

Halophyte Resilience to Roadside Salinity in Urban Southeastern Michigan

By

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Abstract

For the past 70 years, municipalities in southeastern Michigan have used chloride as a deicer in winter months. This has resulted in increasing soil salinity and halophytes (salt tolerant plants) proliferating along roadsides. Three halophytes that have taken root in Michigan are common mugwort (*Artemisia vulgaris*), *Bassia scoparia*, and seaside goldenrod (*Solidago sempervirens*) were studied along with Canada goldenrod (*Solidago canadensis*) as a control. Roadside soil was collected to measure its sodium content, texture, moisture content, organic matter content, and pH. The sodium content of the halophytes stems, roots leaves, secondary stems, fruits, and flowers were also measured. Results have demonstrated all three species have adapted to saline environments as included halophytes. The perennials seaside goldenrod and common mugwort were found to have contained more sodium than the annual *Bassia scoparia*. Sequestered sodium was highest in the leaves and stem of the seaside goldenrod, the secondary stems of common mugwort, and the fruit or leaves of *Bassia scoparia*. Soil sodium content was highest at soil by highways and lowest in residential areas. Additionally, salinity is affected by moisture content and soil texture. Lastly, the sodium content of plants increases with soil salinity. Halophyte sodium content was highest in those collected from roadsides while halophytes growing in soil with no to little salt contain no or little sodium as well. Common mugwort was found growing in soil with the highest salinity measured, seaside goldenrod the second most, and *Bassia scoparia* the least.

Chapter 1 – Introduction

Halophytic plants, or halophytes, are vascular plants that have adapted to live in saline environments. Most halophytic plants are facultative halophytes rather than obligate halophytes and can live in various levels of salinity. Normally, vascular plants that absorb a large amount of salt undergo salt stress, causing physiological processes to break down and stunting growth. Halophytes avoid salt stress through three adaptations: inclusion, exclusion, and extrusion/secretion, with inclusion and extrusion being the most commonly researched adaptations (Chen et al., 2018). When salt enters a salt includer halophyte, it is in an aqueous state and separates into sodium and chlorine ions. These ions are then sequestered within vacuoles which are then transported to one of the halophyte's organs, such as the leaves (Flowers, 1985). The ions later are disposed of through the salt-inducible enzyme Na^+/H^+ antiporter. Salt excluders block salt from entering the plant's tissues through two possible methods. Salt is either prevented from entering the roots or is trapped inside the roots then later sent back into the ground (Chen et al., 2018). Salt extruders, like includers, allow salt to enter the halophytes. With extruders, the salt is excreted out of the leaves, falling to the ground via leaf abscission. In habitats such as salt marshes and mangroves swamps the salt is washed away, preventing its reabsorption by the halophytes (Parida and Das, 2004). In both excluders and includers, Na ions are moved throughout a plant via Na^+ transporters, antiporters, and ion channels (Wu, 2018). Additional adaptations to prevent salt stress are mechanical responses such as cell shape alteration and leaf rolling (Thomas, 1996).

Halophyte adaptations are not limitless, however. If too much salt enters a halophyte at once, its defenses are overwhelmed and it experiences salt stress (Wang, 2015). In recent years, halophytes have been more extensively researched due to the threat of widespread salinization. Unchecked salinization in farmlands and forests leads to crop failure.

With the soil essentially sterilized the land is abandoned, threatening local and potentially global food supplies. Salinization has been exacerbated in recent years due to a combination of human actions and rising sea levels (Daliakopoulos, 2016). The natural salt tolerance of halophytes has led to research on how halophytes can be utilized as alternative food sources,

livestock feed, and remediation (Abd El-Hack, 2018, Hasanuzzaman, 2014, Panta, 2014). Research has even been performed on inoculating non-halophytes with salt-resistant bacteria from halophytes, finding that the inoculation increases salt tolerance in non-halophytes (Komaresofla, 2019). It is important to study salinization in the big picture, but research can also be gleaned by studying small-scale salinization.

1.1 History of High Salinity Environments in Michigan

One of Michigan's many natural communities is that of inland salt marshes. Inland salt marshes are located in areas with Silurian and Devonian halite deposits and brine aquifers that seep to the surface. Both environmental features have resulted in high-salinity environments. As most vascular plants are unable to tolerate such a high-saline environment, halophytes dominated inland salt marshes (Kost et al., 2017). Halophytes in Michigan are either native, distributed by migratory birds from the east coast, or accidentally introduced by humans (Panta, 2014, Ogle, 1981, Reznicek, 1980). At present, however, nearly every Michigan inland salt marsh has been destroyed through human actions.

During the mid-19th century, a salt industry developed around Michigan's brine aquifers. Salty brine was extensively pumped aboveground to be converted into salt for food (Winchell, 1861). The unchecked salt removal eventually dried up the brine aquifers, killing off salt marshes. Concomitant with 20th century urbanization, Michigan's inland salt marshes have declined. The only extant Michigan salt marsh is along Maple River in Clinton County (Chapman et al., 1985). However, in recent decades a new high saline environment has emerged in Michigan: urban roadsides.

Several decades ago Detroit and other cities began to spread salt as a de-icer to prevent motor vehicle accidents, a practice which continues to this day. After the salt melts the snow and ice, traffic splashes water onto the roadside. The salt-laced meltwater flows down to lower elevations and ditches, increasing the nearby soil's salinity. With each passing year the salinity of roadside soil increases (Reznicek, 1980). For the most part, ecosystems near the roadsides have been negatively impacted with the additional salt disrupting the ecosystem (Findlay and Kelly, 2011). After low salt tolerant plants died off from the road salt, a new vegetative community arose in its place. As a result of years of road salting vascular halophytes and other salt tolerant plants have proliferated by roadsides (Reznicek, 1980). These roadsides have become an ideal testing ground for the effects of salt on roadside ecosystems. Three halophytic

plants found by Michigan's roadsides are the common mugwort, *Artemisia vulgaris*, Mexican fireweed or burning bush, *Bassia scoparia*, and seaside goldenrod, *Solidago sempervirens*.

1.2 Physiology and Natural History of Common Mugwort, *Artemisia vulgaris*

Common mugwort (*Artemisia vulgaris*), or mugwort for short, is a perennial plant native to Eurasia and Indo-China that can grow up to 2.5 m (Ekiert et al., 2020). Mugwort has been found to have high plasticity, with even mugwort individuals found in the same locations exhibit variable morphologies. Mugwort has several diagnostic traits for identification, most prominently its leaves have a wooly abaxial surface. The lower leaves are also dissected and give off an intense odor when crushed (Figure 1, Weston, 2005). It is unknown which method common mugwort uses in order to avoid salt stress, but it is known the species is highly salt tolerant with absorbed sodium concentrated in the roots and middle leaves. In addition, common mugwort organs were found to contain less Na⁺ than the organs its relative *Artemisia scoparia* when both species were undergoing salt stress (Guan et al., 2013).



Figure 1. Common mugwort (*Artemisia vulgaris*). Reznicek et al., 2011 a.

Artemisia vulgaris in the United States are concentrated in the Midwest, Southwest, Northeast, and Pacific Northwest. Only a few states have mugwort colonies which are limited to a few counties each (USDA, Web 1). The first common mugwort sighting in Michigan was in 1886 in Wayne County (Reznicek et al., 2011 a). Currently, the Michigan mugwort community

is concentrated in the southeast section of the lower peninsula and across the upper peninsula (Figure 2, Reznicek et al., 2011).

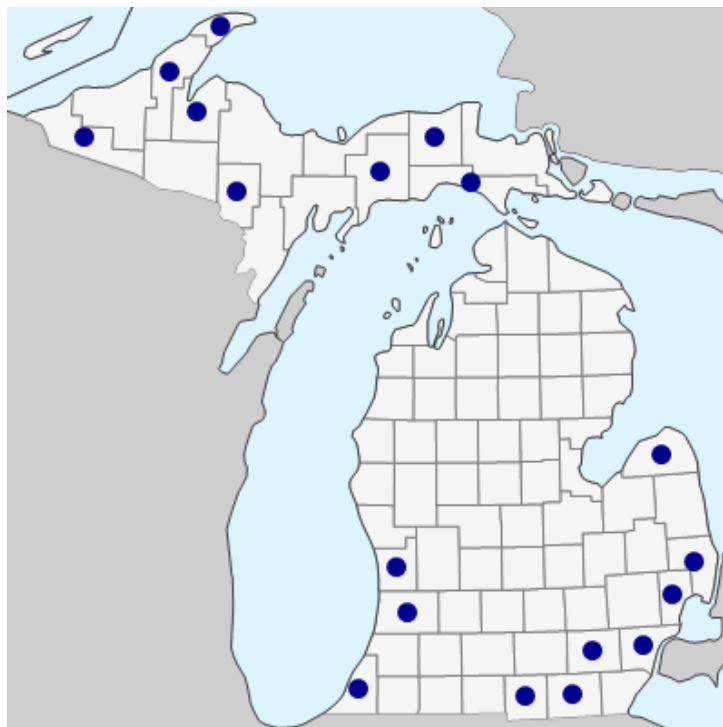


Figure 2. The distribution of common mugwort in Michigan. Reznicek et al., 2011 a.

The invasive nature of mugwort lies in its rhizomatous root system that renders removal difficult as mugwort can regrow from even transplanted soil. Besides a recalcitrant root system, Mugwort's allelopathy makes it major threat to native and cultivated crops due its allelopathic nature. Local plant life diversity declines due to native species competition with mugwort. (Weston et al., 2005).

1.3 Physiology and Natural History of Burning Bush, *Bassia scoparia*

Bassia scoparia, or burning bush, is an erect, annual, forb native to Asia with wild and domestic breeds. Its resilience to extreme environments, such as high salinity soil and roadside temperatures, has allowed it to spread outside its native range (USDA, 2010). *Bassia scoparia* has several traits for identification, most prominently the red shade its stems assume as it matures. The leaves are randomly set, linear, grow up to 2 inches, and hairs appear as *Bassia scoparia* ages. Additional traits are leaf-like green bract flowers, tiny fruits with a black or brown oval seed within and a spike. The shape or growth habit of *Bassia scoparia* depends on its environment (Figure 3, USDA, 2010). It is also known the species can grow up to a foot (Scott,

n.d.). Currently, it is unknown how *Bassia scoparia* adapts to a saline environment whether as an excluder, include, or extruder. However, one of the goals of this project is to determine how the species adapted to high-salinity environments.



Figure 3. *Bassia scoparia*. Reznicek et al., 2011 b.

The first *Bassia scoparia* sighted in Michigan was in Wayne County in 1917. Other communities did not appear in other counties, primarily in Southern Michigan, until years later (Reznicek et al., 2011 b). According to Reznicek et al., 2011 b, the populations in Michigan are concentrated in the southeast section of the state (Figure 4).

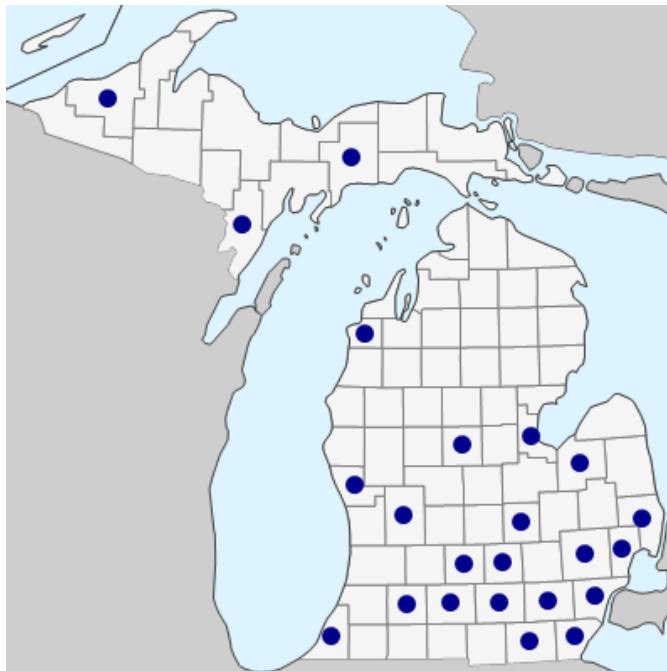


Figure 4. The distribution of *B. scoparia* in Michigan. Reznicek et al., 2011 b.

Bassia scoparia are a threat to invaded ecosystems because it is both highly adaptable and its allelopathy. Specimens have been found to rapidly evolve resistance to common herbicides (Varansi 2015). Livestock that overgraze *Bassia scoparia* have died from its toxins (Friesen et al., 2008). While *Bassia scoparia*'s is toxic, livestock can eat it in small amounts and not all competing plants are killed off (Karachi, 1987, Madrid, 1996). However, as *Bassia scoparia* grows in normally inhospitable environments, specimens are unlikely to harm native salt intolerant species.

1.4 Physiology and Natural History of Seaside Goldenrod, *Solidago sempervirens*

Seaside goldenrod (*Solidago sempervirens*) is a perennial native to the salt marshes and sand dunes of the United States east coast. The species has since spread inland to high saline areas at the shorelines along the Great Lakes in both the United States and Canada (Leonard, et al., 2015, USDA, 2014). Seaside goldenrod can be easily identified by the ray florets being yellow with a tint of orange. Its erect stems can grow from 0.4 to 2.5 meters tall. The structure of the leaves is simple and the blades oblanceolate (Figure 5, Leonard et al., 2015). In seaside goldenrod ions are stored in vacuoles and sequestered. For this reason, one goal of the project is to determine the distribution of sodium among the plant's organs and tissues.



Figure 5. Seaside goldenrod (*Solidago sempervirens*). Reznicek, et al. 2011 d.

The first seaside goldenrod specimen to be found in Michigan was in Wayne County in 1978 (Reznicek et al., 2011 d). Specimens are primarily concentrated in Michigan's southeastern counties and one county to the southwest along Lake Michigan (Figure 6). While seaside goldenrod displays allelopathy on grasses, it is not considered a threat to low salt ecosystems (Leonard et al., 2015).

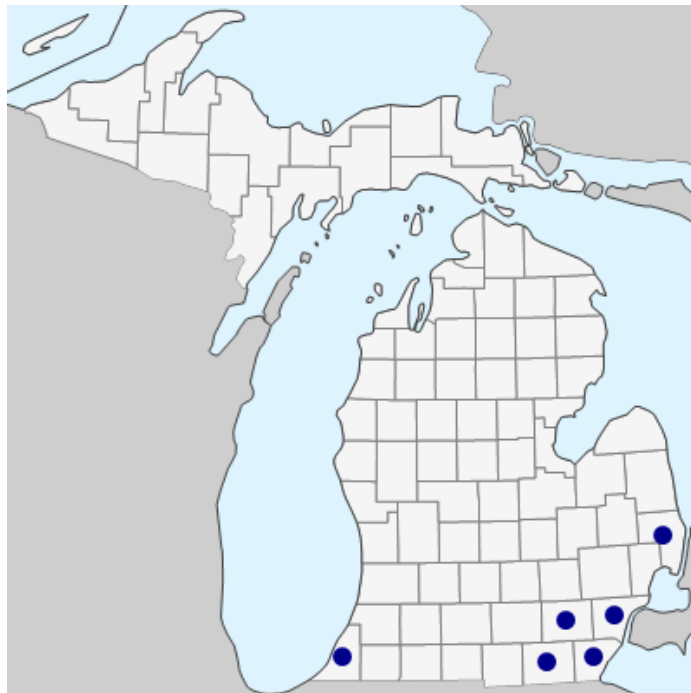


Figure 6. The distribution of seaside goldenrod in Michigan. Reznicek, et al. 2011 d.

1.5 Physiology and Natural History of Canada Goldenrod, *Solidago canadensis*

Canada goldenrod (*Solidago canadensis*) is a perennial plant native to Mexico, Canada, and the eastern and southern United States whose native range is between the latitudes of 26°N and 65°N. The species has since spread from its native range to both the western US and other continents (Parker and Popay, 2014). The flowers of Canada goldenrod are yellow like seaside goldenrods and its smooth stems can 0.3 to 2.1 meters tall. Unlike the smooth leaves of seaside goldenrod, Canada goldenrod leaves are lanceolate and sharply toothed (USDA, 2012). Seaside goldenrod is a close relative of the Canada goldenrod, with the two species capable of hybridizing. Canada goldenrod was chosen as a control due this relationship, the species being known to grow by roads, and that Canada goldenrod grows on campus. (Parker and Popay, 2014).



Figure 7. Canada goldenrod (*Solidago canadensis*) Reznicek et al., 2011 c.

Canada Goldenrod is an abundant species in open fields and rain gardens at the University of Michigan-Dearborn. Additionally, Canada goldenrod can be found in nearly all of Michigan's counties across various ecosystem, with the population concentrated in the southeastern portion of the state. (Reznicek et al., 2011 c). In countries which introduced Canada goldenrod as an ornament, it is considered invasive due to its allelopathy, rhizomatous root system, and being able to outcompete native plants. Additionally, patches of land in Europe dominated by Canada goldenrod were found to result in lower insect diversity (Parker and Popay, 2014).

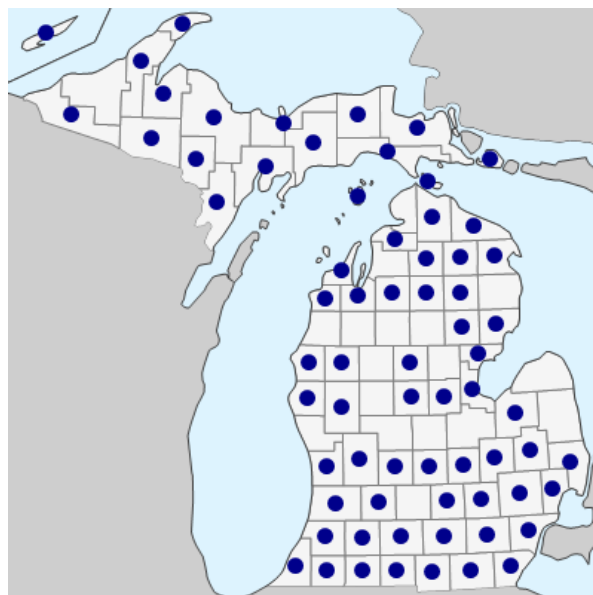


Figure 8. Canada goldenrod distribution in Michigan. Reznicek et al., 2011 c.

1.6 Goals of the Project

Roadsides may increase in salinity each year due to yearly salting if the salt does not percolate through the soil. Nevertheless, if this annual process is uninterrupted, salt-intolerant plants would likely die off, leaving only salt-tolerant plants. However, salinity may increase in soils with low percolation to a degree such that even halophytes cannot survive, leaving the area barren. Salinization of soils is one of the numerous environmental issues facing the 21st century, especially agricultural lands. Soil salinity of southeastern Michigan soil and sodium distribution in three invasive halophytes were measured to review how Michigan's road salt procedures may promote intrusion and dominance of invasive salt tolerant species.

The research project has three goals. First, collect soil samples near the beforementioned halophytes in Detroit and Dearborn, Michigan to measure soil sodium content along with other variables to determine the soil conditions the three species can grow in. In addition, find if salinity affects or is affected by other environmental factors. Second, determine whether the three halophytes are excluders, extruders, or includers by measuring the sodium content of the halophytes' organs and determine the distribution of sodium throughout the plants. Third, compare the soil and total plant sodium content to determine how salinity affects plant sodium content.

Chapter 2 - Methods

2.1 Acquiring Samples

Plant and soil samples were acquired along roadsides and intersections in Dearborn and Detroit, Michigan. Seaside goldenrod was collected alongside Edward N Hines Drive between West Outer Drive and the Parkland Picnic area (Hines Drive and Outer Drive). Mugwort was collected at South Junction Street and Driggs Street (Junction and Driggs), South Fort Street and Oakwood Boulevard (Fort Street and Oakwood) in Dearborn and Schaefer Highway and Greenfield Road (Schaefer and Greenfield) in Detroit. *Bassia scoparia* was collected at Wyoming Avenue and CSX railway (Wyoming and CSX), West Fort Street and Dragoon Street (Fort Street and Dragoon), and South Junction Street and West Jefferson Avenue (Junction and Jefferson). Canada goldenrod, a non-halophyte, was collected at the U of M Dearborn (UM-D) Environmental Interpretive Center South Rain Garden (EIC Rain Garden) and along the nearby Fair Lane Drive to serve as controls. The roadside and urban plant and soil samples were located and collected within a maximum distance of 0.6 m from the road, the rain garden samples 12 m from the road, and the Fairlane Drive samples 4 m from the road. Additionally, the Schaefer and Greenfield sites contained nearby gravel, the Fort Street and Dragoon soil was only about 10 cm deep and at the edge of a sidewalk, the Junction and Driggs samples were also by a sidewalk, and a fence was situated between the Junction and Jefferson soil and the intersection.

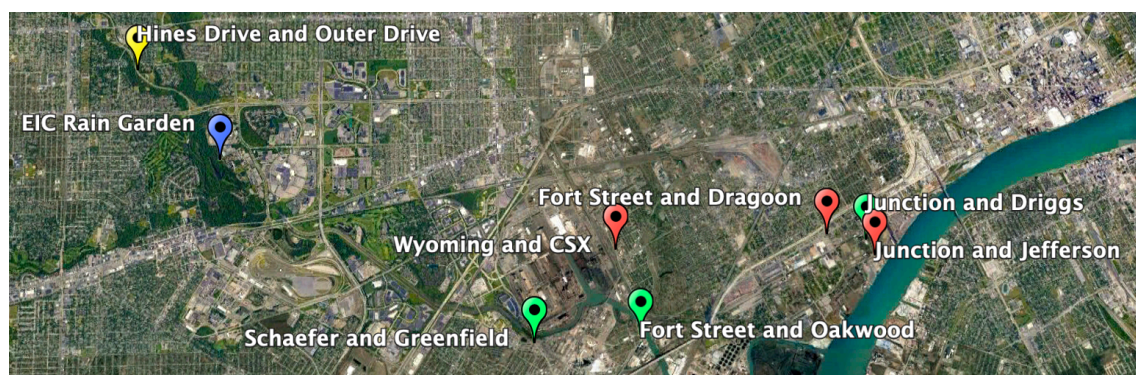


Figure 9. The locations of the collection sites in Dearborn and Detroit. Blue represents Canada goldenrod sites, yellow seaside goldenrod sites, green common mugwort sites, and red *B. scoparia* sites. Created from Google Earth Pro.



Figure 10. Some of the sites where soil and plants were collected. The Environmental Interpretive Center Rain Garden (1), Fairlane Drive (2), Hines Drive (3), Fort Street and Dragoon (4), and Wyoming and CSX (5).

Soil samples were collected with a bucket auger at various depths depending on when the auger encounters an impenetrable material at a specific site. The samples were labeled according to site locations and depth and stored in labeled Ziploc bags. A 0.3 m deep sample of soil was collected at each site. If the bucket auger encountered concrete or rocks additional sediment was collected nearby. Plants were cut off from the stem at around 15 cm above the ground. If possible, soil that stuck to roots was stored in bags as well. After collection, plants from the same site were bound together with tape to prevent samples from being mixed-up.

2.2 Preparation of Soil Samples for Analysis of Soil Classification, Soil Moisture, Soil Organic Matter Content, and pH

Soil was sieved to remove any rocks, roots, and other debris prior to preparing the soil for analysis, with at least 120 grams collected from each sample. Plant organs were dried in a drying oven set to 60°C for two days prior to being pulverized or chopped up for sodium analysis (Heald, 1965).

The following organs were analyzed for sodium or chloride content: roots, lower and middle leaves, upper leaves, stems, secondary stems, fruits, and flowers. If both fruits and flowers were present on a plant the organs were separated. Each organ type was stored in Ziploc bags labeled with organ type and site location.

2.3 Soil Analysis for Sand, Silt, and Clay

The percentage of sand, silt, and clay in soil was determined by a method called mechanical analysis using a hydrometer. Particles suspended in water settle differentially depending upon the amount of surface per unit volume. Clay particles have a high amount of surface area per unit volume and settle slowly, while sand particles settle rapidly because of their low specific surface. In this method, the Bouyous method, the amount of particulate matter in suspension is determined by using a hydrometer to measure the density of the suspension.

Fifty grams of soil and 50 ml of 5% (w/v) sodium hexametaphosphate were poured into a vegetable blender filled a third of the way with reverse osmosis (RO) water. The 5% sodium hexametaphosphate was acquired through mixing 50 grams of Calgon™ and 1,000 mL of water in a flask. The vegetable blender was set to the lowest setting and ran for five minutes, after which the mixture was poured into a graduated cylinder. Additional RO water was poured into the 1,000 mL graduated cylinder until it read 1,000 mL. The graduated cylinder was then tilted and shaken until all sediment was suspended in water. A Bouyous hydrometer measured in

percentages was gently inserted into the graduated cylinder and the reading at forty seconds was recorded as a measure of percentage of silt and clay remaining in suspension after the sand settled. After two hours the hydrometer was read again to record the percentage of clay in the sample. As the hydrometer was designed to measure soil composition of 100 g soil samples the percentages were multiplied by two. Soil texture was determined through the inputting the soil percentages into an online soil calculator (USDA, 2021).

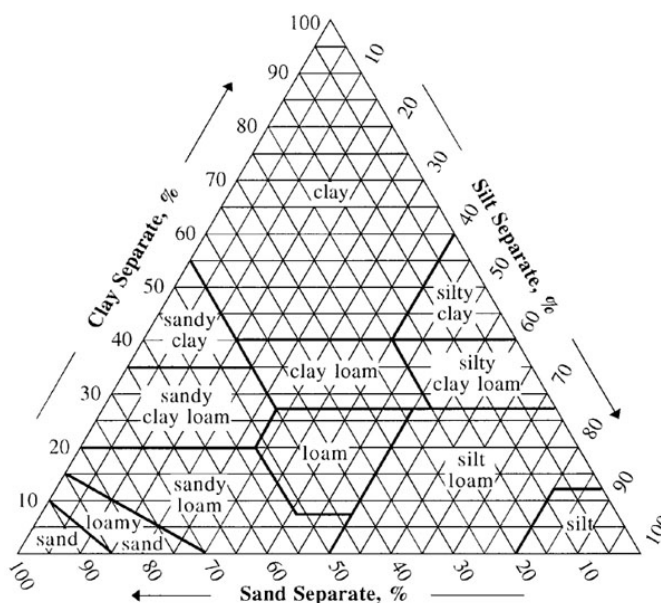


Figure 11. The soil texture pyramid. Data was taken from the hydrometer readings. For example,, a sample from the UM-D rain garden, the soil reading was 20% clay, 10% sand, and 70% silt, making the soil mostly silt loam. USDA 2021.

2.4 Soil Moisture Analysis

Around 300 to 800 grams of soil from each sample were placed within pre-weighed beakers. Weight was measured with a Mettler balance to a tenth of a gram. The soil was then placed in a drying oven set to 60°C for at least two days to dry out the soil. After removal from the furnace the beakers and soil were weighed again to determine moisture loss. The dried soil was then pulverized for other forms of soil analysis.

2.5 Soil Organic Matter Analysis

Fifty grams of soil were placed in a pre-weighed porcelain evaporating dishes. The dishes were then placed within a muffle furnace set to 600 °C for at least two days to combust the organic matter. The crucibles were weighed, and the weight of the evaporating dish subtracted to determine the percentage of organic matter.

2.6 Soil pH Analysis

Ten grams of soil and 25 ml of water were placed into a 50 mL beaker. A glass stirring rod was used to mix the soil and water until all the soil particles suspended in the water. pH value was measured through an Oaklon pH/mV/degree C meter. A pH value was determined when the pH measurements came to equilibrium.

2.7 Plant Organ Ashing

Preparation for analysis of sodium content began with ashing the plant organs, based on a modified protocol of Nerdy (2018). Plant organs were placed in porcelain crucibles cleaned with isopropyl alcohol and weighed. Organ samples were placed into the crucibles and weighed in a tared analytical balance. The samples were then inserted into a drying oven set to 80°C for twenty or more hours to remove moisture. A Thermolyne© model muffle furnace was heated to 200°C two to three hours prior to placing with crucibles with plant organs inside. After placing the porcelain crucibles into the furnace, it was set to 300°C. The furnace door was left partially open so smoke could escape. Three hours later the door was fully closed and the temperature was increased to 500°C. The organs were left in the oven for 20 or more hours. The crucibles and ashed contents were weighed to determine the quantity of ash available for analysis. After the ash was collected, it was stored inside labeled Ziploc bags and the porcelain crucibles were again cleaned with isopropyl alcohol.

2.8 Preparation of Soil for Sodium Analysis by Atomic Absorption Spectrophotometry

Analysis of soil for sodium was based on and modified from the procedure of Ward et al., (2016). Approximately 0.5 grams of dried and decarbonated soil were placed in pre-weighed 15 mL polypropylene tubes and weighed on a DeltaRange© analytic balance. A volumetric pipet was then used to transfer 2 mL of 6 M HCl (Fisher trace-metal grade) into the centrifuge tube. The tubes were vigorously shaken to extract sodium from the soil. As sodium is a soluble element, no further treatment of the soil was need. Up to six tubes were placed in a Fisher Scientific© Centrifuge and centrifuged for five minutes at 10,000 rpm to eliminate particles in the supernatant. Using a transfer pipet, approximately 1 mL of the supernatant was placed into a 50 mL pre-zeroed polypropylene centrifuge tube then diluted with approximately 49 mL of reverse osmosis (RO) water. Total solution volume was weighed on the analytical balance. The final concentration of the HCL was 0.24 – 0.26 M. During method development, it was found that due to high ionization of sodium in the samples, a modifier was required to deionize the

solutions. According to the recommended sodium conditions on the Perkin Elmer Syngistix software for AA (Version 3), an “alkali salt or lanthanum (0.1-1%) must be added to control ionization.” To do so a 10% lanthanum solution consisting of lanthanum chloride heptahydrate ($\text{LaCl}_3 \cdot 7\text{H}_2\text{O}$) was prepared with 0.24 M HCl. The soil extract was then diluted 9:1 with the lanthanum solution so it can be run on the atomic absorption spectrophotometer.

2.9 Preparation of Plant Ash for Sodium Analysis by Atomic Absorption Spectrophotometry

Atomic absorption spectrophotometer analysis of plant ash was based off of Rowan (et al., 1982). The plant ash was prepared for AA analysis with the same tools and equipment used to prepare soil for AA analysis with some modifications.

Up to approximately 0.3 g of an ash sample was placed pre-zeroed 15 mL polypropylene centrifuge tubes and weighed on an analytical balance. Not all plant organs could be analyzed due to high carbon content that was combusted during the ashing procedures. Since starting materials were significantly lower in mass compared to the soil samples, steps were taken beforehand to reduce the number of transfers and dilutions. One change was that a 1.5% La solution was prepared beforehand using the 6 M HCl used for extraction by mixing 253 mL of deionized water, 247 mL of concentrated HCl, and 13.38 g of $\text{LaCl}_3 \cdot 7\text{H}_2\text{O}$. An Eppendorf volumetric pipet was used to transfer 0.625 mL of the 6 M HCl/1.5% La solution (Fisher trace-metal grade) centrifuge tube and allowed to react. Reactions observed included smoke emitting from the ash and bubbling. The tubes caps were screwed back on after the reactions stopped. The centrifuge tubes were zeroed on the analytical balance, diluted with 14-15 mL of RO water and reweighed to determine the solution's exact mass. The tube was vigorously shaken to extract sodium from the soil. The tubes were then centrifuged for five minutes at 10,000 rpm to remove particles in the supernatant. Using a transfer pipet, approximately 8-10 mL of the supernatant was transferred to a clean centrifuge tube and analyzed. If a sample exceeded the calibration curve the solution was further diluted. Using an Eppendorf pipet, 0.4 mL of the lanthanum extract then 1 mL of the solution into a 15 mL polypropylene tube. Next, RO water was poured into the tube until it read 10 mL.

2.10 Flame Ionization Atomic Absorption (FIAA)

The soil and plant extracts were analyzed on a Perkin Elmer 900 T flame Ionization AA Spectrophotometer. A large burner head was set at 45° to increase the analytical dynamic range. Default sodium analysis values as determined by the AA's Syngistix software. A sodium hollow cathode lamp was used to measure sodium content. To accurately determine sodium content, the wavelength emitted by the flame was set to 589.000 nm and the slit width to 0.2 nm. Time parameters were set with a time of 3 seconds and a delay time of 3 seconds. Other parameters were an oxidant flow (Air) set to 10 L/min and acetylene flow at 2.5 L/min. Samples were read thrice as ppm and averaged.

2.11 Calibration Curve Development

During method development and testing and shifting the angle of the burner head, the dynamic range of sodium of the AA was found to be approximately 0-75 mg Na/L. A 1,000 mg Na/L (ppm) stock solution was created by measuring approximately 2.542 g of Puratronic© 99.998 % (metal basis) NaCl and diluting it with 1 L of RO water in an analytically clean volumetric flask (Rowan et al., 1982). The solution was then transferred into a clean 1 L polypropylene bottle to prevent sodium from leaching from the sodium borosilicate glass from the volumetric flask. Glass containers were avoided whenever possible to avoid contamination (Rowan et al., 1982). Sub-standards were created through diluting the stock solution with 0.24 M HCl to closely matrix-match the samples. Individual standards were prepared gravimetrically by using an analytical balance to accurately determine concentrations. Concentrations were calculated through the formula $C_1M_1=C_2M_2$ where C_1 represents the concentration of the stock solution, M_1 was the stock solution's mass, C_2 is the concentration of the new standard, and M_2 is the mass of the new standard. C_1 , C_2 , and M_2 are user-defined so that M_1 is calculated. Approximately 50 mL of each calibration standard was made and later modified through the addition of the lanthanum modifier. A 9/1 dilution of standard lanthanum was used. Concentrations were adjusted with the added dilution of the lanthanum modifier by multiplying by 0.9. The calibration curve solutions diluted from the original 1,000 ppm solutions were approximately 0.9506 (1 ppm), 2.9528 (3 ppm), 4.8836 (5 ppm), 6.7521 (7 ppm), 10.8696 (10 ppm), 27.4508 (25 ppm), 63.6305 (50 ppm), and 80.2116 (75 ppm) ppm.

The sodium soil calibration curve was created through the 0, 1, 3, 5, 7, and 10 ppm standards and the plant ash calibration curve through the 0, 5, 10, 25, 50 and 75 ppm standards,

with the 5 solution unused for twice diluted plant ash samples (Table 1). The energy of the lamp was checked every six samples to see if it has dropped. If the plant ash readings vastly exceeded the calibration curve the solutions were further diluted. Using an Eppendorf pipet, 0.4 mL of the lanthanum extract were transferred into a 15 mL polypropylene tube, then 1 mL of the solution was transferred as well. RO water was then squirted into the test tube until it read 10 mL. If the twice diluted solution did not detect any sodium, the initial reading was used.

Table 1a. The calibration curve solutions for soil sample analysis Na⁺ concentration and absorption.

Soil Calibration Curve Sample	Na ⁺ Concentration (ppm)	Absorption
0 ppm	0	0
1 ppm	0.9506	0.0415
3 ppm	2.9528	0.086
5 ppm	4.8836	0.1288
7 ppm	6.7521	0.1703
10 ppm	10.8696	0.2617

Table 1b. The calibration curve samples for plant ash sample analysis Na⁺ concentration and absorption.

Plant Ash Calibration Curve Sample	Na ⁺ Concentration (ppm)	Absorption
0 ppm	0	0
5 ppm	4.8836	0.1288
10 ppm	10.8696	0.2617
25 ppm	27.4508	0.6298
50 ppm	63.6305	1.433
75 ppm	80.2116	1.801

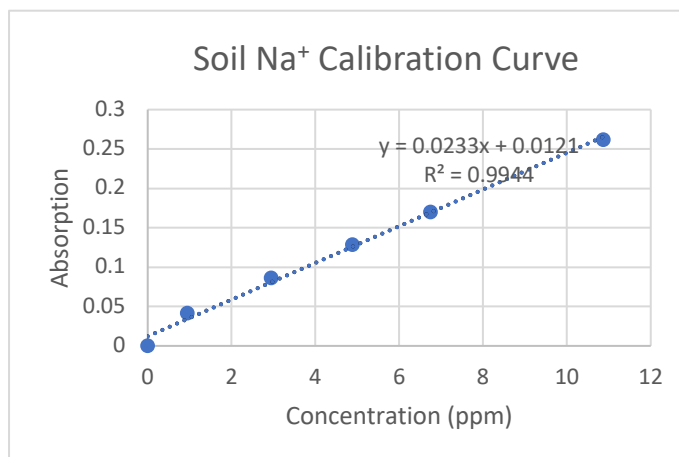


Figure 12a. The calibration curve, linear equation, and coefficient of determination for soil Na⁺ (left) and plant ash Na⁺ analysis (right).

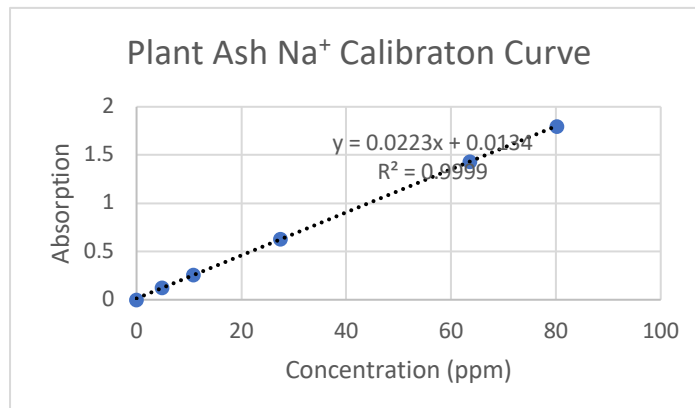


Figure 12b. The calibration curve, linear equation, and coefficient of determination for plant ash Na⁺ analysis.

2.12 Calculation of Actual Concentration

The sodium in ppm read by the AA was not the actual concentration of the soil and plant organs, rather it is the value after several dilutions. The actual concentrations of the samples were found with the following equations:

$$\text{Concentration of Sodium Ions in Soil} = R \times 10 \times D \times 2 \div 1 \div E \div S$$

Where R is the raw mean (ppm); 10 is the lanthanum added (mL); D is the solution weight after dilution; 2 is the HCl added (mL); 1 is the lanthanum spike added (1 mL); E is the extract weight (g); and S is the soil weight (g).

$$\text{Concentration of Sodium Ions in Plant Organs} = R \times A \div W$$

Where C is the concentration of sodium ions in the plant organs; R is the raw mean (ppm); A is the weight of plant ash (g); and W is the weight of the total solution (g).

For plant ash solutions with two solutions the value was calculated with mean raw ppm (ppm) * ash weight / total solution weight (g) * 10 mL / 0.4 mL.

$$\text{Concentration of Sodium Ions in Plant Organs} = R \times A \div W \times 10 \div 0.4$$

Where R is the raw mean (ppm); A is the weight of plant ash (g); W is the weight of the total solution; 10 is the total amount of the second dilution solution (mL); and 0.4 is the lanthanum added to the second dilution (mL).

Chapter 3 – Results

3.1 Analysis of Soil Classifications (Appendix B)

Table 2. The types of soil found and the locations the samples were found in.

Sand	Loamy Sand	Sandy Loam	Sandy Clay Loam
5	15	30	3
Fort St. and Dragoon, Junction and Jefferson	Hines and Outer Drive Site 3, Fort St. and Dragoon, Fort St. and Oakwood, Junction and Driggs, Junction and Jefferson, Schaefer and Greenfield, Wyoming and CSX	Fairlane Dr., Fort St. and Oakwood, Hines Dr., Hines Dr. Site 1, Hines Dr. Site 2, Hines Dr. Site 3, Schaefer and Greenfield, Wyoming and CSX	Hines and Outer Dr. Site 1, Hines and Outer Dr. Site 2, Hines and Outer Dr. Site 3

Sand was the primary component in all of the 52 soil samples in both roadside and control sites with five determined to be sand, 15 as loamy sand, 30 as sandy loam, and three as sandy clay. The three samples with the largest clay percentage were found in the deepest samples along Hines Drive, a floodplain that was raised with fill to establish the roadway.

Loamy sand and sandy loam soil were found throughout all of the sites, in both urban roadside and control sites. However, a few sites had other soil types. The lowest layers of the Hines Drive soils were sandy clay loam. Nearly all of the Fort Street and Dragoon soil and the upper two layers at Junction and Jefferson were sand (Table 2).

3.2 Analysis of Moisture Content of Soil Samples (Appendix C)

Table 3a. The soil moisture content (M) in percentage of overall weight of the EIC and Fairlane Drive sites by depth.

EIC Rain Garden		Fairlane Drive	
Depth (m.)	Moisture (%)	Depth (m.)	Moisture (%)
0.0-0.12	24.4	0.0-0.10	14.5
0.12-0.23	17.4	0.10-0.15	10.9
0.23-0.27	10.6	0.15-0.23	11.5
Root	5.8	0.23-0.27	9.8
		0.27-0.30	8.7
		Root	17.2

Table 3b. The soil moisture content in percentage of overall weight of the Hines Drive and Outer and Hines Drive sites by depth.

Hines Dr.		Outer and Hines Drive					
Site 1		Site 1		Site 2		Site 3	
Depth (m.)	Moisture (%)	Depth (m.)	Moisture (%)	Depth (m.)	Moisture (%)	Depth (m.)	Moisture (%)
0.0-0.15	15.2	0.0-0.14	24.9	0.0-0.11	24.6	0.0-0.10	26.3
0.15-0.24	16.6	0.14-0.23	14.6	0.11-0.24	14.6	0.10-0.24	19.1
		0.23-0.35	26.0	0.24-0.30	14.8	0.24-0.30	14.6
				Root	35.3	Root	38.9

Table 3c. The mean soil moisture content in percentage of overall weight for the Fort Street and Oakwood sites by depth with the Schaefer and Greenfield sites moisture content listed individually.

Fort St. and Oakwood		Junction and Driggs		Schaefer and Greenfield					
Sites 1 and 2		Sites 1 and 2		Site 1		Site 2		Site 3	
Depth (m.)	M (%)	Depth (m.)	M (%)	Depth (m.)	M (%)	Depth (m.)	M (%)	Depth (m.)	M (%)
0.0-0.15	15.85	0.0-0.14	11.8	0.0-0.08	7.7	0.0-0.09	4.3	0.0-0.09	3.4
0.15-0.23	9.35	0.14-0.30	13.85	0.08-0.15	7.2	0.09-0.15	5.6	0.09-0.15	4.1
Root	13.5			0.15-0.23	13.4	0.15-0.23	11.0	0.15-0.23	8.0

Table 3d. The mean soil moisture content in percentage of overall weight for Fort Street and Dragoon, Junction and Jefferson, and Wyoming and CSX sites by depth.

Fort St. and Dragoon		Junction and Jefferson		Wyoming and CSX	
Sites 1, 2, and 3		Sites 1 and 2		Sites 1 and 2	
Depth (m)	M (%)	Depth (m)	M (%)	Depth (m)	M (%)
0.0-0.09	11.0	0.0-0.20	11.4	0-0.15	16.2
0.09-0.24	7.3	0.20-0.30	9.1	0.15-0.21	14.7
				0.21-0.34	14.2

Moisture content of soil samples varied by site location and depth. Because the samples were collected on different dates, rainfall date and amount may have possibly affected the moisture content.

At the Hines Drive by Outer Drives sites and EIC rain garden, the topmost soil layers moisture content was the largest. Six of the thirteen Hines Drive by Outer Drive sites had the

highest moisture content of all of the sites, with the lowest moisture content there still greater than soil from most of the other sites. Even the moisture content of both layers of the Hines Drive Site was greater than some of the urban sites. Moisture content at each of the three Hines and Outer Drive sites initially decreased by depth, but whether soil moisture content continued to decrease or began to increase varied from site to site. At Hines Site 1 moisture content increased, at Site 2 closer to Outer Drive moisture increased by only 0.2 %, and at Site 3 closest to Outer Drive moisture further decreased.

At urban roadside sites, moisture content was lower than control sites on the UM-D campus and Hines Drive sites. The only exception was at Wyoming and CSX where the maximum moisture was comparable to those from the control and Hines Drive sites. Similar to the control and Hines Drive by Outer Drive sites, moisture content decreased with depth and if it did increase it was by a small margin. The only exception being both Junction and Driggs sites where moisture content increased with depth. Six of the eight Schaefer and Greenfield sites had the driest of the soil samples. Aside from Schaefer and Greenfield Site 1 moisture continuously increased with depth, though at all three sites the deepest layer contained the most moisture. (Table 3).

3.3 Analysis of Soil Organic Matter (Appendix D)

Table 4a. The soil organic matter content (OM) in percentage of overall weight of the EIC Rain Garden and Fairlane Drive by depth.

EIC Rain Garden		Fairlane Drive	
Depth (m.)	Organic Matter (%)	Depth (m.)	Organic Matter (%)
0.0-0.12	14.8	0.0-0.10	9.2
0.12-0.23	8.0	0.10-0.15	7.1
0.23-0.27	5.6	0.15-0.23	6.8
Root	8.3	0.23-0.27	6.6
		0.27-0.30	6.4
		Root	11.5

Table 4b. The soil organic matter content in percentage of overall weight of the Hines Drive and Outer and Hines Drive sites by depth.

Hines Dr.		Outer and Hines Drive					
Site 1		Site 1		Site 2		Site 3	
Depth (m.)	OM (%)	Depth (m.)	OM (%)	Depth (m.)	OM (%)	Depth (m.)	OM (%)
0.0-0.15	7.9	0.0-0.14	10.3	0.0-0.11	10.2	0.0-0.10	10.1
0.15-0.24	7.3	0.14-0.23	5.8	0.11-0.24	7.0	0.10-0.24	7.1
		0.23-0.35	9.2	0.24-0.30	8.0	0.24-0.30	8.2
				Root	11.4	Root	11.6

Table 4c. The mean soil organic matter content in percentage of overall weight for the Fort Street and Oakwood sites by depth with the Schaefer and Greenfield sites moisture content listed individually.

Fort St. and Oakwood		Junction and Driggs		Schaefer and Greenfield					
Sites 1 and 2		Sites 1 and 2		Site 1		Site 2		Site 3	
Depth (m.)	OM (%)	Depth (m.)	OM (%)	Depth (m.)	OM (%)	Depth (m.)	OM (%)	Depth (m.)	OM (%)
0.0-0.15	7.1	0.0-0.14	6.65	0.0-0.08	12.70	0.0-0.09	12.0	0.0-0.09	12.4
0.15-0.23	6.5	0.14-0.30	8.80	0.08-0.15	13.2	0.09-0.15	12.0	0.09-0.15	13.5
Root	8.60			0.15-0.23	8.8			0.15-0.23	12.6

Table 4d. The mean organic matter content in percentage of overall weight for Fort Street and Dragoon, Junction and Jefferson, and Wyoming and CSX sites by depth.

Fort St. and Dragoon		Junction and Jefferson		Wyoming and CSX	
Sites 1, 2, and 3		Sites 1 and 2		Sites 1 and 2	
Depth (m.)	Organic Matter (%)	Depth (m.)	Organic Matter (%)	Depth (m.)	Organic Matter (%)
0.0-0.09	4.87	0.0-0.20	5.6	0-0.15	12.75
0.09-0.24	3.2	0.20-0.30	4.75	0.15-0.21	16.7
				0.21-0.34	18.4

Organic matter among the sites either continuously decreased, initially decreases then slightly increases, or continuously increases with depth. Only at the Junction and Driggs sites did the top layer start with significantly less organic matter than the lower layers.

At the EIC Rain Garden control sites and Fair Lane Drive sites the topmost layers were the second highest in organic matter, with organic matter decreasing with depths. At urban areas and the Hines Drive Sites, organic matter content was lower in content, with organic matter continuously decreasing or decreasing then slightly increasing. The only exceptions were the Wyoming and CSX and Schaefer and Greenfield sites, which contained the most organic matter out of all the urban sites (Table 4).

3.4 Analysis of Soil pH (Appendix E)

Table 5. The mean pH of soil samples from each site.

Location	Mean Soil pH
EIC South Rain Garden	6.8
Fair Lane Drive	7.9
Hines Drive	8.7
Hines Drive by Outer Drive Site 1	8.3
Hines Drive by Outer Drive Site 2	8.6
Hines Drive by Outer Drive Site 3	8.7
Fort Street and Dragoon	8.2
Fort Street and Oakwood	7.7
Junction and Driggs	8.2
Junction and Jefferson	6.7
Schaefer and Greenfield Site 1	7.6
Schaefer and Greenfield Site 2	9.3
Schaefer and Greenfield Site 3	8.6
Wyoming and CSX	8.1

pH of soil across all sites was in a range of 6.1-9.6. Five soil samples had a pH values of 6.1-6.8 or below and 47 soil samples had a pH value of 7.0 or above. Soils at the UM-Dearborn Campus were slightly acidic (6.2-7.1) as was the soil at Junction and Jefferson (6.1-7.1). Soil at the majority of the other sites was more alkaline at around 8 (7.2-8.9), with the Schaefer and Greenfield sites being the most alkaline (7.8-9.6). Fort Street and Oakwood soil was alkaline (7.1-7.9) like other urban areas, but closer to neutral (Table 5)

3.5 Analysis of Soil Salinity (Appendix F)

Table 6a. The soil sodium content of the EIC Rain Garden and Fairlane Drive sites by depth.

EIC Rain Garden		Fairlane Drive	
Depth (m.)	Soil Na ⁺ Content (ppm)	Depth (m.)	Soil Na ⁺ Content (ppm)
0.0-0.12	4.71	0.0-0.10	NDA
0.12-0.23	NDA	0.10-0.15	NDA
0.23-0.27	NDA	0.15-0.23	NDA
Root	NDA	0.23-0.27	NDA
		0.27-0.30	253.9
		Root	NDA

Table 6b. The soil sodium content of the Hines Drive and Outer and Hines Drive sites by depth.

Hines Dr.		Outer and Hines Drive					
Site 1		Site 1		Site 2		Site 3	
Depth (m.)	Soil Na ⁺ Content (ppm)	Depth (m.)	Soil Na ⁺ Content (ppm)	Depth (m.)	Soil Na ⁺ Content (ppm)	Depth (m.)	Soil Na ⁺ Content (ppm)
0.0-0.15	5,341	0.0-0.14	675.1	0.0-0.11	1,949	0.0-0.10	3,042
0.15-0.24	6,955	0.14-0.23	637.2	0.11-0.24	1,319	0.10-0.24	1,531
		0.23-0.35	4,026	0.24-0.30	2,919	0.24-0.30	2,445
				Root	1,920	Root	4,293

Table 6c. The mean soil sodium content for the Fort Street and Oakwood sites by depth with the Schaefer and Greenfield sites moisture content listed individually.

Fort St. and Oakwood		Junction and Driggs		Schaefer and Greenfield					
Sites 1 and 2		Sites 1 and 2		Site 1		Site 2		Site 3	
Depth (m.)	Soil Na ⁺ Content (ppm)	Depth (m.)	Soil Na ⁺ Content (ppm)	Depth (m.)	Soil Na ⁺ Content (ppm)	Depth (m.)	Soil Na ⁺ Content (ppm)	Depth (m.)	Soil Na ⁺ Content (ppm)
0.0-0.15	478.7	0.0-0.14	306	0.0-0.08	4,291	0.0-0.09	10,693	0.0-0.09	1,850
0.15-0.23	2,219	0.14-0.30	919	0.08-0.15	3,355	0.09-0.15	10,870	0.09-0.15	3,288
Root	195.8			0.15-0.23	4,891			0.15-0.23	2,173

Table 6d. The mean soil sodium content for the Fort Street and Dragon, Junction and Jefferson, and Wyoming and CSX sites by depth.

Fort St. and Dragon		Junction and Jefferson		Wyoming and CSX	
Sites 1, 2, and 3		Sites 1 and 2		Sites 1 and 2	
Depth (m)	Soil Na ⁺ Content (ppm)	Depth (m)	Soil Na ⁺ Content (ppm)	Depth (m)	Soil Na ⁺ Content (ppm)
0.0-0.09	363.7	0.0-0.20	NDA	0-0.15	2,763
0.09-0.24	233.5	0.20-0.30	NDA	0.15-0.21	1,002
				0.21-0.34	1,427

All but two of the fourteen soil samples from the EIC Rain Garden, Fair Lane Drive, and Junction and Jefferson sites had no detectable amounts (NDA) of sodium. The only samples with detectable and measurable sodium were the EIC Rain Garden site's 0.0-0.4 ft. soil sample and the Fair Lane Drive site's 0.9-1.0 ft. soil sample. Both of these soil samples were among the lowest recorded sodium ppm values of all the soil samples.

Seven of the eight Fort Street and Dragon and Junction and Driggs soil samples had a sodium content of less than 676 ppm. The exception was the Junction and Driggs Site 2 at 0.45-

1.0 ft soil sample (1,374 ppm). Soil sodium content at the Fort Street and Dragoon decreased with depth. In contrast, soil sodium content at both Junction and Driggs sites increased with depth.

All but two of 25 Wyoming and CSX, Schaefer and Greenfield, Hines Drive and Hines Drive by Outer Drive sites soil samples had more than 1,000 ppm in sodium. While the sodium content of Hines Drive by Outer Drive Site 1 soil samples from 0.0 to 0.75 ft. were less than 1,000 ppm, the 0.75-1.15 ft. samples sodium content significantly spiked. Schaefer and Greenfield soil in particular had the largest recorded levels and range of sodium among the sites.

How sodium levels changed with depth varied from site to site. At Wyoming and CSX site 1, Schaefer and Greenfield Site 1, and Outer and Hines Drive Site 1 sodium content decreased then increased. At Schaefer and Greenfield Site 2, Hines Drive, and Outer and Hines Drive Site 3 sodium soil content increased with depth. At Schaefer and Greenfield Site 3 sodium soil content increased then decreased. At Outer and Hines Drive Site 2 sodium content decreased then increased. The Fort Street and Oakwood sites stood out amongst the sites. Similar to Hines and Outer Drive Site 1, The topmost soil samples had a ppm of less than 1,000, then the following layers spiked in sodium content, though not to the same extent as Outer and Hines Drive Site 1.

In addition, unless the surrounding soil contained no salt, soil attached to the halophyte's roots had detectable sodium. However, sodium content of the upper soil and root soil was not always of equal or similar value. For example, while the upper and root soil of Hines Drive by Outer Drive Site 2 have similar amounts of sodium the nearby Site 3 had a disparity in the sodium content of upper and root soil and. (Table 6).

3.6 Plant Sodium Content (Appendices G, H, I, J, and K)

Table 7a. A summary of the mean sodium content in organs of seaside goldenrods.

Seaside Goldenrod				
Organ	Mean Na ⁺ Content (ppm)	Standard Deviation	Range	Sample Size
Flower and Fruits*	5,991	1,981	NDA-8,587	24
Leaves	12,901	5986	NDA-23,294	26
Stems	16,614	3195	12,385-20,200	13
Roots	2,608	777.0	1,517-3,525	5
Overall Mean	9,528			

* Six fruit and flower samples and four leaf samples were NDA.

Table 7b. A summary of the mean sodium content in organs of common mugworts.

Common Mugwort				
Organ	Mean Na ⁺ Content (ppm)	Standard Deviation	Range	Sample Size
Flower and Fruits*	8,795	3270	NDA-13,685	7
Leaves	7,623	4535	1,705-19,804	20
Secondary Stems	12,877	5625	1,180-17,108	9
Stems	8,246	4,327	3,050-15,767	12
Roots	3,260	985.2	2,076-4,362	4
Overall Mean	8,160			

*Three fruit samples were NDA.

Table 7c. A summary of the mean sodium content in organs of *B. scoparia*.

<i>Bassia scoparia</i>				
Organ	Mean Na ⁺ Content (ppm)	Standard Deviation	Range	Sample Size
Fruits	4,069	4111	412-9,875	5
Leaves	3,380	1,898	384-5,947	10
Secondary Stems	2,826	1157	1,325-3,881	5
Stems	3,317	926.4	2,647-4,864	5
Roots	1,611	866.0	659-2,450	4
Overall Mean	3,041			

Table 8. The mean total sodium content of the halophytes and the soil sodium content range of each site.

Location	Plant	Mean Total Sodium of All Samples Per Site (ppm)	Soil Sodium Content Range (ppm)
EIC South Rain Garden	Canada Goldenrod	NDA	0-4.714
Fair Lane Drive	Canada Goldenrod	2,152	0-253.9
Hines Drive*	Seaside Goldenrod	112,870	5,341-6,955
Hines Drive by Outer Drive Site 1	Seaside Goldenrod	36,613	637.2-4,026
Hines Drive by Outer Drive Site 2	Seaside Goldenrod	44,432	1,319-2,919
Hines Drive by Outer Drive Site 3	Seaside Goldenrod	56,625	1,531-4,293
Fort Street and Dragoon	<i>Bassia scoparia</i>	21,791	233.5-484.6
Fort Street and Oakwood	Common Mugwort	38,795	193.7-1,909
Junction and Driggs	Common Mugwort	11,313	160.8-1,374
Junction and Jefferson	<i>Bassia scoparia</i>	7,515	NDA
Schaefer and Greenfield	Common Mugwort	88,403	1,850-10,870
Wyoming and CSX	<i>Bassia scoparia</i>	20,101	1,002-3,564

*Total sodium content summed from multiple plants.

None of the ten Canada goldenrod organs from the EIC rain garden contained sodium while only four of the twenty-three from Fair Lane Drive did. The four Canada goldenrod organs with sodium were two stems (1,561 and 3,781 ppm), a root (416 ppm), and some leaves (143 ppm) (Appendix F).

Sodium was found to be distributed throughout the other three halophytes. Additionally, where sodium concentration was highest depends on the species. For seaside goldenrods sodium contents were highest in the leaves and the stem. The lower and middle leaves generally had more sodium than the upper leaves. Sodium content of the flowers and fruits varied from sample to sample and was significantly lower in comparison to that of the leaves and stems. Seaside goldenrod roots on average contained less sodium than the other organs. (Appendix G).

Mugwort secondary stems contained the most sodium of all the halophytes organs. Unlike seaside goldenrod, mugwort lower and middle leaves and upper leaves had closer levels of sodium. Where sodium content was highest in the leaves depended on the individual plant. Mugwort stem sodium content is either close to that of the leaves or lower. Mugwort flowers, if

present. were found to contain more sodium than most leaves, which was also true for the fruits. As with seaside goldenrod sodium was found to be lowest in the roots (Appendix H).

B. scoparia sodium content is greatest in the fruits. Similar to seaside goldenrod, lower and middle leaves contained more sodium than the upper leaves. In contrast to the mugwort plants most of the secondary stems contained less sodium than the upper or lower and middle leaves. The stems, and the roots contained the lowest amounts on average along with the secondary stems. (Appendix H, I, and J).

Notably, the Junction and Jefferson plants organs had the overall lowest amount of sodium organ content amongst roadsides in urban areas or highways with no sodium found in the soil. In contrast, sodium content in organs was highest at the Outer and Hines Drive sites which had the highest. The other urban area sites had values in-between those two areas (Appendix G and I, Table 7).

Chapter 4 – Discussion

4.1 Classification of Soil Samples

Fine soil is capable of containing high salt concentration due to high specific area (Zhao et al., 2016). The deepest soil samples of Outer and Hines Drive sites 1 and 3 were sandy clay loam in addition to possessing some of the highest sodium values in contrast to the upper layers. Because clay traps water flowing off the road and down the embankment, sites with loamy sand, sandy loam, and sand, varied in where sodium was highest. Regardless, water can more easily flow through soil with higher percentages of sand and soil in urban areas is only about a 0.33 m when water reaches concrete. Additionally, further analysis would be needed because only a three of the fifty-three soil samples skewed toward clay.

Seaside goldenrod and Canada goldenrod were found to grow in sandy loam soil. As the native range of seaside goldenrod is near the Atlantic Ocean, it can be assumed the species is most sustainable in sandy soil. *B. scoparia* and mugwort have been found to also grow in predominantly sandy soil, which has high percolation rates, indicating that both species are adapted to grow in soils with low moisture content. The plants growing along roadways treated with salt may reflect mugwort and *B. scoparia* introduction into the roadsides. There, these halophytes use their salt-tolerant traits to promote these species, take root and flourish throughout in Detroit and Dearborn.

4.2 Moisture Content of Soil Samples

Difference in moisture content between urban and undeveloped sites was likely due to location. The sites along Hines Drive were adjacent to a swamp with open water most of the year and surrounded by open forests. Along with Hines Drive being at a slight tilt, water can easily run off into the soil. Additionally, Hines Drive is a parkway for commuter traffic with a 40-mph speed limit, so water is likelier to be splashed into the roadside when more salt is spread to prevent accidents. Also, since the roadside soil was 0.6 m from the curve it was likelier for water to be splashed into it. However, moisture content depends on rainfall and snow melt thus frequency of precipitation will affect moisture content. In the case of the controls in the rain

garden and Fair Lane Drive, the moisture content was around or above 10% compared to the urban sites.

At urban sites, the asphalt and concrete curbs would prevent water that isn't immediately absorbed by the soil from running off the roadside and percolating in to the soil, or being carried to storm water/sewage systems. However, highways with an incline, tilt, or no curbs would allow runoff salt and water to flow into soil some distance away. Soil at Wyoming and CSX was located near a road and an incline, so the soil was likelier to absorb runoff water from the railroad bed. While it is possible that there is a correlation between salinity and moisture content, further research is needed.

The native range of seaside goldenrods is by frequently wet areas (Leonard et al., 2015). It can be assumed that the species requires moist soil to survive. It can be assumed seaside goldenrod is more likely to be found by roadsides frequently exposed to runoff and snow melt. In contrast, *B. scoparia* is known to survive in otherwise inhospitable settings of low moisture, and mugwort can grow in multiple types of ecosystem (USDA, 2010, Weston et al., 2004). The resilience of both species enables them to survive in soil patches just a few inches deep.

4.3 Organic Matter Content of Soil Samples

Similar to moisture, organic matter concentration varied by location. The Hines Drive sites were located near forests and wetlands, granting more opportunity for organic matter to decay and enter the soil. Since plant life is limited to small patches of soil with less moisture in Detroit and Dearborn, there were fewer opportunities to accumulate and decompose organic matter. The only exception for urban areas was the Wyoming and CSX soil.

There are two possible factors for why the Wyoming and CSX soil had high organic matter content. During soil extraction a pig bone was found in the soil. It is possible that the nearby sausage factory buries pig carcasses in the soil, adding to the organic matter, though not likely. The other factor was proximity to a train yard. Trains can unintentionally carry coal and plants from other parts of the country and coal, so it possibly contributed organic matter as well. Due to Wyoming and CSX being on a heavily industrialized roadway, with more frequent disturbances, additional unknown factors could contribute to the organic matter content (Reznicek, 1980).

Similar dynamics to moisture content can be assumed. Seaside goldenrod was found on a parkway bordered with forests and trees where organic matter is constantly added (Leonard et

al., 2015). *B. scoparia* and mugwort are more adaptable to constantly disturbed roadside sites along roadsides and require less organic matter (USDA, 2010, Weston et. al 2014). While it is possible high soil salinity lowers organic matter through preventing most plants from colonizing it, there is not enough data to conclude if this is true.

4.4 pH Levels and Sodium Content

While sodium has been associated with alkalization, other factors could affect roadside soil pH (Findlay and Kelly, 2011). For example, at the Schaefer and Greenfield sites the mugwort was growing within 2 m of the curb with heavy truck traffic which can send pulverized concrete, which contains limestone, into the soil which increased soil alkalinity. This also applies to the highway and other urban site soil is likely to be disturbed and the soil was alkaline (6.8-9.6). In contrast, soil samples from the Rain Garden, Fair Lane Drive, and Junction and Jefferson and Fort Street and Oakwood were areas with less disturbance, with the pH acidic or close to neutral (6.1-7.9).

Canada goldenrod, seaside goldenrod, common mugwort, and *B. scoparia* are all capable of surviving in basic soil to varying degrees. Canada goldenrod at the very least can tolerate a pH of up to 8 and even slightly acidic soil, the other species have a greater tolerance for alkaline soil. Mugwort and *B. scoparia* can survive in soil of around 8-8.5 pH, seaside goldenrod was found in soil with a pH up to 8.7, and mugwort can grow in soil of a pH of up to at least 9.6.

While the upper limit of alkaline tolerance of the halophytes and acidity tolerance is unknown, it is clear that each of the three salt-tolerant species can survive alkalization of soil to a degree. Mugwort, in particular, has shown the greatest tolerance. To determine when alkalization begins to poison the halophytes, each species would need to be grown in soils of various pH under laboratory conditions.

4.5 Salinity of Soil Samples

Three factors which affect soil salinity in urban areas are proximity to a road, quantity of road salt applied, and the angle of the soil. While it is possible for additional rainfall to wash away the salt, soil could retain sodium due to dry periods and water flowing vertically. (Robinson et al., 2017). As the control site along Fair Lane Drive at the EIC rain garden was located 4 meters away from the road, there was little opportunity for water mixed with salt pieces to be splashed into it, with what little salt there was percolating to the bottommost layer (253.9 ppm). Even then, since vehicles on campus go slowly water won't be sent into the soil. This is

seen to an even greater degree at the EIC rain garden itself. With the rain garden being located 10 m from the road, it was at a far enough distance to prevent high levels of salinization, with the one topmost soil sample containing a miniscule amount of sodium (4.714 ppm). With both sites being on level ground and slightly elevated, road salt couldn't flow into the soil. These factors allowed the two sites to serve as controls.

Soil salinity could also be influenced by the amount of salt laid on a road. Highways would be prioritized for salting to prevent accidents, leading to high salinity in the nearby soil. All the other sites aside from Junction and Jefferson were places where the speed limit was above walking speed and where accidents were likely. Soils located adjacent to high traffic roadways are likeliest to receive road salt mixed with water from passing vehicles. Additionally, even when vast amounts of road salt are laid on road it is not guaranteed to enter nearby soil. If the soil is located far enough from the road or water from the road cannot enter it salinity would remain unchanged.

A few of the sites sampled had inclines that water carrying road salt could flow down. The sections of Hines Drive where soil was collected had a slight tilt allowing water to flow in the soil, and on some sections of Hines Drive water can flow directly into the Rouge River. Along with the soil moisture content and soil sodium content being higher than the majority of the urban sites, suggests that water had ample opportunities to carry road salt into the soil. Additionally, the second Wyoming and CSX site was at the bottom of a small incline and contained around three times as much sodium than the first site (3563 ppm).

Seaside goldenrod has a high tolerance of salt since the species native range is near the Atlantic Ocean. This is supported by how the soil around the root of the site 3 goldenrods had 4292 ppm of sodium. With this in consideration seaside goldenrod is capable of surviving by roadsides with yearly increasing salinity to some degree especially if some clay is in the soil.

Soils from the mugwort sites had even greater salt concentrations than seaside goldenrod. Schaefer and Greenfield Sites 1 and 3 had similar sodium content to the Hines Drive and Hines Drive by Outer Drive. The Site 2 soil sodium content in particular exceeded 10,000 ppm. With this assumption, mugwort can take root in and thrive by roadsides in which other halophytes can't survive. By comparison, *B. scoparia* was found to live in areas with sodium content of up to 3,563. While *B. scoparia* can live in saline soil that is inhospitable to non-halophytes, it appears that it has less salt tolerance than seaside goldenrod and mugwort. What is notable is that

the roadside soil sodium content exceeded the 2015 Michigan soil sodium mean of 58.7 ppm. This disparity was either because those soil samples were taken from non-roadside sites or that mean was calculate after dilution and no further calculations were performed (DEQ, 2015).

4.6 Sodium Concentrations of Plant Organs

All three of the halophytes sampled are includers, one of the two most commonly researched halophyte type, as indicated by sodium being found in all the organs of all three non-control species (Chen et al., 2018). Sodium is also concentrated in either the stem or the plant's extremities. If these plant were indeed extruders or excluders, the surrounding soil would have had greater or equal amounts of sodium.

Sodium content of plants is influenced by the same factors that affect soil salinity (Robinson et al., 2017). The sodium from the road salt enters the plant through the roots then distributed throughout the body. Additionally, regardless of the collection site some plant organs contained more sodium than the soil. This may be due to bioaccumulation in the two perennial species: seaside goldenrod and common mugwort. With the roads being salted year after year, the successive generations of roadside plants will continuously accumulate sodium. Other evidence for this theory is that *B. scoparia* is an annual species and was found on average to contain the lowest amounts of sodium amongst the halophytes.

As mentioned in the introduction, seaside goldenrod adapted to saline environments by transporting sodium through vacuoles. The high levels of sodium in the seaside goldenrods leaves and stems indicates this is correct and the vacuoles transport from the roots to stem to the leaves, with some of it ending up in the fruits and flowers. Similarly, mugwort contain the most sodium in the secondary stems. For *B. scoparia* sodium is highest in the leaves or the fruit depending on the sample. Notably, sodium content of the sampled plants flowers and fruits wildly varied among the sample sites, which may be due to the amount of salt laid in an area. Also, leaves on the lower and middle section of the stem were generally higher than those on the upper section of the stem, though in some of the halophyte's sodium was concentrated in the upper leaves. However, for most samples the amount of sodium in the upper leaves was close to those in the lower and middle leaves. This disparity, along with those in the leaves and fruit of *B. scoparia*, could be due to the stage of maturity or plasticity, but more research is needed to determine the cause.

Plant sodium content possibly depends on the location's salinity. Of the few Fair Lane Drive and Junction and Jefferson plant organs that contained sodium, sodium content was highest in the stems. With these as a reference, it appears that in environments with low salinity, sodium is only present in a few organs. When sodium isn't constantly added to the soil it is either taken up by the plants or what little accumulates is washed away. However, further analysis of halophytes from low salinity sites is required to address this theory.

Regardless, what is certain is that flowering or mature halophytes sodium content depends on the environment's salinity. The two previously mentioned sites and the EIC rain garden contained little and virtually no salt respectively, resulting in plants with the lowest sodium content. This association is further confirmed when contrasting the sites. The strongest evidence to support this argument is that only in sites next to roadways was sodium of 10,000 or more was measured in an individual organ.

As indicted by the Schaefer and Greenfield and Hines Drive sites mugwort and seaside goldenrod organs are capable of containing sodium of 10,000 ppm or greater in an organ without undergoing salt stress. *B. scoparia* organs were found with lower levels of sodium. While it is clear what levels of sodium each of these three halophytes is substantial, the upper limit of the three halophytes unknown.

Chapter 5 - Conclusion

All three plant species are included where sodium ions are sequestered throughout their organs. Sodium is stored in the stem enroute and ends up in the plant's extremities: the leaves, secondary stems, fruits, and flowers. In low salinity environments halophytes take up little sodium, with the majority of it concentrated in the stem. In high salinity soil, sodium can be found in all of a halophyte's organs. Additionally, total sodium content of the plants shows that *B. scoparia* contained the least sodium, mugwort the highest, and seaside goldenrod was in-between.

Plants near highways and certain intersections are likelier to be exposed to sodium through splash and spray water mixed with road salt. However, proximity to a road doesn't guarantee increased soil salinity and plant sodium content. Salinity can only increase if the road has sufficient vehicle traffic and is laid with vast amounts road salt during Winter. Otherwise, salinity will increase slowly or not at all.

The other factor which affects soil salinity in Southeast Michigan's urban areas is that the soil is primarily sand. Sand allows the salt to percolate downward faster than clay moving from the upper to lower soil layers. Increase in soil salinity would also be dependent on the amount of salt placed onto the roads. While plants that regrow from roots may maintain sodium content, it is unknown by how much if at all.

Mugwort and *B. scoparia* have been found to live in soil with high alkalinity, low moisture content, and little organic matter. This indicates that both species can survive in otherwise inhospitable conditions. Seaside goldenrod was found in areas with both high moisture and organic matter, which means it is likely seaside goldenrod is reliant on both conditions.

Lastly, sodium content of plants depends on soil salinity. Halophytes sampled from areas with high salinity were found to have the largest sodium content. Conversely, areas with little soil salinity result in halophytes containing little to no sodium. In addition, road salt increases the alkalinity of the soil.

As cities in southeastern Michigan will continue to salt roads to aid in transportation and prevent accidents, salinity of roads and sodium content of roadside plants will continue to persist

even though the soil is primarily sand through which the salt can percolate, aside from the clay soils. One day, the salinity and alkalinity will increase to the point where even these halophytes may die off. The upper limit of the three halophytes is unknown, but what is tolerable for the halophytes has been found. What is certain is that halophytes will continue to dominate urban areas and roadsides in Michigan. While increased soil salinity from road salt in the middle of cities won't threaten plant diversity, it does at roadsides near forests. To determine the answer, public forums can be held to gather support for road salt abatement.

Appendices

Appendix A – Step-by-Step Protocol for Sample Preparation for Atomic Absorption Spectroscopy of Soil and Ashed Plant Samples

Soil Preparation for AA Analysis

1. Soil samples were weighed with a DeltaRange© analytic balance. Prior to weighing a sample, an empty 15 ml polypropylene test tube was placed on the balance, then the scale was tared. Every time a different test tube was used, the balance was re-zeroed. Approximately 0.5 grams of soil was collected from each sample and weighed to three decimal points.
2. Approximately 2 mL of the 6 M HCl was extracted with a volumetric pipet and mixed with the soil samples. The tubes were vigorously shaken to extract sodium from the soil. As sodium is a soluble element, no further treatment of the soil was need
3. Up to six tubes were placed in a Fisher Scientific© Centrifuge and spun for five minutes at 10,000 rpm to remove particles in the supernatant.
4. Approximately 1 ml of the resulting supernatant was collected with a transfer pipet then placed in a 50 ml polypropylene tube previously tared on the analytical balance. If soil particles were sucked up they were returned to the extract tube. If the tube was disturbed and soil was suspended in the mixture, then the solution was placed back in the centrifuge for another separation.
5. After recording the weight of the supernatant, the tube was filled with approximately 49 ml of RO water, diluting the HCl to 0.24 M.
6. To prevent the HCl from interfering with the AA readings, the solutions were deionized with Lanthanum Chloride Heptahydrate ($\text{LaCl}_3 \cdot 7\text{H}_2\text{O}$). The deionized solutions were created by using a 1,000 microliter Eppendorf pipet to transfer 1 ml of $\text{LaCl}_3 \cdot 7\text{H}_2\text{O}$ then 9 ml of the 50 ml soil solutions into 15 ml polypropylene tubes.

Plant Organ Preparation for AA Analysis

1. Plant organs were placed in porcelain crucibles, cleaned with isopropyl alcohol, and weighed.
2. Organ samples were placed into the crucibles and weighed in a tared analytical balance.

3. The samples were inserted into a drying oven set to 80°C for twenty or more hours to remove moisture.
4. A Thermolyne© model muffle furnace was heated to 200°C two to three hours prior to placing with crucibles with plant organs inside.
5. After placing the porcelain crucibles into the furnace, it was set to 300°C. The furnace door was left partially open so smoke could escape.
6. Three hours later the door was fully closed and the temperature was increased to 500°C. The organs were left in the oven for 20 or more hours.
7. The crucibles and ashed contents were weighed to determine the quantity of ash available for analysis.
8. After the ash was collected, it was stored inside labeled Ziploc bags and the porcelain crucibles were again cleaned with isopropyl alcohol.

Soil Calibration Curve Development

1. RO water was poured into a 1,000 mL graduated cylinder until it read 960 mL. 6 M HCl was then added until the cylinder was at 1,000 mL. Prior to pouring into a 50 mL polypropylene tube, the scale was tared with it. Afterwards, the solution was poured until the tube read 40-50 mL. The weight of the solutions was recorded.
2. Approximately 2.545 g of Puratronic 99.998 % (metals basis) NaCl salt was mixed with RO water in a sterilized bottle. The bottle was shaken to dissolve the salt. The resulting solution was the 1,000 ppm solution.
3. The other solutions were created through diluting the 1,000 ppm solution with the 0.24 M HCl solution. For example, a 500-ppm solution can be formed through the mixture of approximately 25.00 mL of a 1,000 ppm solution and 25 mL of the 0.24 M HCl solution in a 50 mL tube. The initial dilutions were further diluted to prepare the solutions needed for the calibration curve. During the dilutions all samples were weighed twice in an analytic balance. First with the salt solution alone, then again after HCl was added. The scale was tared with each tube. The solutions weight was recorded twice, with the salt solution, then after the HCl was added.
4. 1 ml of $\text{LaCl}_3 \cdot 7\text{H}_2\text{O}$ and 9 ml of the calibration solutions were transferred via Eppendorf pipet into 15 ml polypropylene tubes to deionize the HCl.

5. To create the calibration curve, the 1,000 ppm solution was initially read with the AA to see if the sodium concentration was at or near 1,000 ppm. The actual concentration of the 1,000 ppm solution was confirmed by dividing weight of the salt by the molecular weight of salt then multiplying it by the molecular weight of sodium (22.98977).
6. The concentration of the other solutions, aside from 0 ppm, was calculated with the previously recorded weights. The actual concentration the solutions were found by multiplying the actual concentration of the pre-diluted solution by the first recorded weight, divided by the second, and multiplied by .90 (Actual concentration * weight 1 / weight 2 * .90).

Plant Solution Second Dilution

1. Using an Eppendorf pipet, 0.4 mL of lanthanum extract was transferred into a 15 mL polypropylene tube.
2. Another Eppendorf pipet is used to extract 1 mL of solution then transferred into the same tube.
3. RO water was squirted into the tube until it read 10 mL.

Appendix B – Soil Classifications

Sample ID	Depth (m.)	Soil Type
Control: 10/29/2020 - UM-Dearborn EIC South Rain Garden – <i>S. canadensis</i>	0.0-0.12	Sandy Loam
Control: 10/29/2020 - UM-Dearborn EIC South Rain Garden – <i>S. canadensis</i>	0.12-0.23	Sandy Loam
Control: 10/29/2020 - UM-Dearborn EIC South Rain Garden – <i>S. canadensis</i>	0.23-0.27	Sandy Loam
Control: 10/29/2020 - UM-Dearborn EIC South Rain Garden – <i>S. canadensis</i>	Root	Sandy Loam
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.0-0.10	Sandy Loam
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.10-0.15	Sandy Loam
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.15-0.23	Sandy Loam
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.23-0.27	Sandy Loam
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.27-0.30	Sandy Loam
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	Root	Sandy Loam
9/30/2020 - Hines Dr. - <i>S. sempervirens</i>	0.0-0.15	Sandy Loam
9/30/2020 - Hines Dr. - <i>S. sempervirens</i>	0.15-0.24	Sandy Loam
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 1 - <i>S. sempervirens</i>	0.0-0.14	Sandy Loam
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 1 - <i>S. sempervirens</i>	0.14-0.23	Sandy Loam
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 1 - <i>S. sempervirens</i>	0.23-0.35	Sandy Clay Loam
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	0.0-0.11	Sandy Loam
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	0.11-0.24	Sandy Loam
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	0.24-0.30	Sandy Clay Loam
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	Root	Sandy Loam

Sample ID	Depth (m.)	Soil Type
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	0.0-0.10	Sandy Loam
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	0.10-0.24	Sandy Loam
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	0.24-0.30	Sandy Clay Loam
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	Root	Loamy Sand
11/23/2020 - Fort St. and Dragoon Detroit Site #1 - <i>B. scoparia</i>	0.0-0.09	Sand
11/23/2020 - Fort St. and Dragoon Detroit Site #2 - <i>B. scoparia</i>	0.0-0.09	Sand
11/23/2020 - Fort St. and Dragoon Detroit Site #3 - <i>B. scoparia</i>	0.0-0.09	Loamy Sand
11/23/2020 - Fort St. and Dragoon Detroit Site #3 - <i>B. scoparia</i>	0.09-0.24	Sand
11/23/2020 - Fort St. and Oakwood Detroit Site 1 - <i>A. Vulgaris</i>	0.0-0.15	Sandy Loam
11/23/2020 - Fort St. and Oakwood Detroit Site 1 - <i>A. Vulgaris</i>	0.15-0.23	Sandy Loam
11/23/2020 - 11/23/2020 - Fort St. and Oakwood Detroit Site 2 - <i>A. Vulgaris</i>	0.0-0.15	Sandy Loam
11/23/2020 - Fort St. and Oakwood Detroit Site 2 - <i>A. Vulgaris</i>	0.15-0.23	Loamy Sand
11/23/2020 - Fort St. and Oakwood Detroit - <i>A. Vulgaris</i>	Root	Sandy Loam
11/23/2020 - Junction & Driggs Detroit Site 1 - <i>A. Vulgaris</i>	0.0-0.14	Loamy Sand
11/23/2020 - Junction & Driggs Detroit Site 1 - <i>A. Vulgaris</i>	0.14-0.23	Loamy Sand
11/23/2020 - Junction & Driggs Detroit Site 2 - <i>A. Vulgaris</i>	0.0-0.14	Loamy Sand
11/23/2020 - Junction & Driggs Detroit Site 2 - <i>A. Vulgaris</i>	0.14-0.30	Loamy Sand
11/23/2020 - Junction & Jefferson Detroit Site 1 - <i>B. scoparia</i>	0.0-0.14	Sand
11/23/2020 - Junction & Jefferson Detroit Site 1 - <i>B. scoparia</i>	0.14-0.30	Sand
11/23/2020 - Junction & Jefferson Detroit Site 2 - <i>B. scoparia</i>	0.0-0.20	Loamy Sand
11/23/2020 - Junction & Jefferson Detroit Site 2 - <i>B. scoparia</i>	0.20-0.30	Loamy Sand
9/26/2020 - Schaefer and Greenfield Dearborn Plant 1 #1 – <i>A. vulgaris</i>	0.0-0.08	Sandy Loam
9/26/2020 - Schaefer and Greenfield Dearborn <i>A. vulgaris</i> Plant 1 #2 – <i>A. vulgaris</i>	0.08-0.15	Sandy Loam
9/26/2020 - Schaefer and Greenfield Dearborn Plant 1 #3 – <i>A. vulgaris</i>	0.15-0.23	Sandy Loam

Sample ID	Depth (m.)	Soil Type
9/26/2020 - Schaefer and Greenfield Dearborn Plant 2 #1 – <i>A. vulgaris</i>	0.0-0.09	Loamy Sand
9/26/2020 - Schaefer and Greenfield Dearborn Plant 2 #2 – <i>A. vulgaris</i>	0.09-0.15	Loamy Sand
9/26/2020 - Schaefer and Greenfield Dearborn Plant 3 #1 – <i>A. vulgaris</i>	0.0-0.09	Loamy Sand
9/26/2020 - Schaefer and Greenfield Dearborn Plant 3 #2 – <i>A. vulgaris</i>	0.09-0.15	Loamy Sand
9/26/2020 - Schaefer and Greenfield Dearborn Plant 3 #3 – <i>A. vulgaris</i>	0.15-0.23	Sandy Loam
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #1 - <i>B. scoparia</i>	0.0-0.14	Sandy Loam
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #1 - <i>B. scoparia</i>	0.14-0.21	Loamy Sand
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #1 - <i>B. scoparia</i>	0.21-0.34	Sandy Loam
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #2 - <i>B. scoparia</i>	0.0-0.15	Loamy Sand

Appendix C – Soil Moisture Content

Sample ID	Depth (m.)	Weight Before Drying (g)	% Water
Control: 10/29/2020 - UM-Dearborn Canada Goldenrod South Rain Garden – <i>S. canadensis</i>	0.0-0.12	488	24.4
Control: 10/29/2020 - UM-Dearborn Canada Goldenrod South Rain Garden – <i>S. canadensis</i>	0.12-0.23	559	17.4
Control: 10/29/2020 - UM-Dearborn Canada Goldenrod South Rain Garden – <i>S. canadensis</i>	0.23-0.27	431	10.6
Control: 10/29/2020 - UM-Dearborn Canada Goldenrod South Rain Garden – <i>S. canadensis</i>	Root	496	5.8
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S.</i> <i>canadensis</i>	0.0-0.10	490.4	14.5
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S.</i> <i>canadensis</i>	0.10-0.15	527.8	10.9
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S.</i> <i>canadensis</i>	0.15-0.23	638.2	11.5
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S.</i> <i>canadensis</i>	0.23-0.27	482.4	9.8
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S.</i> <i>canadensis</i>	0.27-0.30	682.6	8.7
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S.</i> <i>canadensis</i>	Root	281.4	17.2
9/30/2020 - Hines Dr. - <i>S.</i> <i>sempervirens</i>	0.0-0.15	534	15.2
9/30/2020 - Hines Dr. - <i>S.</i> <i>sempervirens</i>	0.15-0.24	746	16.6
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 1 - <i>S. sempervirens</i>	0.0-0.14	559.7	24.9

Sample ID	Depth (m.)	Weight Before Drying (g)	% Water
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 1 - <i>S. sempervirens</i>	0.14-0.23	765.3	14.6
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 1 - <i>S. sempervirens</i>	0.23-0.35	388.9	26.0
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	0.0-0.11	454.3	24.6
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	0.11-0.24	673.9	14.6
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	0.24-0.30	875.4	14.8
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	Root	265.2	35.3
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	0.0-0.10	438	26.3
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	0.10-0.24	607.9	19.1
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	0.24-0.30	709.6	14.6
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	Root	261.5	38.9
11/23/2020 - Fort St. and Dragoon Detroit Site #1 - <i>B. scoparia</i>	0.0-0.09	629.8	10.8
11/23/2020 - Fort St. and Dragoon Detroit Site #2 - <i>B. scoparia</i>	0.0-0.09	482.9	11.5
11/23/2020 - Fort St. and Dragoon Detroit Site #3 - <i>B. scoparia</i>	0.0-0.09	490.7	10.6
11/23/2020 - Fort St. and Dragoon Detroit Site #3 - <i>B. scoparia</i>	0.09-0.24	530.7	7.3
11/23/2020 - Fort St. and Oakwood Detroit Site 1 - <i>A. Vulgaris</i>	0.0-0.15	520	15.9
11/23/2020 - Fort St. and Oakwood Detroit Site 1 - <i>A. Vulgaris</i>	0.15-0.23	684	9.2
11/23/2020 - 11/23/2020 - Fort St. and Oakwood Detroit Site 2 - <i>A. Vulgaris</i>	0.0-0.15	497	15.8

Sample ID	Depth (m.)	Weight Before Drying (g)	% Water
11/23/2020 - Fort St. and Oakwood Detroit Site 2 - <i>A. Vulgaris</i>	0.15-0.23	675	9.5
11/23/2020 - Fort St. and Oakwood Detroit - <i>A. Vulgaris</i>	Root	599	13.5
11/23/2020 - Junction & Driggs Detroit Site 1 - <i>A. Vulgaris</i>	0.0-0.14	494.2	11.0
11/23/2020 - Junction & Driggs Detroit Site 1 - <i>A. Vulgaris</i>	0.14-0.23	730.2	14.2
11/23/2020 - Junction & Driggs Detroit Site 2 - <i>A. Vulgaris</i>	0.0-0.14	513.1	12.6
11/23/2020 - Junction & Driggs Detroit Site 2 - <i>A. Vulgaris</i>	0.14-0.30	662.1	13.5
11/23/2020 - Junction & Driggs Detroit Site 1 - <i>A. Vulgaris</i>	0.0-0.14	494.2	11.0
11/23/2020 - Junction & Driggs Detroit Site 1 - <i>A. Vulgaris</i>	0.14-0.23	730.2	14.2
11/23/2020 - Junction & Driggs Detroit Site 2 - <i>A. Vulgaris</i>	0.0-0.14	513.1	12.6
11/23/2020 - Junction & Driggs Detroit Site 2 - <i>A. Vulgaris</i>	0.14-0.30	662.1	13.5
11/23/2020 - Junction & Jefferson Detroit Site 1 - <i>B. scoparia</i>	0.0-0.14	595.7	9.5
11/23/2020 - Junction & Jefferson Detroit Site 1 - <i>B. scoparia</i>	0.14-0.30	551.8	9.8
11/23/2020 - Junction & Jefferson Detroit Site 2 - <i>B. scoparia</i>	0.0-0.20	587.9	13.3
11/23/2020 - Junction & Jefferson Detroit Site 2 - <i>B. scoparia</i>	0.20-0.30	554.4	8.4
9/26/2020 - Schaefer and Greenfield Dearborn Plant 1 #1 - <i>A. vulgaris</i>	0.0-0.08	500	7.7
9/26/2020 - Schaefer and Greenfield Dearborn <i>A. vulgaris</i> Plant 1 #2 - <i>A. vulgaris</i>	0.08-0.15	415	7.2
9/26/2020 - Schaefer and Greenfield Dearborn Plant 1 #3 - <i>A. vulgaris</i>	0.15-0.23	438	13.4
9/26/2020 - Schaefer and Greenfield Dearborn Plant 2 #1 - <i>A. vulgaris</i>	0.0-0.09	299	4.3
9/26/2020 - Schaefer and Greenfield Dearborn Plant 2 #2 - <i>A. vulgaris</i>	0.09-0.15	327	5.6
9/26/2020 - Schaefer and Greenfield Dearborn Plant 2 #3 - <i>A. vulgaris</i>	0.15-0.23	167	11.0
9/26/2020 - Schaefer and Greenfield Dearborn Plant 3 #1 - <i>A. vulgaris</i>	0.0-0.09	304	3.4

Sample ID	Depth (m.)	Weight Before Drying (g)	% Water
9/26/2020 - Schaefer and Greenfield Dearborn Plant 3 #2 – <i>A. vulgaris</i>	0.09-0.15	217	4.1
9/26/2020 - Schaefer and Greenfield Dearborn Plant 3 #3 – <i>A. vulgaris</i>	0.15-0.23	404	8.0
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #1 - <i>B. scoparia</i>	0.0-0.14	681.3	16.9
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #1 - <i>B. scoparia</i>	0.14-0.21	693.6	14.7
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #1 - <i>B. scoparia</i>	0.21-0.34	672.7	14.2
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #2 - <i>B. scoparia</i>	0.0-0.15	620.1	15.5

Appendix D – Soil Organic Matter Content

Sample ID	Depth (m.)	Organic Matter (%)
Control: 10/29/2020 - UM-Dearborn Canada Goldenrod South Rain Garden – <i>S. canadensis</i>	0.0-0.12	14.8
Control: 10/29/2020 - UM-Dearborn Canada Goldenrod South Rain Garden – <i>S. canadensis</i>	0.12-0.23	8.0
Control: 10/29/2020 - UM-Dearborn Canada Goldenrod South Rain Garden – <i>S. canadensis</i>	0.23-0.27	5.6
Control: 10/29/2020 - UM-Dearborn Canada Goldenrod South Rain Garden – <i>S. canadensis</i>	Root	8.3
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.0-0.10	9.2
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.10-0.15	7.1
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.15-0.23	6.8
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.23-0.27	6.6
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.27-0.30	6.4
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	Root	11.5
9/30/2020 - Hines Dr. - <i>S. sempervirens</i>	0.0-0.15	7.9
9/30/2020 - Hines Dr. - <i>S. sempervirens</i>	0.15-0.24	7.3
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 1 - <i>S. sempervirens</i>	0.0-0.14	10.3
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 1 - <i>S. sempervirens</i>	0.14-0.23	5.8
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 1 - <i>S. sempervirens</i>	0.23-0.35	9.2
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	0.0-0.11	10.2
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	0.11-0.24	7.0
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	0.24-0.30	8.0
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	Root	11.4

Sample ID	Depth (m.)	Organic Matter (%)
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	0.0-0.10	10.1
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	0.10-0.24	7.1
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	0.24-0.30	8.2
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	Root	11.6
11/23/2020 - Fort St. and Dragoon Detroit Site #1 - <i>B. scoparia</i>	0.0-0.09	5.0
11/23/2020 - Fort St. and Dragoon Detroit Site #2 - <i>B. scoparia</i>	0.0-0.09	4.6
11/23/2020 - Fort St. and Dragoon Detroit Site #3 - <i>B. scoparia</i>	0.0-0.09	5.0
11/23/2020 - Fort St. and Dragoon Detroit Site #3 - <i>B. scoparia</i>	0.09-0.24	3.2
11/23/2020 - Fort St. and Oakwood Detroit Site 1 - <i>A. Vulgaris</i>	0.0-0.15	6.7
11/23/2020 - Fort St. and Oakwood Detroit Site 1 - <i>A. Vulgaris</i>	0.15-0.23	6.0
11/23/2020 - 11/23/2020 - Fort St. and Oakwood Detroit Site 2 - <i>A. Vulgaris</i>	0.0-0.15	7.5
11/23/2020 - Fort St. and Oakwood Detroit Site 2 - <i>A. Vulgaris</i>	0.15-0.23	7.0
11/23/2020 - Fort St. and Oakwood Detroit - <i>A. Vulgaris</i>	Root	8.60
11/23/2020 - Junction & Driggs Detroit Site 1 - <i>A. Vulgaris</i>	0.0-0.14	6.1
11/23/2020 - Junction & Driggs Detroit Site 1 - <i>A. Vulgaris</i>	0.14-0.23	9.2
11/23/2020 - Junction & Driggs Detroit Site 2 - <i>A. Vulgaris</i>	0.0-0.14	7.2
11/23/2020 - Junction & Driggs Detroit Site 2 - <i>A. Vulgaris</i>	0.14-0.30	8.4
11/23/2020 - Junction & Jefferson Detroit Site 1 - <i>B. scoparia</i>	0.0-0.14	6
11/23/2020 - Junction & Jefferson Detroit Site 1 - <i>B. scoparia</i>	0.14-0.30	4.5
11/23/2020 - Junction & Jefferson Detroit Site 2 - <i>B. scoparia</i>	0.0-0.20	5.2
11/23/2020 - Junction & Jefferson Detroit Site 2 - <i>B. scoparia</i>	0.20-0.30	5
9/26/2020 - Schaefer and Greenfield Dearborn Plant 1 #1 - <i>A. vulgaris</i>	0.0-0.08	12.70

Sample ID	Depth (m.)	Organic Matter (%)
9/26/2020 - Schaefer and Greenfield Dearborn <i>A. vulgaris</i> Plant 1 #2 – <i>A. vulgaris</i>	0.08-0.15	13.2
9/26/2020 - Schaefer and Greenfield Dearborn Plant 1 #3 – <i>A. vulgaris</i>	0.15-0.23	8.8
9/26/2020 - Schaefer and Greenfield Dearborn Plant 2 #1 – <i>A. vulgaris</i>	0.0-0.09	12.0
9/26/2020 - Schaefer and Greenfield Dearborn Plant 2 #2 – <i>A. vulgaris</i>	0.09-0.15	12.0
9/26/2020 - Schaefer and Greenfield Dearborn Plant 3 #1 – <i>A. vulgaris</i>	0.0-0.09	12.4
9/26/2020 - Schaefer and Greenfield Dearborn Plant 3 #2 – <i>A. vulgaris</i>	0.09-0.15	13.5
9/26/2020 - Schaefer and Greenfield Dearborn Plant 3 #3 – <i>A. vulgaris</i>	0.15-0.23	12.6
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #1 - <i>B. scoparia</i>	0.0-0.14	18.0
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #1 - <i>B. scoparia</i>	0.14-0.21	16.7
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #1 - <i>B. scoparia</i>	0.21-0.34	18.4
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #2 - <i>B. scoparia</i>	0.0-0.15	7.5

Appendix E – Soil pH

Sample ID	Depth (m.)	pH
Control: 10/29/2020 - UM-Dearborn Canada Goldenrod South Rain Garden– <i>S. canadensis</i>	0.0-0.12	6.2
Control: 10/29/2020 - UM-Dearborn Canada Goldenrod South Rain Garden – <i>S. canadensis</i>	0.12-0.23	6.7
Control: 10/29/2020 - UM-Dearborn Canada Goldenrod South Rain Garden – <i>S. canadensis</i>	0.23-0.27	7.1
Control: 10/29/2020 - UM-Dearborn Canada Goldenrod South Rain Garden – <i>S. canadensis</i>	Root	7.1
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.0-0.10	7.4
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.10-0.15	7.5
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.15-0.23	7.7
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.23-0.27	7.9
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.27-0.30	7.9
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	Root	7.7
9/30/2020 - Hines Dr. - <i>S. sempervirens</i>	0.0-0.15	8.6
9/30/2020 - Hines Dr. - <i>S. sempervirens</i>	0.15-0.24	8.8
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 1 - <i>S. sempervirens</i>	0.0-0.14	8.4
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 1 - <i>S. sempervirens</i>	0.14-0.23	8.0
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 1 - <i>S. sempervirens</i>	0.23-0.35	8.5
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	0.0-0.11	8.6
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	0.11-0.24	8.7
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	0.24-0.30	8.7
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	Root	8.4

Sample ID	Depth (m.)	pH
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	0.0-0.10	8.8
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	0.10-0.24	8.5
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	0.24-0.30	8.9
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	Root	8.4
11/23/2020 - Fort St. and Dragoon Detroit Site #1 - <i>B. scoparia</i>	0.0-0.09	8.2
11/23/2020 - Fort St. and Dragoon Detroit Site #2 - <i>B. scoparia</i>	0.0-0.09	8.1
11/23/2020 - Fort St. and Dragoon Detroit Site #3 - <i>B. scoparia</i>	0.0-0.09	8.2
11/23/2020 - Fort St. and Dragoon Detroit Site #3 - <i>B. scoparia</i>	0.09-0.24	8.4
11/23/2020 - Fort St. and Oakwood Detroit Site 1 - <i>A. Vulgaris</i>	0.0-0.15	7.2
11/23/2020 - Fort St. and Oakwood Detroit Site 1 - <i>A. Vulgaris</i>	0.15-0.23	7.8
11/23/2020 - 11/23/2020 - Fort St. and Oakwood Detroit Site 2 - <i>A. Vulgaris</i>	0.0-0.15	7.5
11/23/2020 - Fort St. and Oakwood Detroit Site 2 - <i>A. Vulgaris</i>	0.15-0.23	7.9
11/23/2020 - Fort St. and Oakwood Detroit - <i>A. Vulgaris</i>	Root	7.9
11/23/2020 - Junction & Driggs Detroit Site 1 - <i>A. Vulgaris</i>	0.0-0.14	8.1
11/23/2020 - Junction & Driggs Detroit Site 1 - <i>A. Vulgaris</i>	0.14-0.23	8.2
11/23/2020 - Junction & Driggs Detroit Site 2 - <i>A. Vulgaris</i>	0.0-0.14	8.2
11/23/2020 - Junction & Driggs Detroit Site 2 - <i>A. Vulgaris</i>	0.14-0.30	8.3
11/23/2020 - Junction & Jefferson Detroit Site 1 - <i>B. scoparia</i>	0.0-0.14	6.1
11/23/2020 - Junction & Jefferson Detroit Site 1 - <i>B. scoparia</i>	0.14-0.30	6.6
11/23/2020 - Junction & Jefferson Detroit Site 2 - <i>B. scoparia</i>	0.0-0.20	7.0
11/23/2020 - Junction & Jefferson Detroit Site 2 - <i>B. scoparia</i>	0.20-0.30	7.1
9/26/2020 - Schaefer and Greenfield Dearborn Plant 1 #1 - <i>A. vulgaris</i>	0.0-0.08	6.8
9/26/2020 - Schaefer and Greenfield Dearborn <i>A. vulgaris</i> Plant 1 #2 - <i>A. vulgaris</i>	0.08-0.15	7.8
9/26/2020 - Schaefer and Greenfield Dearborn Plant 1 #3 - <i>A. vulgaris</i>	0.15-0.23	8.2
9/26/2020 - Schaefer and Greenfield Dearborn Plant 2 #1 - <i>A. vulgaris</i>	0.0-0.09	9.6
9/26/2020 - Schaefer and Greenfield Dearborn Plant 2 #2 - <i>A. vulgaris</i>	0.09-0.15	9.0
9/26/2020 - Schaefer and Greenfield Dearborn Plant 3 #1 - <i>A. vulgaris</i>	0.0-0.09	8.6

Sample ID	Depth (m.)	pH
9/26/2020 - Schaefer and Greenfield Dearborn Plant 3 #2 – <i>A. vulgaris</i>	0.09-0.15	8.7
9/26/2020 - Schaefer and Greenfield Dearborn Plant 3 #3 – <i>A. vulgaris</i>	0.15-0.23	8.4
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #1 - <i>B. scoparia</i>	0.0-0.14	8.1
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #1 - <i>B. scoparia</i>	0.14-0.21	8.0
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #1 - <i>B. scoparia</i>	0.21-0.34	8.0
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #2 - <i>B. scoparia</i>	0.0-0.15	8.4

Appendix F – Soil Salinity

Sample ID	Depth (m.)	Sodium (ppm)
Control: 10/29/2020 - UM-Dearborn Canada Goldenrod South Rain Garden – <i>S. canadensis</i>	0.0-0.12	4.714
Control: 10/29/2020 - UM-Dearborn Canada Goldenrod South Rain Garden – <i>S. canadensis</i>	0.12-0.23	NDA
Control: 10/29/2020 - UM-Dearborn Canada Goldenrod South Rain Garden – <i>S. canadensis</i>	0.23-0.27	NDA
Control: 10/29/2020 - UM-Dearborn Canada Goldenrod South Rain Garden – <i>S. canadensis</i>	Root	NDA
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.0-0.10	NDA
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.10-0.15	NDA
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.15-0.23	NDA
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.23-0.27	NDA
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	0.27-0.30	253.9
Control: 11/7/2020 - UM-Dearborn Along Fair Lane Dr. Sidewalk - <i>S. canadensis</i>	Root	NDA
9/30/2020 - Hines Dr. - <i>S. sempervirens</i>	0.0-0.15	5,341
9/30/2020 - Hines Dr. - <i>S. sempervirens</i>	0.15-0.24	6,955
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 1 - <i>S. sempervirens</i>	0.0-0.14	675.1
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 1 - <i>S. sempervirens</i>	0.14-0.23	637.2
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 1 - <i>S. sempervirens</i>	0.23-0.35	4,026
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	0.0-0.11	1,949
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	0.11-0.24	1,319
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	0.24-0.30	2,919
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 2 - <i>S. sempervirens</i>	Root	1,920

Sample ID	Depth (m.)	Sodium (ppm)
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	0.0-0.10	3,042
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	0.10-0.24	1,531
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	0.24-0.30	2,445
11/10/2020 - Hines Dr. ¼ miles east of Outer Drive north side of roadway Site 3 - <i>S. sempervirens</i>	Root	4,293
11/23/2020 - Fort St. and Dragoon Detroit Site #1 - <i>B. scoparia</i>	0.0-0.09	484.6
11/23/2020 - Fort St. and Dragoon Detroit Site #2 - <i>B. scoparia</i>	0.0-0.09	312.1
11/23/2020 - Fort St. and Dragoon Detroit Site #3 - <i>B. scoparia</i>	0.0-0.09	294.0
11/23/2020 - Fort St. and Dragoon Detroit Site #3 - <i>B. scoparia</i>	0.09-0.24	233.5
11/23/2020 - Fort St. and Oakwood Detroit Site 1 - <i>A. Vulgaris</i>	0.0-0.15	763.7
11/23/2020 - Fort St. and Oakwood Detroit Site 1 - <i>A. Vulgaris</i>	0.15-0.23	2,528
11/23/2020 - 11/23/2020 - Fort St. and Oakwood Detroit Site 2 - <i>A. Vulgaris</i>	0.0-0.15	193.7
11/23/2020 - Fort St. and Oakwood Detroit Site 2 - <i>A. Vulgaris</i>	0.15-0.23	1,909
11/23/2020 - Fort St. and Oakwood Detroit - <i>A. Vulgaris</i>	Root	195.8
11/23/2020 - Junction & Driggs Detroit Site 1 - <i>A. Vulgaris</i>	0.0-0.14	160.8
11/23/2020 - Junction & Driggs Detroit Site 1 - <i>A. Vulgaris</i>	0.14-0.23	464.0
11/23/2020 - Junction & Driggs Detroit Site 2 - <i>A. Vulgaris</i>	0.0-0.14	451.2
11/23/2020 - Junction & Driggs Detroit Site 2 - <i>A. Vulgaris</i>	0.14-0.30	1,374
11/23/2020 - Junction & Jefferson Detroit Site 1 - <i>B. scoparia</i>	0.0-0.14	NDA
11/23/2020 - Junction & Jefferson Detroit Site 1 - <i>B. scoparia</i>	0.14-0.30	NDA
11/23/2020 - Junction & Jefferson Detroit Site 2 - <i>B. scoparia</i>	0.0-0.20	NDA
11/23/2020 - Junction & Jefferson Detroit Site 2 - <i>B. scoparia</i>	0.20-0.30	NDA
9/26/2020 - Schaefer and Greenfield Dearborn Plant 1 #1 – <i>A. vulgaris</i>	0.0-0.08	4,291
9/26/2020 - Schaefer and Greenfield Dearborn <i>A. vulgaris</i> Plant 1 #2 – <i>A. vulgaris</i>	0.08-0.15	3,355
9/26/2020 - Schaefer and Greenfield Dearborn Plant 1 #3 – <i>A. vulgaris</i>	0.15-0.23	4,891

Sample ID	Depth (m.)	Sodium (ppm)
9/26/2020 - Schaefer and Greenfield Dearborn Plant 2 #1 – <i>A. vulgaris</i>	0.0-0.09	10,693
9/26/2020 - Schaefer and Greenfield Dearborn Plant 2 #2 – <i>A. vulgaris</i>	0.09-0.15	10,870
9/26/2020 - Schaefer and Greenfield Dearborn Plant 3 #1 – <i>A. vulgaris</i>	0.0-0.09	1,850
9/26/2020 - Schaefer and Greenfield Dearborn Plant 3 #2 – <i>A. vulgaris</i>	0.09-0.15	3,288
9/26/2020 - Schaefer and Greenfield Dearborn Plant 3 #3 – <i>A. vulgaris</i>	0.15-0.23	2,173
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #1 - <i>B. scoparia</i>	0.0-0.14	1,961
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #1 - <i>B. scoparia</i>	0.14-0.21	1,002
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #1 - <i>B. scoparia</i>	0.21-0.34	1,427
11/23/2020 - Wyoming Ave and CSX Driveway Dearborn Site #2 - <i>B. scoparia</i>	0.0-0.15	3,564

Appendix G - Canada Goldenrod Sodium Content

Plant Organ	Location	Number of Dilutions	Actual Na ⁺ Content (ppm)
Flower	Rain Garden, Site 1	1	NDA
Flower	Rain Garden, Site 2	1	NDA
Flower	Fair Lane Drive, Site 2	1	NDA
Flower	Fair Lane Drive, Site 4	1	NDA
Flower	Fair Lane Drive, Site 5	1	NDA
Flower Stem Leaves	Fair Lane Drive, Site 1	1	NDA
Fruit	Rain Garden, Site 1	1	NDA
Fruit	Rain Garden, Site 2	1	NDA
Fruit	Fair Lane Drive, Site 2	1	NDA
Leaves	Fair Lane Drive, Site 3	1	143
Leaves ?	Fair Lane Drive, Site 4	1	NDA
Leaves Lower Middle	Rain Garden, Site 1	1	NDA
Leaves Lower Middle	Rain Garden, Site 2	1	NDA
Leaves Lower Middle	Fair Lane Drive, Site 1	1	NDA
Leaves Lower Middle	Fair Lane Drive, Site 2	1	NDA
Leaves Lower Middle	Fair Lane Drive, Site 4	1	NDA
Leaves Lower Middle	Fair Lane Drive, Site 5	1	NDA
Leaves, Upper	Rain Garden, Site 1	1	NDA
Leaves Upper	Rain Garden, Site 2	1	NDA

Plant Organ	Location	Number of Dilutions	Actual Na ⁺ Content (ppm)
Leaves Upper	Fair Lane Drive, Site 1	1	NDA
Leaves Upper	Fair Lane Drive, Site 2	1	NDA
Leaves Upper	Fair Lane Drive, Site 5	1	NDA
Stem	Rain Garden, Site 1	1	NDA
Stem	Rain Garden, Site 1	1	NDA
Stem	Fair Lane Drive, Site 3	1	NDA
Stem	Fair Lane Drive, Site 4	1	NDA
Stem	Fair Lane Drive, Site 5	1	NDA
Stem	Fair Lane Drive, Site 1	1	1,561
Stem	Fair Lane Drive, Site 2	1	3,781
Root	Fair Lane Drive, Site 2	1	NDA
Root	Fair Lane Drive, Site 3	1	NDA
Root	Fair Lane Drive, Site 4	1	NDA
Root	Fair Lane Drive, Site 1	1	416

Appendix H – Seaside Goldenrod Sodium Content

Plant Organ	Location	Number of Dilutions	Actual Na ⁺ Content (ppm)
Flowers	Outer and Hines Site 3, Site 3	1	742
Flowers	Outer and Hines Site 2, Site 2	1	3,321
Flowers	Outer and Hines Site 1, Site 3	1	4,345
Flowers	Outer and Hines Site 1, Site 1	1	5,404
Flowers	Outer and Hines Site 2, Site 4	1	5,791
Flowers	Outer and Hines Site 2, Site 1	1	6,959
Flowers	Outer and Hines Site 3, Site 3	1	7,514
Flowers	Outer and Hines Site 3, Site 1	1	7,886
Flowers	Outer and Hines Site 3, Site 4	1	8,439
Flowers	Outer and Hines Site 2, Site 3	1	8,587
Flowers	Outer and Hines Site 1, Site 2	1	NA
Flowers (Fruits?)	Outer and Hines Site 1, Site 3	1	NA
Flowers 1	Hines Drive	1	5,748
Flowers 2	Hines Drive	1	5,528
Flowers Flat	Hines Drive	1	4,631
Fruit	Outer and Hines Site 2, Site 1	1	5,051
Fruit	Outer and Hines Site 1, Site 1	1	6,035
Fruit	Outer and Hines Site 3, Site 3	1	6,690
Fruit	Outer and Hines Site 3, Site 1	1	6,971
Fruit	Outer and Hines Site 3, Site 4	1	8,197
Fruit	Outer and Hines Site 3, Site 2	1	NA
Fruits	Outer and Hines Site 2, Site 2	1	NA
Fruits	Outer and Hines Site 2, Site 3	1	NA
Fruits	Outer and Hines Site 2, Site 4	1	NA
Leaves 3.0-4.5'	Hines Drive	2	14,308
Leaves 4.5-5.5'	Hines Drive	2	6,027
Leaves Lower	Hines Drive	2	23,294
Leaves Lower Middle	Outer and Hines Site 3, Site 2	2	7,898

Plant Organ	Location	Number of Dilutions	Actual Na ⁺ Content (ppm)
Leaves Lower Middle	Outer and Hines Site 1, Site 1	2	9,719
Leaves Lower Middle	Outer and Hines Site 2, Site 4	2	9,757
Leaves Lower Middle	Outer and Hines Site 3, Site 1	2	12,270
Leaves Lower Middle	Outer and Hines Site 2, Site 3	2	13,451
Leaves Lower Middle	Outer and Hines Site 3, Site 3	2	14,684
Leaves Lower Middle	Outer and Hines Site 1, Site 3	2	15,336
Leaves Lower Middle	Outer and Hines Site 3, Site 4	2	16,233
Leaves Lower Middle	Outer and Hines Site 2, Site 2	1	16,679
Leaves Lower Middle	Outer and Hines Site 2, Site 1	2	16,840
Leaves Lower Middle	Outer and Hines Site 1, Site 2	1	20,306
Leaves Upper	Outer and Hines Site 3, Site 3	1	1,877
Leaves Upper	Outer and Hines Site 1, Site 1	2	3,266
Leaves Upper	Outer and Hines Site 3, Site 2	1	3,534
Leaves Upper	Hines Drive	2	8,474
Leaves Upper	Outer and Hines Site 2, Site 4	1	12,736
Leaves Upper	Outer and Hines Site 3, Site 4	1	17,435
Leaves Upper	Outer and Hines Site 2, Site 1	1	18,144

Plant Organ	Location	Number of Dilutions	Actual Na ⁺ Content (ppm)
Leaves Upper	Outer and Hines Site 3, Site 1	1	21,546
Leaves Upper	Outer and Hines Site 1, Site 2	1	NA
Leaves Upper	Outer and Hines Site 1, Site 3	1	NA
Leaves Upper	Outer and Hines Site 2, Site 2	1	NA
Leaves Upper	Outer and Hines Site 2, Site 3	1	NA
Root	Outer and Hines Site 2, Site 1	1	1,517
Root Sample 2	Outer and Hines Site 3, Site 2	1	2,923
Root Samples 1	Outer and Hines Site 3, Site 1	1	2,864
Roots Sept 29	Hines Drive	1	3,525
Roots Sept 30	Hines Drive	1	2,212
Seed/Bud	Hines Drive	1	6,266
Stem	Outer and Hines Site 1, Site 1	2	13,377
Stem	Outer and Hines Site 2, Site 4	2	13,382
Stem	Outer and Hines Site 2, Site 3	2	13,784
Stem	Outer and Hines Site 1, Site 3	2	15,981
Stem	Outer and Hines Site 1, Site 2	2	16,071
Stem	Outer and Hines Site 3, Site 3	2	18,654
Stem	Outer and Hines Site 2, Site 1	2	18,978
Stem	Outer and Hines Site 3, Site 2	2	19,873
Stem	Outer and Hines Site 3, Site 4	2	20,070
Stem	Outer and Hines Site 3, Site 1	2	20,200
Stem	Outer and Hines Site 2, Site 2	2	12,750
Stem 0.0-2.0'	Hines Drive	2	20,475
Stem 2.0-5.0'	Hines Drive	2	12,385

Appendix I - Common Mugwort Sodium Content

Plant Organ	Location	Number of Dilutions	Actual Na ⁺ Content (ppm)
Flowers	Fort St. and Oakwood Site 1	2	6,841
Flowers	Fort St. and Oakwood Site 2	2	7,190
Flowers	Fort St. and Oakwood Site 3	2	7,464
Fruits	Junction and Driggs, Site 1	1	NA
Fruits	Junction and Driggs, Site 2	1	NA
Fruits	Junction and Driggs, Site 3	1	NA
Fruits Lower	Schaefer and Greenfield, Site 1	1	13,685
Leaf Distal	Schaefer and Greenfield, Site 1	2	8,087
Leaf Lower Proximal and Distal	Schaefer and Greenfield, Site 3	2	8,993
Leaf Lower Half	Schaefer and Greenfield, Site 2	2	11,020
Leaf Lower Middle	Junction and Driggs, Site 1	1	3,392
Leaf Lower Middle	Fort St. and Oakwood Site 1	2	3,641
Leaf Lower Middle	Fort St. and Oakwood Site 3	2	3,829
Leaf Lower Middle	Junction and Driggs, Site 3	1	4,050
Leaf Lower Middle	Fort St. and Oakwood Site 2	2	4,086
Leaf Lower Middle	Junction and Driggs, Site 2	1	5,846
Leaf Lower Proximal	Schaefer and Greenfield, Site 1	2	19,804
Stem, Secondary	Fort St. and Oakwood Site 3	2	1,180
Stem, Secondary	Fort St. and Oakwood Site 2	1	14,907
Stem, Secondary	Fort St. and Oakwood Site 1	1	15,561

Plant Organ	Location	Number of Dilutions	Actual Na ⁺ Content (ppm)
Stem, Secondary Lower Primary	Schaefer and Greenfield, Site 3	2	11,462
Stem, Secondary Lower Secondary	Schaefer and Greenfield, Site 3	2	17,108
Stem, Secondary Upper	Schaefer and Greenfield, Site 3	2	6,177
Stem, Secondary Upper	Schaefer and Greenfield, Site 2	2	15,781
Stem, Secondary Upper	Schaefer and Greenfield, Site 2	2	16,871
Stem, Secondary Upper Distal	Schaefer and Greenfield, Site 1	1	16,850
Leaf Upper	Junction and Driggs, Site 3	1	1,705
Leaf Upper	Junction and Driggs, Site 1	1	3,135
Leaf Upper	Schaefer and Greenfield, Site 3	2	4,351
Leaf Upper	Junction and Driggs, Site 2	1	4,456
Leaf Upper	Fort St. and Oakwood Site 2	1	9,145
Leaf Upper	Fort St. and Oakwood Site 3	1	10,405
Leaf Upper	Fort St. and Oakwood Site 1	1	10,963
Leaf Upper Distal	Schaefer and Greenfield, Site 1	2	11,140
Leaf Upper Half	Schaefer and Greenfield, Site 2	2	11,644
Leaf Upper Proximal	Schaefer and Greenfield, Site 1	2	12,768
Root	Schaefer and Greenfield, Site 1	1	2,076
Root	Fort St. and Oakwood Site 1	1	2,919
Root	Schaefer and Greenfield, Site 2	2	3,685
Root	Schaefer and Greenfield, Site 3	2	4,362
Stem	Junction and Driggs, Site 3	1	3,050
Stem	Junction and Driggs, Site 1	1	3,235
Stem	Junction and Driggs, Site 2	1	5,072
Stem	Fort St. and Oakwood Site 2	1	5,507

Plant Organ	Location	Number of Dilutions	Actual Na ⁺ Content (ppm)
Stem	Fort St. and Oakwood Site 1	1	5,565
Stem	Fort St. and Oakwood Site 3	1	7,180
Stem	Schaefer and Greenfield, Site 3	2	8,735
Stem	Schaefer and Greenfield, Site 2	2	14,835
Stem Distal	Schaefer and Greenfield, Site 1	2	15,767
Stem Lower Proximal	Schaefer and Greenfield, Site 1	2	10,809
Stem Main	Schaefer and Greenfield, Site 1	2	6,640
Stem Upper Proximal	Schaefer and Greenfield, Site 1	2	12,561

Appendix J – *Bassia scoparia* Sodium Content

Plant Organ	Location	Number of Dilutions	Actual Na ⁺ Content (ppm)
Fruits	Junction and Jefferson, Site 1	1	412
Fruits	Fort St. and Dragoon, Site 2	2	1,321
Fruits	Wyoming and CSX, Site 1	2	1,839
Fruits	Wyoming and CSX, Site 2	1	6,898
Fruits	Fort St. and Dragoon, Site 1	1	9,875
Leaf Lower Middle	Junction and Jefferson, Site 1	1	384
Leaf Lower Middle	Wyoming and CSX, Site 1	2	2,681
Leaf Lower Middle	Fort St. and Dragoon, Site 1	2	3,723
Leaf Lower Middle	Fort St. and Dragoon, Site 2	2	5,458
Leaf Lower Middle	Wyoming and CSX, Site 2	2	5,947
Leaf Upper	Junction and Jefferson, Site 1	1	306
Leaf Upper	Wyoming and CSX, Site 2	2	3,190
Leaf Upper	Fort St. and Dragoon, Site 1	2	3,225
Leaf Upper	Wyoming and CSX, Site 1	2	4,149
Leaf Upper	Fort St. and Dragoon, Site 2	2	4,734
Root	Fort St. and Dragoon, Site 1	2	659
Root	Fort St. and Dragoon, Site 2	2	1,106
Root	Wyoming and CSX, Site 2	1	2,231
Roots	Junction and Jefferson, Site 1	1	2,450
Stem	Junction and Jefferson, Site 1	1	2,647
Stem	Fort St. and Dragoon, Site 2	2	2,967
Stem	Fort St. and Dragoon, Site 1	2	3,460
Stem	Wyoming and CSX, Site 1	1	2,647
Stem	Wyoming and CSX, Site 2	1	4,864
Stem, Secondary	Junction and Jefferson, Site 1	1	1,325
Stem, Secondary	Wyoming and CSX, Site 2	2	1,874
Stem, Secondary	Fort St. and Dragoon, Site 1	2	3,299

Plant Organ	Location	Number of Dilutions	Actual Na ⁺ Content (ppm)
Stem, Secondary	Fort St. and Dragoon, Site 2	2	3,754
Stem, Secondary	Wyoming and CSX, Site 1	1	3,881

Appendix K – Total Plant Sodium Content

Location	Plant Species	Total Na ⁺ (ppm)
Rain Garden, Site 1	Canada goldenrod	NDA
Rain Garden, Site 1	Canada goldenrod	NDA
Fair Lane Drive, Site 1	Canada goldenrod	1,977
Fair Lane Drive, Site 2	Canada goldenrod	4,337
Fair Lane Drive, Site 3	Canada goldenrod	143
Fair Lane Drive, Site 4	Canada goldenrod	NDA
Fair Lane Drive, Site 5	Canada goldenrod	NDA
Junction and Jefferson, Site 1	<i>Bassia scoparia</i>	7,515
Fort Street and Dragoon, Site 1	<i>Bassia scoparia</i>	24,240
Fort Street and Dragoon, Site 2	<i>Bassia scoparia</i>	19,341
Wyoming and CSX, Site 1	<i>Bassia scoparia</i>	15,198
Wyoming and CSX, Site 2	<i>Bassia scoparia</i>	25,004
Hines Drive*	Seaside goldenrod	112,870
Outer and Hines Drive Site 1, Site 1	Seaside goldenrod	37,801
Outer and Hines Drive Site 1, Site 2	Seaside goldenrod	36,377
Outer and Hines Drive Site 1, Site 3	Seaside goldenrod	35,662
Outer and Hines Drive Site 2, Site 1	Seaside goldenrod	67,489
Outer and Hines Drive Site 2, Site 2	Seaside goldenrod	32,749
Outer and Hines Drive Site 2, Site 3	Seaside goldenrod	35,822
Outer and Hines Drive Site 2, Site 4	Seaside goldenrod	41,666
Outer and Hines Drive Site 3, Site 1	Seaside goldenrod	71,737
Outer and Hines Drive Site 3, Site 2	Seaside goldenrod	34,227
Outer and Hines Drive Site 3, Site 3	Seaside goldenrod	50,160
Outer and Hines Drive Site 3, Site 4	Seaside goldenrod	70,375
Junction and Driggs, Site 1	Common mugwort	9,762
Junction and Driggs, Site 2	Common mugwort	15,374
Junction and Driggs, Site 3	Common mugwort	8,804
Fort Street and Oakwood, Site 1	Common mugwort	45,491
Fort Street and Oakwood, Site 2	Common mugwort	40,836
Fort Street and Oakwood, Site 3	Common mugwort	30,057
Schaefer and Greenfield, Site 1	Common mugwort	130,189
Schaefer and Greenfield, Site 2	Common mugwort	73,834
Schaefer and Greenfield, Site 3	Common mugwort	61,187

*Total sodium content summed from multiple plants.

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