	PR	89.4	0.0	-89.4	1.7	0.0	-1.7
Gray Fox	PR	84.5	3.3	-81.1	0.0	0.0	0.0
Premium	PR	86.7	0.6	-86.1	0.6	0.0	-0.6
Replicator[3]	PR	66.7	0.0	-66.7	0.0	0.0	0.0
Stellar	PR	89.4	0.6	-88.9	1.7	0.0	-1.7
BAR BIF 1GRL	SB	55.6	4.4	-51.1	0.0	0.0	0.0
Blue Mesa	SH	63.3	0.0	-63.3	0.0	0.0	0.0
J-248	SH	52.2	0.0	-52.2	0.0	0.0	0.0
Quatro	SH	40.0	2.8	-37.2	0.0	0.0	0.0
10RT DE	SL	83.9	15.0	-68.9	0.0	0.0	0.0
Sea Mist	SL	68.3	0.0	-68.3	0.0	0.0	0.0
Seabreeze GT	SL	79.5	9.4	-70.0	1.7	0.0	-1.7
Shoreline	SL	73.3	1.1	-72.2	0.6	0.0	-0.6
FRR 72 M2	ST	64.5	0.0	-64.5	0.0	0.0	0.0
Kent	ST	57.8	0.6	-57.2	0.6	0.0	-0.6
Navigator II	ST	52.2	0.0	-52.2	0.0	0.0	0.0

Ruddy	ST	60.0	0.0	**-60.0**	0.6	0.0	**-0.6**
Xeric	ST	51.1	0.0	**-51.1**	0.0	0.0	**0.0**
Avenger II	TF	69.4	0.0	**-69.4**	3.3	0.0	**-3.3**
Birmingham	TF	68.9	1.7	**-67.2**	2.2	0.0	**-2.2**
Black Tail	TF	61.7	2.8	**-58.9**	4.4	0.0	**-4.4**
Fayette	TF	73.9	1.7	**-72.2**	0.6	0.0	**-0.6**
JT-621	TF	63.9	4.4	**-59.5**	3.3	0.0	**-3.3**
MNKY	TF	68.9	0.6	**-68.3**	0.0	0.0	**0.0**
Saltillo	TF	77.2	6.7	**-70.6**	4.4	0.0	**-4.4**
Thunderstruck	TF	66.6	12.8	**-53.9**	1.1	0.0	**-1.1**
MI DOT THV	MX	83.9	66.1	**-17.8**	51.7	53.3	**1.7**
MI DOT TUF	MX	85.0	73.9	**-11.1**	59.4	61.1	**1.7**
MN DOT 25-131	MX	63.9	0.0	**-63.9**	0.0	0.0	**0.0**
MN DOT MNST-12	MX	58.3	1.1	**-57.2**	0.6	0.0	**-0.6**
NE DOT Rural Region 2	MX	18.3	0.0	**-18.3**	0.0	0.0	**0.0**
NE DOT Urban and Turf	MX	90.0	21.7	**-68.4**	7.2	0.0	**-7.2**
NJ DOT A-4	MX	46.1	0.6	**-45.5**	0.0	0.0	**0.0**
NJ DOT Type B	MX	45.5	0.0	**-45.5**	1.1	0.0	**-1.1**
WI DOT #20	MX	43.9	0.0	**-43.9**	0.6	0.0	**-0.6**
WI DOT #40	MX	31.1	0.0	**-31.1**	0.0	0.0	**0.0**
LSD (0.05)		32.7	17.9	34.0	10.4	17.9	15.0

1. When treatment F tests were significant (p≤0.05), the Fisher's Protected Least Significant Difference Test (LSD) (α=0.05) was used to separate means. NS = not significant. For % TC Change (when significant), the most positive value within a column is shaded blue, while the most negative value within a column is shaded red. Remaining cells are shaded in a blue-purple-red gradient with zero shaded purple. Negative values indicate a reduction in turf coverage of desired species, whereas a positive value means the turf coverage of the plot increased.
2. Species tested include: AL = alkaligrass (*Puccinellia distans*); AM = seaside alkaligrass (*Puccinellia maritima*); CH = Chewings fescue (*Festuca rubra* ssp. *fallax*); HD = hard fescue (*Festuca brevipila*); KB = Kentucky bluegrass (*Poa pratensis*); PR = perennial ryegrass (*Lolium perenne*); SB = smooth bromegrass (*Bromus inermis*); SL = slender creeping red fescue (*Festuca rubra* ssp. *littoralis*); ST = strong creeping red fescue (*Festuca rubra* ssp. *rubra*); TF = tall fescue (*Schedonorus arundinaceus*); MX = DOT-specified mixtures.
3. Tetraploid perennial ryegrass

Table 3.10 New Jersey Urban – Total living turf cover [Total Cover (TC)] for Fall 2016, Spring 2017, Fall 2017 and Spring 2018; and percent total cover change from 2016 to 2017 (2016-2017 % TC Change) and percent total cover change from 2017 to 2018 (2017-2018 % TC Change).

		Fall 2016[1]	Spring 2017	2016-2017	Fall 2017	Spring 2018	2017-2018
Turfgrass Entry	Species[2]	Total Cover (TC)		% TC Change	Total Cover (TC)		% TC Change
BAR PD06N17	AL	98.3	85.6	-12.8	7.8	1.1	-6.7
BAR PD9032	AL	59.4	38.9	-20.6	32.2	55.0	22.8
Fults	AL	75.6	57.8	-17.8	55.6	74.4	18.9
Salton Sea	AL	23.9	23.9	0.0	14.4	53.9	39.4
SeaSalt	AL	25.6	28.9	3.3	28.3	60.6	32.2
Oceania Maritima	AM	63.4	62.2	-1.2	36.1	62.2	26.1
Castle	CH	69.4	30.6	-38.9	17.2	20.0	2.8
Compass II	CH	72.2	18.9	-53.3	22.8	30.0	7.2
FRC 43 M2	CH	67.8	20.6	-47.2	14.4	22.2	7.8
Heathland	CH	72.8	17.2	-55.6	19.4	17.8	-1.7
Beacon	HD	75.6	40.5	-35.0	22.2	32.8	10.6
Gladiator	HD	55.6	8.9	-46.7	13.3	20.0	6.7
Nanook	HD	69.4	20.6	-48.9	13.9	26.1	12.2
Soil Guard	HD	47.2	16.7	-30.5	12.8	20.0	7.2
Sword	HD	57.2	16.7	-40.5	15.6	37.2	21.7
Barduke	KB	31.1	4.4	-26.7	4.4	15.0	10.6
J-525	KB	19.4	0.0	-19.4	1.1	5.6	4.4
J-793	KB	30.5	0.0	-30.5	8.9	20.6	11.7
J-920	KB	28.9	5.6	-23.3	7.2	18.3	11.1
Milagro	KB	16.6	1.1	-15.5	0.6	3.3	2.8
Morocco	KB	31.1	2.8	-28.3	16.7	33.9	17.2
Tirem	KB	33.9	6.7	-27.2	24.4	40.6	16.1
Volt	KB	27.8	2.8	-25.0	2.8	16.7	13.9
16-14-Lp 145	PR	96.1	72.8	-23.4	28.3	43.9	15.6
BAR Lp 10970	PR	90.6	68.3	-22.2	41.7	50.0	8.3
Gray Fox	PR	88.4	83.3	-5.0	25.6	45.0	19.4
Premium	PR	93.9	77.2	-16.7	30.0	42.2	12.2
Replicator[3]	PR	80.0	47.8	-32.2	32.2	29.4	-2.8
Stellar	PR	95.0	72.8	-22.2	26.7	36.1	9.4
BAR BIF 1GRL	SB	87.2	62.8	-24.5	31.7	41.7	8.3
Blue Mesa	SH	73.9	20.6	-53.3	10.0	18.3	8.3
J-248	SH	73.3	27.8	-45.6	22.8	31.1	8.3
Quatro	SH	55.5	15.5	-40.0	13.3	21.7	12.2
10RT DE	SL	84.4	41.7	-42.8	38.3	50.6	1.1
Sea Mist	SL	77.2	42.2	-35.0	31.1	32.2	17.8
Seabreeze GT	SL	83.9	60.0	-23.9	45.0	62.8	13.9
Shoreline	SL	71.1	47.8	-23.3	61.7	75.6	10.0
FRR 72 M2	ST	68.3	26.1	-42.2	8.9	24.4	15.6
Kent	ST	61.1	32.2	-28.9	27.8	38.3	10.6
Navigator II	ST	67.2	27.2	-40.0	27.8	38.3	10.6

Ruddy	ST	70.0	25.0	-45.0	8.9	22.2	13.3
Xeric	ST	75.0	31.1	-43.9	23.9	39.4	15.6
Avenger II	TF	57.8	47.8	-10.0	43.3	59.4	16.1
Birmingham	TF	78.9	57.8	-21.1	38.3	52.8	14.4
Black Tail	TF	73.9	60.0	-13.9	74.4	66.7	-7.8
Fayette	TF	58.3	46.6	-11.7	37.8	56.7	18.9
JT-621	TF	77.8	33.3	-44.4	47.8	61.1	13.3
MNKY	TF	55.6	31.7	-23.9	40.6	61.1	20.6
Saltillo	TF	75.5	71.1	-4.4	37.2	60.0	22.8
Thunderstruck	TF	80.6	63.9	-16.7	60.0	69.4	9.4
MI DOT THV	MX	81.6	70.5	-11.1	71.7	88.3	16.7
MI DOT TUF	MX	86.1	66.7	-19.4	62.8	93.9	31.1
MN DOT 25-131	MX	81.1	66.7	-14.4	46.1	58.9	12.8
MN DOT MNST-12	MX	67.8	37.2	-30.6	49.4	61.1	11.7
NE DOT Rural Region 2	MX	29.4	10.6	-18.9	17.8	27.8	10.0
NE DOT Urban and Turf	MX	94.4	83.9	-10.6	44.4	73.9	29.4
NJ DOT A-4	MX	47.8	24.4	-23.4	21.7	40.0	18.3
NJ DOT Type B	MX	56.1	18.4	-37.7	29.4	43.9	14.4
WI DOT #20	MX	59.4	34.4	-25.0	46.7	64.4	17.8
WI DOT #40	MX	55.6	37.8	-17.8	27.2	50.0	22.8
LSD (0.05)		22.3	33.0	NS	NS	NS	NS

1. When treatment F tests were significant ($p \leq 0.05$), the Fisher's Protected Least Significant Difference Test (LSD) ($\alpha=0.05$) was used to separate means. NS = not significant.
2. Species tested include: AL = alkaligrass (*Puccinellia distans*); AM = seaside alkaligrass (*Puccinellia maritima*); CH = Chewings fescue (*Festuca rubra* ssp. *fallax*); HD = hard fescue (*Festuca brevipila*); KB = Kentucky bluegrass (*Poa pratensis*); PR = perennial ryegrass (*Lolium perenne*); SB = smooth bromegrass (*Bromus inermis*); SL = slender creeping red fescue (*Festuca rubra* ssp. *littoralis*); ST = strong creeping red fescue (*Festuca rubra* ssp. *rubra*); TF = tall fescue (*Schedonorus arundinaceus*); MX = DOT-specified mixtures.
3. Tetraploid perennial ryegrass

Table 3.11 Wisconsin Rural – Total living turf cover [Total Cover (TC)] for Fall 2016, Spring 2017, and Fall 2017; and percent total cover change from 2016 to 2017 (2016-2017 % TC Change).

		Fall 2016[1]	Spring 2017	2016-2017	Fall 2018
Turfgrass Entry	Species[2]	Total Cover (TC)		% TC Change	Total Cover (TC)
BAR PD06N17	AL	24.4	45.6	21.1	10.6
BAR PD9032	AL	4.4	23.3	18.9	12.2
Fults	AL	26.7	51.1	24.4	23.9
Salton Sea	AL	6.1	13.9	7.8	6.7
SeaSalt	AL	2.2	38.3	36.1	0.6
Oceania Maritima	AM	15.6	47.8	32.2	16.7
Castle	CH	61.1	30.0	-31.1	5.6
Compass II	CH	64.4	41.1	-23.3	10.0
FRC 43 M2	CH	50.0	36.7	-13.3	15.0
Heathland	CH	56.7	49.4	-7.2	9.4
Beacon	HD	36.1	59.4	23.3	12.8
Gladiator	HD	35.0	50.5	15.5	18.9
Nanook	HD	40.6	56.7	16.1	19.4
Soil Guard	HD	40.0	45.0	5.0	7.8
Sword	HD	62.8	45.6	-17.2	6.7
Barduke	KB	31.1	18.9	-12.3	20.0
J-525	KB	27.8	25.0	-2.8	11.1
J-793	KB	13.3	19.4	6.1	3.3
J-920	KB	18.9	13.3	-5.6	8.3
Milagro	KB	15.0	13.9	-1.1	21.7
Morocco	KB	13.9	23.9	10.0	12.8
Tirem	KB	12.8	27.8	15.0	10.6
Volt	KB	21.1	20.6	-0.5	1.7
16-14-Lp 145	PR	63.3	25.0	-38.3	12.8
BAR Lp 10970	PR	73.3	46.1	-27.2	3.9
Gray Fox	PR	66.1	46.7	-19.4	5.6
Premium	PR	68.9	43.9	-25.0	7.8
Replicator[3]	PR	73.9	50.0	-23.9	12.2
Stellar	PR	76.1	40.5	-35.6	10.0
BAR BIF 1GRL	SB	35.6	21.1	-14.5	0.6
Blue Mesa	SH	50.0	47.2	-2.8	23.9
J-248	SH	40.0	41.7	1.7	4.4
Quatro	SH	35.0	35.6	0.6	13.3
10RT DE	SL	81.1	60.0	-21.1	29.4
Sea Mist	SL	53.9	51.1	-2.8	20.0
Seabreeze GT	SL	64.4	42.2	-22.2	10.0
Shoreline	SL	51.1	52.2	1.1	15.6
FRR 72 M2	ST	57.2	41.7	-15.6	11.7
Kent	ST	44.4	42.8	-1.7	32.2
Navigator II	ST	62.2	55.6	-6.7	25.0
Ruddy	ST	68.3	44.4	-23.9	28.9
Xeric	ST	59.4	35.0	-24.4	19.4
Avenger II	TF	47.2	32.2	-15.0	9.4

Birmingham	TF	53.3	27.8	**-25.5**	15.6
Black Tail	TF	76.1	35.0	**-41.1**	11.1
Fayette	TF	67.8	32.2	**-35.6**	8.3
JT-621	TF	43.3	25.6	**-17.8**	2.2
MNKY	TF	36.1	17.2	**-18.9**	0.0
Saltillo	TF	72.8	22.2	**-50.5**	22.8
Thunderstruck	TF	47.2	20.6	**-26.7**	6.1
MI DOT THV	MX	69.5	52.2	**-17.2**	33.9
MI DOT TUF	MX	67.8	63.9	**-3.9**	47.2
MN DOT 25-131	MX	38.9	30.0	**-8.9**	13.3
MN DOT MNST-12	MX	47.2	42.2	**-5.0**	16.7
NE DOT Rural Region 2	MX	32.8	11.7	**-21.1**	2.8
NE DOT Urban and Turf	MX	49.4	31.7	**-17.8**	23.9
NJ DOT A-4	MX	46.7	34.4	**-12.2**	11.7
NJ DOT Type B	MX	39.5	47.2	**7.8**	22.2
WI DOT #20	MX	52.2	25.5	**-26.7**	3.9
WI DOT #40	MX	29.5	23.9	**-5.6**	0.0
LSD (0.05)		30.0	33.3	29.6	NS

1. When treatment F tests were significant (p≤0.05), the Fisher's Protected Least Significant Difference Test (LSD) (α=0.05) was used to separate means. NS = not significant. For % TC Change (when significant), the most positive value within a column is shaded blue, while the most negative value within a column is shaded red. Remaining cells are shaded in a blue-purple-red gradient with zero shaded purple. Negative values indicate a reduction in turf coverage of desired species, whereas a positive value means the turf coverage of the plot increased.
2. Species tested include: AL = alkaligrass (*Puccinellia distans*); AM = seaside alkaligrass (*Puccinellia maritima*); CH = Chewings fescue (*Festuca rubra* ssp. *fallax*); HD = hard fescue (*Festuca brevipila*); KB = Kentucky bluegrass (*Poa pratensis*); PR = perennial ryegrass (*Lolium perenne*); SB = smooth bromegrass (*Bromus inermis*); SL = slender creeping red fescue (*Festuca rubra* ssp. *littoralis*); ST = strong creeping red fescue (*Festuca rubra* ssp. *rubra*); TF = tall fescue (*Schedonorus arundinaceus*); MX = DOT-specified mixtures.
3. Tetraploid perennial ryegrass

Table 3.12 Wisconsin Urban – Total living turf cover [Total Cover (TC)] for Fall 2017 and Spring 2018; and percent total cover change from 2017 to 2018 (2017-2018 % TC Change).

Turfgrass Entry	Species[2]	Fall 2017[1]	Spring 2018	2017-2018
		Total Cover (TC)		% TC Change
BAR PD06N17	AL	55.6	68.9	13.3
BAR PD9032	AL	8.9	71.1	62.2
Fults	AL	30.6	76.1	45.6
Salton Sea	AL	1.7	45.6	43.9
SeaSalt	AL	8.9	69.4	60.6
Oceania Maritima	AM	31.7	72.2	40.6
Castle	CH	35.6	81.1	45.6
Compass II	CH	58.3	81.7	23.3
FRC 43 M2	CH	37.8	85.0	47.2
Heathland	CH	54.4	79.4	25.0
Beacon	HD	43.3	81.7	38.3
Gladiator	HD	46.1	90.6	44.4
Nanook	HD	32.2	86.1	53.9
Soil Guard	HD	36.1	85.0	48.9
Sword	HD	38.3	78.9	40.6
Barduke	KB	33.3	62.8	29.4
J-525	KB	14.4	53.3	38.9
J-793	KB	24.4	66.7	42.2
J-920	KB	13.3	54.4	41.1
Milagro	KB	15.6	63.3	47.8
Morocco	KB	10.6	56.7	46.1
Tirem	KB	12.8	55.6	42.8
Volt	KB	13.3	47.8	34.4
16-14-Lp 145	PR	84.4	93.9	9.4
BAR Lp 10970	PR	83.9	96.7	12.8
Gray Fox	PR	86.7	96.1	9.4
Premium	PR	89.4	96.7	7.2
Replicator[3]	PR	87.2	97.8	10.6
Stellar	PR	79.4	91.1	11.7
BAR BIF 1GRL	SB	64.4	88.9	24.4
Blue Mesa	SH	53.9	87.2	33.3
J-248	SH	35.6	79.4	43.9
Quatro	SH	33.3	83.3	50.0
10RT DE	SL	42.2	91.1	48.9
Sea Mist	SL	51.7	82.8	31.1
Seabreeze GT	SL	55.6	88.3	32.8
Shoreline	SL	52.8	83.9	31.1
FRR 72 M2	ST	56.7	86.7	30.0
Kent	ST	42.8	83.3	40.6
Navigator II	ST	53.3	78.3	25.0
Ruddy	ST	61.7	90.6	28.9
Xeric	ST	46.1	83.9	37.8

Avenger II	TF	73.9	96.7	**22.8**
Birmingham	TF	71.1	91.1	**20.0**
Black Tail	TF	55.6	87.8	**32.2**
Fayette	TF	61.1	89.4	**28.3**
JT-621	TF	67.8	90.0	**22.2**
MNKY	TF	58.3	81.1	**22.8**
Saltillo	TF	78.3	93.9	**15.6**
Thunderstruck	TF	65.0	92.8	**27.8**
MI DOT THV	MX	73.9	93.9	**20.0**
MI DOT TUF	MX	64.4	87.8	**23.3**
MN DOT 25-131	MX	59.4	86.1	**26.7**
MN DOT MNST-12	MX	43.9	87.2	**43.3**
NE DOT Rural Region 2	MX	23.3	63.9	**40.6**
NE DOT Urban and Turf	MX	86.1	98.9	**12.8**
NJ DOT A-4	MX	33.3	73.9	**40.6**
NJ DOT Type B	MX	51.7	88.3	**36.7**
WI DOT #20	MX	62.8	89.4	**26.7**
WI DOT #40	MX	40.0	78.9	**38.9**
LSD (0.05)		22.4	25.3	29.6

1. When treatment F tests were significant (p≤0.05), the Fisher's Protected Least Significant Difference Test (LSD) (α=0.05) was used to separate means. NS = not significant. For % TC Change (when significant), the most positive value within a column is shaded blue, while the most negative value within a column is shaded red. Remaining cells are shaded in a blue-purple-red gradient with zero shaded purple. Negative values indicate a reduction in turf coverage of desired species, whereas a positive value means the turf coverage of the plot increased.

2. Species tested include: AL = alkaligrass (*Puccinellia distans*); AM = seaside alkaligrass (*Puccinellia maritima*); CH = Chewings fescue (*Festuca rubra* ssp. *fallax*); HD = hard fescue (*Festuca brevipila*); KB = Kentucky bluegrass (*Poa pratensis*); PR = perennial ryegrass (*Lolium perenne*); SB = smooth bromegrass (*Bromus inermis*); SL = slender creeping red fescue (*Festuca rubra* ssp. *littoralis*); ST = strong creeping red fescue (*Festuca rubra* ssp. *rubra*); TF = tall fescue (*Schedonorus arundinaceus*); MX = DOT-specified mixtures.

3. Tetraploid perennial ryegrass

Table 3.13 Michigan rural – Total living turf cover [Total Cover (TC)] by turfgrass species for Fall 2016, Spring 2017, Fall 2017 and Spring 2018; and percent total cover change from 2016 to 2017 (2016-2017 % TC Change) and percent total cover change from 2017 to 2018 (2017-2018 % TC Change).

Turfgrass Species	Fall 2016	Spring 2017	2016-2017	Fall 2017	Spring 2018	2017-2018
	Total Cover (TC) [1]		% TC Change	Total Cover (TC)		% TC Change
Alkaligrass	41.9	42.3	0.4	9.6	12.1	2.5
Chewings fescue	94.0	86.5	-7.5	50.0	68.8	18.8
Hard fescue	89.7	89.3	-0.3	71.8	88.5	16.6
Kentucky bluegrass	61.7	62.5	0.8	55.6	65.8	10.2
Mixture	83.6	80.5	-3.1	67.6	78.9	11.3
Perennial ryegrass	97.2	93.4	-3.8	74.2	74.5	0.3
Sheep fescue	91.5	89.1	-2.4	68.7	83.8	15.1
Slender creeping red fescue	93.5	89.5	-4.0	58.6	72.5	13.8
Smooth bromegrass	85.6	84.4	-1.1	97.7	90.5	-7.2
Strong creeping red fescue	91.6	88.1	-3.4	62.4	77.7	15.3
Tall fescue	94.9	89.0	-5.8	83.4	87.2	3.8
Tetraploid perennial ryegrass	95.0	91.1	-3.9	65.0	77.2	12.2
LSD (0.05)	9.8	9.3	7.8	15.8	13.4	12.0

1. When treatment F tests were significant (p≤0.05), the Fisher's Protected Least Significant Difference Test (LSD) (α=0.05) was used to separate means. NS = not significant. For % TC Change (when significant), the most positive value within a column is shaded blue, while the most negative value within a column is shaded red. Remaining cells are shaded in a blue-purple-red gradient with zero shaded purple. Negative values indicate a reduction in turf coverage of desired species, whereas a positive value means the turf coverage of the plot increased.

Table 3.14 Michigan Urban – Total living turf cover [Total Cover (TC)] by turfgrass species for Fall 2016, Spring 2017, Fall 2017 and Spring 2018; and percent total cover change from 2016 to 2017 (2016-2017 % TC Change) and percent total cover change from 2017 to 2018 (2017-2018 % TC Change).

	Fall 2016	Spring 2017	2016-2017	Fall 2017	Spring 2018	2017-2018
Turfgrass Species	**Total Cover (TC)[1]**		**% TC Change**	**Total Cover (TC)**		**% TC Change**
Alkaligrass	55.6	34.4	-21.1	56.2	66.0	9.8
Chewings fescue	90.9	82.4	-8.4	53.0	65.1	12.0
Hard fescue	92.9	87.1	-5.7	53.8	65.4	11.5
Kentucky bluegrass	59.6	26.4	-33.2	55.8	66.7	10.0
Mixture	93.6	86.9	-6.6	53.6	66.2	12.6
Perennial ryegrass	99.1	96.4	-2.6	57.1	67.6	10.5
Sheep fescue	90.9	89.0	-1.8	55.9	67.5	11.6
Slender creeping red fescue	96.1	89.0	-6.8	54.5	69.0	14.4
Smooth bromegrass	97.7	92.7	-5.0	57.7	70.5	12.7
Strong creeping red fescue	91.9	83.7	-8.1	56.1	68.2	12.1
Tall fescue	97.2	91.3	-5.7	54.9	68.1	13.2
Tetraploid perennial ryegrass	100.0	97.8	-2.2	52.7	62.2	9.4
LSD (0.05)	8.0	8.1	6.4	NS	NS	NS

1. When treatment F tests were significant (p≤0.05), the Fisher's Protected Least Significant Difference Test (LSD) (α=0.05) was used to separate means. NS = not significant. For % TC Change (when significant), the most positive value within a column is shaded blue, while the most negative value within a column is shaded red. Remaining cells are shaded in a blue-purple-red gradient with zero shaded purple. Negative values indicate a reduction in turf coverage of desired species, whereas a positive value means the turf coverage of the plot increased.

Table 3.15 Minnesota Rural – Total living turf cover [Total Cover (TC)] by turfgrass species for Fall 2017 and Spring 2018; percent total cover change from 2017 to 2018 (2017-2018 % TC Change).

	Fall 2017	Spring 2018	2017-2018
Turfgrass Species	**Total Cover (TC)[1]**		**% TC Change**
Alkaligrass	54.0	26.2	-27.8
Chewings fescue	74.3	11.3	-63.1
Hard fescue	75.3	18.2	-57.1
Kentucky bluegrass	53.8	4.8	-49.0
Mixture	78.8	16.8	-62.1
Perennial ryegrass	86.9	1.1	-85.8
Sheep fescue	77.6	26.1	-51.5
Slender creeping red fescue	88.3	26.3	-62.1
Smooth bromegrass	40.6	1.1	-39.4
Strong creeping red fescue	74.1	19.3	-54.8
Tall fescue	80.5	5.6	-74.9
Tetraploid perennial ryegrass	90.6	1.7	-88.9
LSD (0.05)	17.5	10.6	15.5

1. When treatment F tests were significant (p≤0.05), the Fisher's Protected Least Significant Difference Test (LSD) (α=0.05) was used to separate means. NS = not significant. For % TC Change (when significant), the most positive value within a column is shaded blue, while the most negative value within a column is shaded red. Remaining cells are shaded in a blue-purple-red gradient with zero shaded purple. Negative values indicate a reduction in turf coverage of desired species, whereas a positive value means the turf coverage of the plot increased.

Table 3.16 Minnesota Urban – Total living turf cover [Total Cover (TC)] by turfgrass species for Fall 2016, Spring 2017, Fall 2017 and Spring 2018; and percent total cover change from 2016 to 2017 (2016-2017 % TC Change) and percent total cover change from 2017 to 2018 (2017-2018 % TC Change).

	Fall 2016	Spring 2017	2016-2017	Fall 2017	Spring 2018	2017-2018
Turfgrass Species	**Total Cover (TC)[1]**		**% TC Change**	**Total Cover (TC)**		**% TC Change**
Alkaligrass	91.0	81.3	-9.7	17.4	7.1	-10.3
Chewings fescue	97.9	89.6	-8.3	89.7	10.1	-79.6
Hard fescue	96.8	93.3	-3.4	82.7	12.6	-70.1
Kentucky bluegrass	96.8	46.4	-50.4	70.1	9.2	-61.0
Mixture	98.1	86.1	-12.1	91.1	24.2	-67.0
Perennial ryegrass	97.6	27.5	-70.1	62.7	0.2	-62.4
Sheep fescue	97.2	92.8	-4.4	83.0	10.6	-72.4
Slender creeping red fescue	99.3	95.4	-3.9	89.9	34.6	-55.3
Smooth bromegrass	100.0	94.4	-5.6	37.2	0.0	-37.2
Strong creeping red fescue	97.2	96.2	-1.0	94.0	38.6	-55.4
Tall fescue	98.1	87.6	-10.6	86.0	0.5	-85.5
Tetraploid perennial ryegrass	98.3	1.1	-97.2	25.0	0.6	-24.4
LSD (0.05)	4.6	14.2	14.8	15.9	10.5	17.5

1. When treatment F tests were significant (p≤0.05), the Fisher's Protected Least Significant Difference Test (LSD) (α=0.05) was used to separate means. NS = not significant. For % TC Change (when significant), the most positive value within a column is shaded blue, while the most negative value within a column is shaded red. Remaining cells are shaded in a blue-purple-red gradient with zero shaded purple. Negative values indicate a reduction in turf coverage of desired species, whereas a positive value means the turf coverage of the plot increased.

Table 3.17 Nebraska Rural – Total living turf cover [Total Cover (TC)] by turfgrass species for Fall 2017 and Spring 2018; percent total cover change from 2017 to 2018 (2017-2018 % TC Change).

	Fall 2017	Spring 2018	2017-2018
Turfgrass Species	**Total Cover (TC)[1]**		**% TC Change**
Alkaligrass	0.0	19.9	19.9
Chewings fescue	0.0	12.2	12.2
Hard fescue	0.0	21.3	21.3
Kentucky bluegrass	0.0	13.8	13.8
Mixture	0.0	17.4	17.4
Perennial ryegrass	0.0	16.7	16.7
Sheep fescue	0.0	27.8	27.8
Slender creeping red fescue	0.3	25.4	25.1
Smooth bromegrass	0.0	0.0	0.0
Strong creeping red fescue	0.0	15.2	15.2
Tall fescue	0.0	13.3	13.3
Tetraploid perennial ryegrass	0.0	15.6	15.6
LSD (0.05)	NS	NS	NS

1. There were no significant differences among species treatments.

Table 3.18 Nebraska Urban – Total living turf cover [Total Cover (TC)] by turfgrass species for Fall 2017 and Spring 2018; percent total cover change from 2017 to 2018 (2017-2018 % TC Change).

	Fall 2017	Spring 2018	2017-2018
Turfgrass Species	**Total Cover (TC)[1]**		**% TC Change**
Alkaligrass	8.7	15.4	6.7
Chewings fescue	17.3	17.2	-0.1
Hard fescue	21.0	30.9	9.9
Kentucky bluegrass	33.0	35.2	2.2
Mixture	43.4	52.2	8.8
Perennial ryegrass	68.2	78.3	10.2
Sheep fescue	13.6	29.1	15.5
Slender	22.8	35.3	12.5
Smooth bromegrass	49.6	1.1	-48.5
Strong creeping red fescue	26.1	28.1	2.0
Tall fescue	68.1	76.7	8.7
Tetraploid perennial ryegrass	45.7	68.3	22.6
LSD (0.05)	19.4	20.0	20.8

1. When treatment F tests were significant (p≤0.05), the Fisher's Protected Least Significant Difference Test (LSD) (α=0.05) was used to separate means. NS = not significant. For % TC Change (when significant), the most positive value within a column is shaded blue, while the most negative value within a column is shaded red. Remaining cells are shaded in a blue-purple-red gradient with zero shaded purple. Negative values indicate a reduction in turf coverage of desired species, whereas a positive value means the turf coverage of the plot increased.

Table 3.19 New Jersey Rural – Total living turf cover [Total Cover (TC)] by turfgrass species for Fall 2016, Spring 2017, Fall 2017 and Spring 2018; and percent total cover change from 2016 to 2017 (2016-2017 % TC Change) and percent total cover change from 2017 to 2018 (2017-2018 % TC Change).

	Fall 2016	Spring 2017	2016-2017	Fall 2017	Spring 2018	2017-2018
Turfgrass Species	**Total Cover (TC)[1]**		**% TC Change**	**Total Cover (TC)**		**% TC Change**
Alkaligrass	59.2	61.9	2.7	31.2	45.4	14.2
Chewings fescue	45.6	0.0	-45.6	0.1	0.0	-0.1
Hard fescue	51.3	0.0	-51.3	0.7	0.0	-0.7
Kentucky bluegrass	31.3	8.2	-23.1	0.2	0.0	-0.2
Mixture	56.6	16.3	-40.3	12.1	11.4	-0.6
Perennial ryegrass	84.1	0.9	-83.2	0.8	0.0	-0.8
Sheep fescue	51.8	0.9	-50.9	0.0	0.0	0.0
Slender creeping red fescue	76.3	6.4	-69.9	0.6	0.0	-0.6
Smooth bromegrass	55.6	4.4	-51.1	0.0	0.0	0.0
Strong creeping red fescue	57.1	0.1	-57.0	0.2	0.0	-0.2
Tall fescue	68.8	3.8	-65.0	2.4	0.0	-2.4
Tetraploid perennial ryegrass	66.7	0.0	-66.7	0.0	0.0	0.0
LSD (0.05)	19.8	16.1	17.7	10.4	12.0	7.8

1. When treatment F tests were significant (p≤0.05), the Fisher's Protected Least Significant Difference Test (LSD) (α=0.05) was used to separate means. NS = not significant. For % TC Change (when significant), the most positive value within a column is shaded blue, while the most negative value within a column is shaded red. Remaining cells are shaded in a blue-purple-red gradient with zero shaded purple. Negative values indicate a reduction in turf coverage of desired species, whereas a positive value means the turf coverage of the plot increased.

Table 3.20 New Jersey Urban – Total living turf cover [Total Cover (TC)] by turfgrass species for Fall 2016, Spring 2017, Fall 2017 and Spring 2018; and percent total cover change from 2016 to 2017 (2016-2017 % TC Change) and percent total cover change from 2017 to 2018 (2017-2018 % TC Change).

	Fall 2016	Spring 2017	2016-2017	Fall 2017	Spring 2018	2017-2018
Turfgrass Species	**Total Cover (TC)[1]**		**% TC Change**	**Total Cover (TC)**		**% TC Change**
Alkaligrass	49.6	42.3	-7.2	30.0	55.7	25.7
Chewings fescue	70.6	21.8	-48.8	18.5	22.5	4.0
Hard fescue	61.0	20.7	-40.3	15.6	27.2	11.7
Kentucky bluegrass	31.2	9.1	-22.2	8.3	19.2	11.0
Mixture	65.9	45.1	-20.9	41.7	60.2	18.5
Perennial ryegrass	92.8	74.9	-17.9	30.4	43.5	13.0
Sheep fescue	67.6	21.3	-46.3	15.4	23.7	8.3
Slender creeping red fescue	79.2	47.9	-31.3	44.0	55.3	11.3
Smooth bromegrass	87.2	62.8	-24.5	31.7	41.7	10.0
Strong creeping red fescue	68.3	28.3	-40.0	19.4	32.6	13.1
Tall fescue	69.8	51.5	-18.3	47.4	60.9	13.5
Tetraploid perennial ryegrass	80.0	47.8	-32.2	32.2	29.5	-2.8
LSD (0.05)	14.5	19.4	17.8	23.8	27.0	15.5

1. When treatment F tests were significant (p≤0.05), the Fisher's Protected Least Significant Difference Test (LSD) (α=0.05) was used to separate means. NS = not significant. For % TC Change (when significant), the most positive value within a column is shaded blue, while the most negative value within a column is shaded red. Remaining cells are shaded in a blue-purple-red gradient with zero shaded purple. Negative values indicate a reduction in turf coverage of desired species, whereas a positive value means the turf coverage of the plot increased.

Table 3.21 Wisconsin Rural – Total living turf cover [Total Cover (TC)] by turfgrass species for Fall 2016, Spring 2017, and Fall 2017; and percent total cover change from 2016 to 2017 (2016-2017 % TC Change).

	Fall 2016	Spring 2017	2016-2017	Fall 2017
Turfgrass Species	Total Cover (TC)		% TC Change	Total Cover (TC)
Alkaligrass	11.0	34.9	23.9	11.8
Chewings fescue	58.1	39.3	-18.8	10.0
Hard fescue	42.9	51.4	8.6	13.1
Kentucky bluegrass	19.8	23.2	3.3	11.2
Mixture	47.3	36.3	-11.1	17.6
Perennial ryegrass	69.6	40.4	-29.1	8.0
Sheep fescue	41.7	41.5	-0.2	13.9
Slender creeping red fescue	62.6	51.4	-11.3	18.8
Smooth bromegrass	35.6	21.1	-14.4	0.6
Strong creeping red fescue	58.3	43.9	-14.5	23.4
Tall fescue	55.5	26.6	-28.9	9.4
Tetraploid perennial ryegrass	73.9	50.0	-23.9	12.2
LSD (0.05)	15.7	14.9	15.8	NS

1. When treatment F tests were significant (p≤0.05), the Fisher's Protected Least Significant Difference Test (LSD) (α=0.05) was used to separate means. NS = not significant. For % TC Change (when significant), the most positive value within a column is shaded blue, while the most negative value within a column is shaded red. Remaining cells are shaded in a blue-purple-red gradient with zero shaded purple. Negative values indicate a reduction in turf coverage of desired species, whereas a positive value means the turf coverage of the plot increased.

Table 3.22 Wisconsin Urban - Total living turf cover [Total Cover (TC)] by turfgrass species for Fall 2017 and Spring 2018; percent total cover change from 2017 to 2018 (2017-2018 % TC Change).

	Fall 2017	Spring 2018	2017-2018
Turfgrass Species	**Total Cover (TC)[1]**		**% TC Change**
Alkaligrass	22.9	67.2	44.4
Chewings fescue	46.5	81.8	35.3
Hard fescue	39.2	84.4	45.2
Kentucky bluegrass	17.2	57.6	40.4
Mixture	53.9	84.8	30.9
Perennial ryegrass	84.8	94.9	10.1
Sheep fescue	40.9	83.3	42.4
Slender creeping red fescue	50.6	86.5	36.0
Smooth bromegrass	64.4	88.9	24.5
Strong creeping red fescue	52.1	84.6	32.4
Tall fescue	66.4	90.4	24.0
Tetraploid perennial ryegrass	87.2	97.8	10.6
LSD (0.05)	13.6	8.9	12.1

1. When treatment F tests were significant (p≤0.05), the Fisher's Protected Least Significant Difference Test (LSD) (α=0.05) was used to separate means. NS = not significant. For % TC Change (when significant), the most positive value within a column is shaded blue, while the most negative value within a column is shaded red. Remaining cells are shaded in a blue-purple-red gradient with zero shaded purple. Negative values indicate a reduction in turf coverage of desired species, whereas a positive value means the turf coverage of the plot increased.

CHAPTER 4: DISCUSSION

This experiment highlights the importance of multi-location testing and demonstrates the difficulty of roadside turf establishments, as only 6 of the 10 planned sites provided first year data. Delayed establishment due to weather or human interference ultimately affected total accumulated growing degree days (Table 2.4) for these sites, which is an important parameter for turf establishment (Frank et al., 1998). Accumulated growing degree days has been used to predict plant growth and development (Frank et al., 1998) as well as predicting emergence of annual weed populations (Fidanza et al., 1996). Even when adjusting for potential accumulation days (Table 2.4), growing degree days did not adequately explain differences in turf establishment across locations.

Weather may have been a determining factor for cultivar or species mixture composition success at a particular site. In cases where fine fescue entries had higher spring-rated turf coverage over Kentucky bluegrass (MI, MN, NJ Urban, and WI), higher snowfall amounts were more prevalent at these sites. Increased snowfall may have resulted in increased salt usage, a condition under which the fine fescues have been shown to be more tolerant (Friel et al., 2012). Accumulated salts from high road salt use was apparent at the rural site in New Jersey; this site had the highest electrical conductivity of any of the sites (Table 2.3). Our results suggest that high salt sites would benefit from mixtures with high proportions of alkaligrass; for example, the top performing mixtures at the rural site in New Jersey were the two mixtures from Michigan (THV and TUV) both of which contained alkaligrass (Table 2.1). No other mixtures in our study contained alkaligrass.

In several cases, no significant differences for turfgrass entry were detected suggesting that factors other than genetics must be considered. However, several turfgrasses performed well at multiple sites; this was especially the case for the alkaligrass entries. Mixtures that performed well at urban sites often included high percentages of fine fescues, especially *Festuca rubra* ssp.

Because practitioners always plant mixtures of species along roadsides, future studies should test a range of mixtures across the northern U.S. More precise site-specific ancillary data, such as controlled environment screening for salt stress, may prove useful for better understanding why particular entries or species perform better at particular locations.

CHAPTER 5: WEBSITE DEVELOPMENT

We created a website to increase availability of our research results for stakeholders in our partner states, as well as for department of transportation professionals in other northern states. These results can be found at http://roadsideturf.umn.edu/research/regional-roadside-testing-project. The website topics pertaining to the project are:

1. Introduction - http://roadsideturf.umn.edu/research/regional-roadside-testing-project
2. Materials and methods - http://roadsideturf.umn.edu/regional-roadside-testing-materials-and-methods
3. Results - http://roadsideturf.umn.edu/regional-roadside-testing-results
4. Project partners - http://roadsideturf.umn.edu/regional-roadside-testing-partners-and-collaborators
5. Acknowledgements – http://roadsideturf.umn.edu/regional-roadside-mixtures/funding

We will add research results from other roadside projects as they are completed. We will monitor the number of website visits via Google Analytics.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

Establishment of turfgrass entry was highly variable by state or site. Alkaligrasses tended to perform well at most testing locations; however, previous studies have suggested that this grass does not improve mixture performance (Friell et al., 2015) and in non-roadside turf situations has poor persistence (Watkins et al, 2011). Roadsides that are to be established in the northern U.S. in urban environments should be established with a higher percentage of fine fescues, especially either slender or strong creeping red fescues. Future research projects evaluating optimum cultivars, species, or mixtures for roadsides should include multi-site testing. These future studies could be coordinated with the same group of researchers and even expanded to include other interested states. One approach to regular multi-state cultivar testing would be to partner with the National Turfgrass Evaluation Program (ntep.org) to utilize its existing national turfgrass cultivar testing infrastructure. The methods and results described earlier in this report will be useful to any future national testing program.

This multi-state research project is the first to provide participating departments of transportation with unbiased, up-to-date information about the performance of turfgrass cultivars and mixtures used on roadsides in the northern U.S. Based on our results, we recommend the following:

1. Regular, ongoing roadside cultivar evaluation trials should be funded by state departments of transportation. This could be accomplished through a mechanism similar to the funding of this project, or through the National Turfgrass Evaluation Program (NTEP). The NTEP program is funded by fees paid by entry sponsors; since seed companies would stand to gain significant sales if a cultivar performed well in this type of trial, a fee-based system would likely work well. Based on the frequency of new cultivars being brought to the market, a new trial could be established approximately every 5 years.
2. Future studies should include a greater number of species mixtures.
3. On high-traffic roadways where salt loads are high, newer cultivars of alkaligrass should be included in mixtures.
4. In areas where traffic is lower, and aesthetics are important, mixtures with high percentages of fine fescues will generally be the best choice.
5. Perennial ryegrass should be avoided in areas where winter injury is likely due to harsh winters. If the fast germination rate of perennial ryegrass is desired, it should constitute a low (less than 20%) proportion of the mixture.
6. State departments of transportation should continue to investigate best management practices for turf establishment and maintenance to make sure the genetic potential of adapted cultivars is fulfilled.

REFERENCES

Biesboer, D. D., S. Neid, & B. Darveaux. (1998). *Salt tolerance in short-statured native grasses.* MnDOT Office of Research Services, St. Paul, MN.

Brown, R. N., & J. H. Gorres. (2011). The use of soil amendments to improve survival of roadside grasses. *HortScience, 46*, 1404–1410.

Fidanza, M. A., P. H. Dernoeden, & M. Zhang. (1996). Degree days for predicting smooth crabgrass emergence in cool-season turfgrasses. *Crop Science, 36*, 990–996.

Frank, K., R. E. Gaussoin, T. P. Riordan, & E .D. Miltner. (1998). Date of planting effects on seeded turf-type buffalograss. *Crop Science, 38,* 1210–1213.

Friell, J., E. Watkins, & B. P. Horgan. (2015). Cool-season turfgrass species mixtures for roadsides in Minnesota. *Ecological Engineering, 84,* 579–587.

Friell, J., E. Watkins, & B. Horgan. (2012). Salt tolerance of 75 cool-season turfgrasses for roadsides. *Acta Agriculturae Scandinavica, Section B - Soil & Plant Science, 62*, 44–52. doi:10.1080/09064710.2012.678381

Koch, M. J., & S. A. Bonos. (2011). Correlation of three salinity tolerance screening methods for cool-season turfgrasses. *HortScience, 46,* 1198–1201.

Koch, M. J., & S. A. Bonos. (2011). Salinity tolerance of cool-season turfgrass cultivars under field conditions (Online). *Appl. Turf. Sci*. doi:10.1094/ATS-2011-0725-01-RS

Rose-Fricker, C., & J. K. Wipff. (2001). Breeding for salt tolerance in cool-season turf grasses. *Int. Turfgrass Soc. Res. J., 9*, 206–212.

Watkins, E., S. Fei, D. Gardner, J. Stier, S. Bughrara, D. Li, …. and K. Diesburg (2011). Low-input turfgrass species for the north central United States. *Appl. Turf. Sci.* doi:10.1094/ATS-2011-0126-02-RS