Building urban and community forestry capacity through manipulative social and physical infrastructure changes

A Thesis
SUBMITTED TO THE FACULTY OF
UNIVERSITY OF MINNESOTA
BY

Andrea Dierich

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF SCIENCE

Professor Gary Johnson

October 2014

Acknowledgements

This thesis would not have been possible without the tireless reassurance, patience, and funding from my advisor Professor Gary Johnson. His nudging and guidance have made an undirected mess of ideas into a coherent thought, which has brought me much knowledge along the way. Dave Hanson who spent countless hours correcting and critiquing my work and driving with me all over the State to collect community data. He is both a valued teacher and trusted friend. Chris Starbuck, who took the time to meet with me and share his research and stories about Missouri gravel beds. And Ken Holman, who has quite possibly the largest heart and greatest love for urban forestry that I have witnessed.

I would like to thank the University of Minnesota Forestry Department, University of Minnesota Extension, Minnesota Department of Agriculture and the Minnesota Department of Natural Resources for their funding and support.

Additional gratitude is expressed to the several undergraduates who participated in the Emerald Ash Borer: Rapid Response project, specifically Eric North, Nick Perkins, and Valerie Price along with others, Rebecca Koetter, Chad Giblin, and Sean Peterson. All of this would not be possible without the participation of the communities; Rochester, Hibbing, Hutchinson, Morris, Hendricks and Crookston and their fabulous volunteers.

I would also like to thank my parents, siblings, and friends for providing me the time and constant encouragement to complete this work. Lastly, thank you to my family, Tristan Wilson, who let me chase my degree and still decided to marry me and my twins Ruby and Miles. Although they significantly delayed my completion and caused my advisor strife over ever finishing, they are pure joy and I look forward to being able to spend my new found time outdoors with them.

Abstract

Funding and staffing for urban and community forestry (U&CF) has decreased significantly over the last decade. This strain has hampered programs and affects the health of the urban forest. As our globalized market increases, invasive species become a growing threat that U&CF programs struggle with in their debilitating state. The invasive species, emerald ash borer, has the ability to cause catastrophic harm to Minnesota communities due to the high percentage of ash on public owned property. In an effort to provide assistance, and build capacity for dealing with emerald ash borer, the Emerald Ash Borer: Rapid Response project was developed. This project utilized volunteers and community gravel beds to build U&CF infrastructure to increase the ability of a community to manage not just emerald ash borer, but develop a successful and sustaining U&CF program. The intensive and direct assistance method used in the project provides new ways for states and other organizations to consider building and tracking U&CF capacity in communities.

Table of Contents

List of Tables

List of Figures

Introduction

The idea of *capacity* has become increasingly important as urban and community forestry (U&CF) programs have more influence in the planning, modeling and design of urban areas. The role of trees in human interaction and health have pushed the value of "green" infrastructure in communities, creating a greater demand and desire for their use. Despite this demand external pressures such as funding, staffing, knowledge and invasive species create significant opposition. The ability of a community to handle these types of pressures are imperative to the success of their U&CF programs. The variables of funding, staffing and knowledge can be overcome through specific outreach such as technical assistance and education, but understanding and predicting the limitations and impacts that invasive species create on capacity can be difficult.

The Impact of Introduced Invasive Species

Over the last century the introduction rate of invasive species across the country has increased dramatically. The consumption of imported goods from over-seas has only exacerbated the probability of an invasive species entering the United States, see Table 1. Once ensconced inside United States borders these invasive species can wreak havoc on native plants, animals and even whole ecosystems (Haack and Cavey, 1997). Regardless of the physical ability of pests or pathogens to travel to new un-infested areas in the country, the increase is largely due to

Year	Percent of total US imports that came from China	Percent of total insect interceptions on solid wood packing materials that came from China
1985	1.1%	1.2%
1986	1.3%	1.2%
1987	1.6%	0.7%
1988	1.9%	1.5%
1989	2.5%	0.6%
1990	3.1%	1.2%
1991	3.9%	0.6%
1992	4.8%	4.4%
1993	5.4%	7.3%
1994	5.8%	8.3%
1995	6.1%	11.2%
1996	6.4%	21.2%

Table 1. Growth of US imports and insect interceptions on wood from China (Haack et al., 1997).

developments in cross-continental infrastructure. Roads, rails and planes have allowed greater movement and transportation of insects and diseases (Gibbs, 1978; Hulme, 2009). Areas of high population have significantly more infrastructure to accommodate the flow of people in and out of dense locations, especially those cities that were built with the export and importation of goods in mind and continue as hubs for international and continental trade.

Due to the increase in access, it is not a coincidence that major cities are the point of origin for most invasive species and fungal pathogens (Hulme, 2009). New York City has been the home to chestnut blight, Dutch elm disease and Asian longhorned beetle just as Detroit was the entry point for emerald ash borer (Poland and McCullough, 2006). Both of these cities have major ports and railroad hubs to receive and ship goods. Other pests such as oak wilt and gypsy moth, although not originating from a major city, have been able to spread across entire regions (e.g. the Midwest) through the transportation of infected or infested material, either unfinished wood products or egg masses on cars (Haight et al., 2011; Liebhold, Halverson, and Elmes, 1992).

According the Minnesota Department of Natural Resources website[1], "Invasive species are species that are not native to Minnesota *and* cause economic or environmental harm or harm to human health." The challenges that invasive species create for communities can range from monetary loss to infrastructure loss as whole segments of an urban forest are killed or destroyed. This type of catastrophic loss is increased when communities lack the capacity or the ability to prevent, minimize or manage such damage. Capacity in this sense of the word falls into the Merriam-Webster dictionary definition of capacity as *power* "the facility or power to produce, perform, or deploy". A second addition to this definition is capacity in the sense of *skill* or *aptitude* "an individual's mental or physical ability".[2] In order to understand what type of capacity a community must develop for the management of a potential invasive species two perspectives must be considered: the

---

[1] "invasive species." *Minnesota Department of Natural Resources.* 2011. http://www.dnr.state.mn.us/index.html (30 October 2011)
[2] "capacity. *Merriam-Webster.com*. 2011. http://www.merriam-webster.com (30 October 2011).

length of time a community has to prepare before the infestation occurs and the potential destruction caused by the pest.

In 2009 Minnesota had its first positive identification for emerald ash borer (EAB) in the Twin Cities (specifically, St. Paul). Although the exact method of introduction into the state is unknown, the 2009 confirmation materialized into a need for communities around the state to prepare for the eventuality of heavy losses to their current ash populations. Historically, communities have been reactive to urban forestry threats costing significant amounts of money and time (French, 1993). This is not only true for invasive species but also natural disasters. Building strong and supportive partnerships in communities can begin to foster the proactive approach necessary to deal with these catastrophic events. Education, community engagement and empowerment create the tools needed to increase urban and community forestry capacity for these desired partnerships. To help communities with this preparation, this project was designed to research, develop and evaluate specific capacity building components that would not only prepare a community for EAB but also increase the sustainability of their urban forestry programs.

A History of Invasive Species in Minnesota

The early 20th century, 1904 – 1950s, saw the destruction of millions of chestnut trees due to the chestnut borer and the fungal pathogen it carried, *Cryphonectria parasitica*. Although this pathogen did not affect Minnesota forests until the late 1970s, its devastation played a significant role in shaping the eastern forest ecosystem (French, 1985). It is believed that this fungal introduction occurred via *Castanea spp.* stock imported from Asia (Anagnostakis, 1987; Milgroom et al., 1996; Schlarbaum et al., 1997). Around 1927 a similar shipment of *Ulmus spp.* logs carried another fungal pathogen on the backs of *Scolytus multistriatus*, the European bark beetle (Gibbs, 1978; Brasier, 2000). The speed of infestation increased after the 1940s and was aided by the abundance and high density of the elm trees planted in urban areas due to their favored form and success in highly populated regions. (Gibbs 1978) Although the fungus, *Ophiostoma ulmi,* could be carried by either the European or American elm bark beetle (*Hylurgopinus rufipes)*, root graft transmission was a significant means of infection

(Neely and Himelick, 1963; Cuthbert, 1975). By 1977, Dutch elm disease (DED) had shocked the nation with the devastation of elms across the country. Dutch elm disease scoured all continental 48 states within 30 years of identification.

In Minnesota, DED was originally identified in the city of St. Paul in 1961. Another case within the same year was identified in Monticello. Both of these finds were thought to be human dispersal as the closest infection site was over 100 miles away in Wisconsin (French, 1993). Little was done to prevent or slow the spread of DED which, in part was caused by popular belief that hardy Minnesota winters would kill off any potential beetles and the fungus. Despite the relatively low rate of DED presence from 1961 to 1968, 30 positive cases, the disease multiplied and was the cause of significant damage by 1974 (French, 1993). The millions of dollars spent on elms lost during the epidemic would likely have been moderated by a few preventive control and management practices.

In the 1960s it was still a common practice for nurseries to supply American elm trees for communities to plant after the first positive DED discovery 1961. Elm, being one of the most popular trees for the urban environment, was planted with zeal across the state. Subsequently, communities were devastated by the disease as whole urban sectors were cleared of public and private trees. Due to misconceptions, there was very little preparation and unfortunately in their haste to recreate the urban forest, many communities replanted elm trees with another hardy, fast-growing, and environment forgiving tree, green ash, *Fraxinus pennsylvanica* (Poland and McCullough, 2006; Mazullo, 2011).

In 2002 emerald ash borer, *Agrilus planipennis,* (also known as EAB) moved to the top of the list as the new threat to urban forests. Other invasive species such as Asian long-horned beetle, thousand canker disease and gypsy moth[3] are in the peripheral view for many urban foresters, but will, with time, provide millions of dollars in destruction and severe challenges for communities across the county (Liebhold, Halverson, and Elmes,

[3] "gypsy moth." *Minnesota Department of Agriculture*. 2011. http://www.mda.state.mn.us/gypsymoth (27 December 2011).

1992; Haack et al., 1997; Newton et al., 2011). Similar to DED, emerald ash borer (EAB) was first identified in the City of St. Paul and later in Houston County in 2009. Unlike its fungal predecessor, significant efforts have been made to slow the spread of the emerald ash borer (e.g. Slow Ash Mortality known as the SLAM program[4]). Attempts to prepare communities not only in the metro area of the Twin Cities, but also in Greater Minnesota, have been pushed since the first positive identification of EAB in 2009. The success of these efforts and future ones, specifically in Greater Minnesota, greatly depend on the urban and community forestry capacity of these communities, that is, the ability of communities to respond and manage this threat to their quality of life.

Metropolitan areas such as Chicago or the Twin Cities have significant resources readily available, in other words, their capacity to respond is robust. These resources include equipment, money, expertise, and the headquarters of state agencies. Areas that fall outside metro limits can struggle with obtaining consideration along with the equipment, funding and expertise. Through concentrated efforts to increase the capacity of Greater Minnesota communities, the ability to prevent, minimize or manage the effects of EAB would likely be increased.

Capacity as a Variable

Previous efforts have been made to define the capacity of Minnesota communities. These efforts primarily focused on regional and federal funding, but included administrative and urban and community forestry program descriptions as well. The study conducted by Hauer (2002), gave rise to three distinct capacity definitions to describe the attributes through which urban forestry capacity is understood: urban forestry program capacity, urban forestry development capacity, and urban forestry sustainability capacity (Hauer, 2006; Hauer, Johnson, and Kilgore, 2011; Hauer, 2005). Within all three of these definitions, "infrastructure" is a key element. The definition of "infrastructure" is as follows:

[4] The SLAM program is a concentrated effort of several different tactics to slow the spread of the emerald ash borer these include; insecticide injection, ash removal, and ash wood quarantines.

1: the underlying foundation or basic framework (as of a system or organization)

3: the system of public works of a county, state, or region; *also*: the resources (such as personnel, buildings, or equipment) required for an activity.[5]

Hauer's (2008) work focused on both of these definitions of infrastructure by the role state government plays in the success of urban forestry programs through organization of U&CF programs and the resource funding provided. His research operationalized the concept by weighing the level of success of community efforts and programs against the level of governmental support.

A high U&CF capacity is increasingly important for communities in order to be competitive in obtaining federal and state grants as well as being able to provide city services. Without experienced and trained community staff the purpose and reasoning behind urban forestry maintenance is greatly reduced. In an effort to expand Hauer's 2002 study, the research presented in this thesis focuses on the effects of directed technical assistance rather than funding for U&CF programming.

Community Capacity

Underlying U&CF capacity is the actual social and physical infrastructure of a community, specifically, the importance of community participation and alternative methods of funding, or community assets. With these two aspects in mind, any model for capacity in urban forestry must incorporate integrated approaches to address several concepts that promote U&CF capacity such as education opportunities or increased access to resources.

The Evolution of Community Capacity

The working definition of community capacity refers to a community's ability to change or adapt in a broad manner to anything viewed as an obstacle (Horton, 2003). The concept of community capacity is heavily integrated with the perception of social

[5] "infrastructure".*Merriam-Webster.com*. 2011. http://www.merriam-webster.com (18 September 2011).

science, specifically community participation. Capacity building is a *tool* that addresses a way to change a community system or process. A community without the ability to enact change struggles to successfully grow and/or react to its environment, which then limits the type of programs or assistance a community can provide to its members (Verity, 2007). Although there are multiple capacity definitions used in various fields, the definition provided above captures a dynamic and ordered approach on capacity which provides a general sense of all other capacity definitions. The definition although important, is secondary in comparison to the characteristics or structures authors have attributed to community capacity. An extensive view of community capacity comes from Robert Chaskin (2001).

Chaskin (2001) identifies four distinct capacity characteristics; 1) sense of community, 2) level of commitment among community members, 3) mechanisms of problem solving, and 4) access to resources. He models these characteristics in a rational framework where each input into the model can be viewed through various levels of interaction. A sense of community is reflected through an individual, group or community identity. A change in one level of connectedness alters those above or below it. By affecting or focusing on any of the four characteristics there is the ability to affect the other three both positively or negatively. Any capacity built within a community exemplifies these core characteristics according to Chaskin. "Different communities may have different levels of each, and most communities will have some positive level of all four [characteristics]. Although the existence of these characteristics is a matter of degree, there are likely threshold levels along the continuum that are necessary in order for the community to accomplish certain specific ends" (Chaskin and University of Chicago, Chapin Hall Center for Children, 1999).

Other authors have also created indicators or characteristics of community capacity. Jackson et al. (2003) created a model that "underlines the importance of the conditions and factors that enable or constrain the community [to build capacity]." What is notable in this model is that the communities dictated the actual indicators used in capacity analysis. Rather than setting indicators to be met by members, Jackson et al. considered the barriers and how to remove such barriers within the capacity model: "increasing community capacity means not only improving the skills of the community residents, but also creating the conditions inside and outside the community that maximize the potential for these to develop and find full expression" (Jackson et al., 2003).

By having communities identify their own barriers, the capacity building process begins. Francisco et al. (2001) uses six core competencies for the dynamic and iterative process of community capacity building: 1) understanding community context, 2) collaborative planning, 3) developing leadership and enhancing participation, 4) community action and intervention, 5) evaluating community initiatives, and 6) promoting and sustaining the initiative. These competencies became the basis for the on-line "Community Tool Box" seeking to build healthier communities by providing technical assistance, training and knowledge (Francisco et al., 2001). The tiered approach seeks to cover capacity building from all angles but as an on-line tool it lacks the depth of physical connections that suggest a more integrated approach. The use or misuse of this tool cannot be tracked nor is the assistance available in a form that would strengthen personal relationships or build community trust as other integrated approaches would.

In a completely different take on community capacity modeling, Hinds (2008) proposed a three-element model: community environment, community structures and purpose-based action. Hinds' believes that "purpose" is a general backdrop for capacity building and describes his three-elements in more detail below:

1. The capacity and ability to define a community, describe and understand its unique environment, and take responsibility for community issues and common purposes.
2. The capacity and ability to create, manage and maintain appropriate community structures that address community issues and achieve community purposes.
3. The capacity and ability to take appropriate actions to address community issues and achieve community purposes (Hinds, 2008).

According to Hind's model, a community is only able to develop and build capacity if it applies all three elements of his definition together. This type of capacity framework is considered a reflective model by Lyons and Reimer (2006). The reflective model of capacity views all core components or characteristics necessary for capacity to be achieved or built. If one element or characteristic is low or missing then capacity is low. An alternative model also suggested by Lyons and Reimer is a formative approach. This approach to capacity building allows one characteristic or element to be substituted or the indicators weighted in such a manner to reflect the ability to create capacity (Lyons and Reimer, 2006). The formative approach is flexible in its definition of capacity and recognizes strides a community may be taking in one area as an over-all attempt to increase capacity. Compared to the rigidity of the reflective model, the model developed by Lyons and Reimer is a considerably easier gauge of capacity growth or progress.

Categorizing models into different framework features as Lyons and Reimer (2006) do is innovative but not always black and white. For example, both the Jackson et al. (2003) model and the Francisco et al. (2001) model are considered by Lyons and Reimer to be reflective models of capacity, yet it is clear that both examples take a dynamic and integrative approach. The capacity model developed by Jackson et al. (2003) used each community to create capacity indicators, which as discussed above, are often believed to be the barriers to capacity within a community. Just as the first step in creating a solution is admitting there is a problem, once the barriers are identified at the individual and group level the easier it becomes for a community to overcome these barriers. The Jackson et al. (2003) model never indicated whether all barriers identified by a community need to be removed in order to build capacity. This lack of specification is similar to the Francisco et al. (2001) model as well. Whether removing all of the barriers defines the ability of a community to build capacity is uncertain, yet, as one barrier is overcome new challenges can take its place creating a cyclical issue in the models. Clarifying these aspects increases the likelihood of being able to evaluate when and how a community has increased capacity.

Creating a defined set of characteristics or capacity indicators does not infer that the model is inherently reflective; rather this must be proven in either direct written word or the way in which capacity is assessed after applying an aforementioned model. The inference made by Lyons and Reimer (2006) certainly provides a new view of capacity modeling in the context of capacity framework features. Their five additional features of capacity framework include: capacity as a condition or process, the outcomes considered, capacity as endogenous or exogenous, level of capacity analysis, and character of outcomes (positive or negative). When analyzing capacity models understanding the different framework features of each model provides needed insight into how each capacity model works.

As demonstrated in most capacity models the indicators of capacity can be grouped into six different domains: community, institutional, linking, knowledge, skills and abilities, and resource mobilization/transfer (Verity, 2007). The ways in-which capacity are carried out are considered the strategies, also referred to as indicators within this thesis, which address the different domains. These strategies are the building blocks in capacity models to achieve the community capacity.

Urban and Community Forestry Capacity

Community capacity within U&CF programs has been measured primarily by a singular approach. This approach has well-defined strategies but as Hauer (2006) points out, "… most local U&CF programs vary from inactivity to partial steps leading to sustainable urban forests." Thus, U&CF capacity models are rarely fulfilled. The continuum of capacity that communities are placed on and measured, are reported through a federal program known as the Community Accomplishment Reporting System (CARS).

The primary measures of CARS are stated below[6]:

- Percentage of US population living in communities managing programs to plant, protect and maintain their urban and community trees and forests.

[6] "CARS" *US Forest Service; Budget & Performance*. 2011. http://www.fs.fed.us/ucf/about_budget.shtml (16 October 2011)

- Percentages of US population living in communities developing programs and/or activities to plant, protect, and maintain their urban and community trees and forests.
- Number of people living in communities provided with educational, technical, and/or financial assistance services.
- Number of people living in communities that have the potential to develop management programs for their trees and forests with assistance from UCF technical, financial and/or educational program services.
- Federal United States Forestry Service dollar cost or expenditure per capita in community assisted.

Below are listed the direct indicators for these measurements as defined by CARS.

1. Securing or training professional staff
2. Developing and implementing an urban forestry management plan
3. Building and strengthening citizen advocacy and action organizations
4. Developing and adopting tree and forest ordinances and policies
5. Achieving Tree City USA® accreditation
6. Coordinating community tree and forest management decisions among municipal departments. [7]

[7] "Urban and Community Forestry" *Forest Resources Strategies for Massachusetts*. June 2010. http://www.mass.gov/eea/docs/dcr/stewardship/forestry/massachusetts-forest-resources-strategies.pdf (17 August 2014).

Within this conditional and reflective model of capacity, CARS community success is directly associated with government assistance. An illustrated spectrum displays the interaction between government and communities in regards to community capacity building, see Figure 1 (Cavaye and Queensland. Dept. of Primary Industries, 1999; Arnstein, 1969). The CARS program can range anywhere from 'informing of decisions' to 'structured community involvement.' Since state funding for U&CF programs is dictated by the accomplishments based on the CARS measurements, state programming for U&CF has little independent design. This model leaves a lot to be desired in regards to sustainability of community capacity. The sustainability of capacity requires a dynamic model with a formative approach. One example of this model has been developed by Clark et al. (1997).

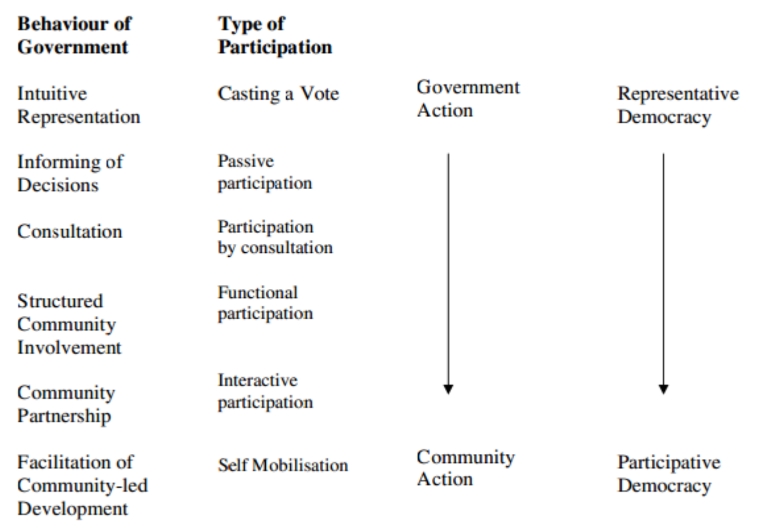


Figure 1. Engagement spectrum of government participation styles (Cavaye, 1990; Pretty, 1995; Arnstein, 1969).

Clark et al. describes "… specific criteria that can be used to evaluate sustainability, as well as measurable indicators that allow assessment of those criteria. In so doing, sustainability (is accepted) as a process rather than a goal" (Clark et al., 1997). The components of Clark et al.'s sustainability are vegetation resources, community framework, and resource management. For each component several criterion are used. Many of these criteria are the standard for U&CF capacity measurement: inventory of urban forest, management plan, funding, staffing, etc. Using a simple 0-4 indicator, Clark et al., creates a replicable survey for future assessment of U&CF sustainability.

What these approaches lack is an evaluation piece which succeeds in identifying the barriers to using or improving U&CF programs once basic components of a program have been met.

A New Approach Defining Capacity

More directed and defined criteria are presented by Hauer (2005) through three different levels of government: federal, state and local U&CF program capacity. The potential inputs at each level affect the next smaller governing level. Hauer combines Clark et al.'s work with previous research in the state of Minnesota to suggest a new model of U&CF capacity driven by financial assistance to communities (Hauer, Johnson, and Kilgore, 2011). Appendix A presents Hauer's (2005) model divided into seven components which then place a community in one of four different areas of U&CF capacity: project, formative, developmental or sustained. This model is taken from USDA-FS Performance Measurement Accountability System (PMAS) which was rolled into the CARS system. Unlike CARS, the PMAS is more detailed and restrictive; less than 10% of communities in the US received a rating of sustainable in 2003 (Hauer and Johnson, 2008). Out of this research also came three new definitions of urban forestry capacity based on available structural components which provide a deeper understanding of capacity building attributes.

> *Urban forestry program capacity* – the infrastructure an urban forestry agency, entity, municipality, non-profit organization and others have in place to support urban forest development and sustainability at a local, regional, or national scale

> *Urban forest development capacity* – the ability to incrementally improve the state of the urban forest to a higher level with a given set of infrastructure or inputs

Urban forest sustainability capacity – the level of infrastructure or inputs needed to maintain the urban forest at a given state within a given time period. (Hauer, 2006)

A community can have a high level (or degree) of capacity in one, two or all three of the above types of capacity. This allows a more liberal take on U&CF capacity providing communities the ability in a structured and defined way of achieving greater capacity in urban forestry. Each definition focuses on a specific set of structural components to break down the idea of U&CF capacity as a whole. Success of capacity is measured in the infrastructural achievements to a program which can be varied in type. The two definitions of specific interest are developmental and sustainable capacity. Inputs used to measure the capacity within each of these definitions included U&CF activities such as: Community Tree Board, Arbor Day celebration, local expertise, management plan, current inventory, educational programs and community tree ordinance (Hauer and Johnson, 2008).

In 2001, Hauer tested this model at a local level using 854 Minnesota communities. These communities received a survey using the Tailored Design Method (TDM) suggested by Dillman (2000). Questions within this survey were based on several previous surveys by the Minnesota Departments of Agriculture and Natural Resources (1987, 1989, 1990 & 1996). Out of the 854 surveys sent, 577 were returned with detailed information regarding current U&CF practices and programs. Using this data, Hauer was able to rank a community's capacity for urban and community forestry. Basic indicators used to rank communities included: administration, education, inventory, maintenance, ordinance, projects and staffing as related to urban and community forestry.

The two areas of interest in much of Hauer's research in U&CF capacity were financial and technical assistance. As stated by Hauer et al. (2011), "Financial assistance and technical assistance are two specific means used to build local U&CF capacity measured through greater local activity in U&CF programs" (Hauer, Johnson, and Kilgore, 2011; Elmendorf, Cotrone, and Mullen, 2003; Dwyer, Nowak, and Noble, 2003). Technical assistance in Hauer's model is clearly linked to the financial assistance provided to local and state levels yet Hauer et al., (2011), backs away from this view as greater data analysis is completed: "…both financial and technical assistance are perceived important; however, contrary to recipient perceptions or desires, this study found technical assistance had a greater impact with increased local activity."

Despite this correlation, there was no attempt to differentiate types or forms of technical assistance. The definition of technical assistance for U&CF capacity measures varies but generally accepted CARS criteria include: management plan development, inventory, tree planting and ordinance development. This limits again the evaluation of success in capacity building as it does not define the qualitative attributes that are necessary to ensure a sustained program. Out of these criteria, inventory and tree planting can have the greatest social impacts as multiple members of a community can be involved with little to no commitment or U&CF knowledge. These two forms of technical assistance are common and provide insight into one of the two areas of U&CF capacity building, people.

Social Infrastructure

Members of a community can often be over-looked as states and the federal government attempt to measure quantitative aspects of U&CF programming. However, the social infrastructure is critical, specifically to U&CF programs, as government funding continues to drop and priorities shift. The power of social infrastructure to provide a measure of importance relies on the ability of U&CF programming to capture the attention of community members and create a linkage between U&CF programs and an individual's top priorities. Luckily, U&CF programs provide multiple types of opportunities for participation which is likely to resonate at some level with any individual. Understanding the need for public participation is another matter.

The foundation of any capacity "building" program has to incorporate essential elements such as the social engagement or empowerment features. These features are key access points to the potential sustainability of any successful community capacity structures

(Cavaye and Queensland. Dept. of Primary Industries, 1999; Simpson, Wood, and Daws, 2003; Fraser et al., 2006). National programs, like the Arbor Day Foundation, recognize this need for citizen participation in U&CF programs and have implemented criteria through their applications to spur communities in this direction[8]. These approaches promote the inclusion of citizen participation, yet not all programs are equal in how this objective is achieved nor do all programs consider the best strategy to fully engage the participant.

Participation & Engagement

The success of citizen participation is heavily influenced by the ability of an activity or action to engage and empower the participant. Activities engage the participant and community decision makers then empower the participant further through accepting or displaying signs of active listening. This work of empowering participants, actively listening and in parting decision making ability, results in the participants feeling empowered. The two concepts of engagement and empowerment generally go hand-in-hand, implying that a person has already been engaged if they are considered to be empowered as well. In research presented by this thesis, engagement is assumed by a volunteer's willingness to participate in the project, freely giving up valuable time to take part in training and inventorying their urban forest. This capturing of attention is the first step in gathering participation. Although not readily implied, this concept is apparent in Rowe and Frewer's (2005) argument of defining public participation as a form of engagement. To better understand how to engage a participant in urban forestry organizations, practitioners need to understand the motivation behind a willing and un-willing participant. Since engagement and empowerment fall into the psychological arena it only makes sense to study these motivations through a lens of psychology as well.

A recently published study from Moskell et al. (2010) analyzes urban forestry volunteers using two psychological theories. The Volunteer Process Model (VPM) and the Volunteer Functions Inventory (VFI). The VPM first developed by Snyder and Omoto

[8] Arbor Day Foundation requires an Arbor Day planting ceremony and tree board consisting of community citizens or a department head for the planning and managing of U&CF programs.

(2008), “is a social psychological framework that addresses the antecedents, experiences and consequences of volunteerism at individual, interpersonal, organizational and societal levels” (Moskell et al., 2010). Originally used in the public health field, this model allows for the understanding that individuals have a variety of motivations for volunteering all based on different needs and desires. These motivations or “functions” are defined in the VFI, see Table 2.

Function	Conceptual Definition
Values	The individual volunteers in order to express or act upon important values that are important to them like humanitarianism
Understanding	The volunteer is seeking to learn more about the world or exercise skills that are often unused
Enhancement	The volunteer can grow and develop psychologically through volunteer activities
Career	The volunteer has the goal of gaining career-related experience through volunteering
Social	Volunteering allows an individual to strengthen his or her social relationships
Protective	The individual uses volunteering to reduce negative feelings such as guilt or to address personal problems

Table 2. Volunteer Functions Inventory (Adapted from Clary and Snyder, 1999, p. 157; Moskell et. al., 2010)

As Moskell et al. (2010) notes in their review of prior motivational studies, very little work has been conducted with a specific focus on urban forestry volunteers. Still and Gerhold (1997) is one of the few studies that predate Moskell et al. with results that present some general uniqueness to the field of U&CF. “Improving one's neighborhood was the most important reason for volunteering, and the desire for education was also important. The desire for social interaction was only moderately important” (Still and Gerhold, 1997). Moskell et al. adds to this body of knowledge by analyzing the motivations of volunteers specifically through tree-planting efforts. The largest percentage of agreement on motivation for tree-planting was for the environmental benefits a tree provides.[9] Two other considerations from this study include that nearly all

[9] 30% of survey respondents viewed the environmental benefits as the number one reason they volunteer to plant trees, following this the largest groups were community service at 23%, benefits to youth 20%, and enjoyment of planting trees 20%. (Moskell, Broussard Allred, and Ferenz, 2010)

respondents (93.3 percent) had behavioral intentions of participating in a similar tree-planting activity in the future and 80 percent of volunteer respondents were affiliated with an organization rather than participating as a solitary individual (Moskell, Broussard Allred, and Ferenz, 2010). Utilizing the motivations for volunteering is necessary to providing a directed solicitation for participation, in combining this with methods of citizen involvement a link is created between individual priorities and U&CF programming.

Participation & Empowerment

Public participation in the realm of public planning has been dissected by quite a few scholars. Arnstein (1969) used a model of citizen involvement and ownership to describe the level of participation based on empowerment, see Figure 2. This understanding is the basis of most early public participation work. Arnstein looked upon participation as a result of what an authority allowed for involvement rather than what a community group could achieve. In this sense participants had no choice as to where they fit on the ladder. The goal of programs attempting to sustain long-term is to achieve participation somewhere in the top portion of the scale, which would also provide more involvement for the participants as well (Arnstein, 1969).

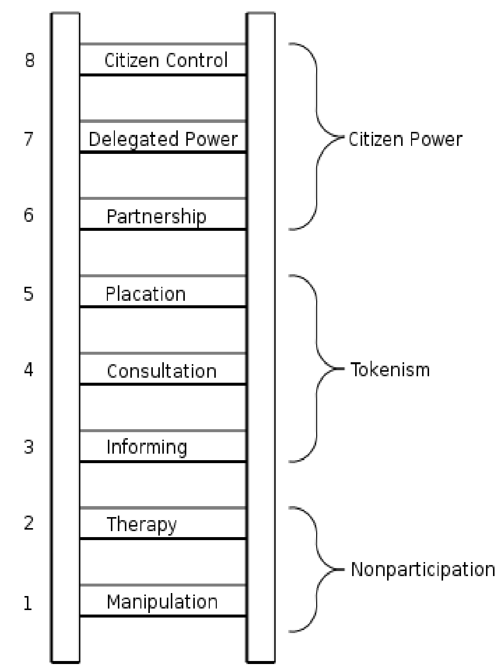


Figure 2. 8 Rungs on the ladder of citizen participation. (Arnstein, 1969)

Glass (1979) moved the field of research further by focusing on the objectives of participation. He held five objectives to be the root of participation practices: *information exchange, education, support building, decision-making supplement, and* *representational input*. These objectives could be used in four techniques of participation as well: *unstructured, structured, active process, and passive process* (Glass, 1979). These objectives and techniques fit well with the general reasoning behind volunteer motivation. The motivation in natural resource related projects has been described by Ryan et al. (2001) to involve two aspects, "… a desire to help the environment and to learn new things as part of their volunteer effort." This reinforces the results from Moskell et al., 2010, and Still and Gerhold, 1997. The desire for education and affecting the environment are echoed in several directed studies for volunteers in tree plantings and other urban forestry projects (Moskell, Broussard Allred, and Ferenz, 2010; Austin, 2002; Westphal, 2003; Westphal, 1993). These motivations of participation when successful are positively correlated to the concept of empowerment (Florin and Wandersman, 1984; Prestby et al., 1990).

Empowerment & Active Involvement

Empowerment in the context of urban forestry has been studied at length by Westphal in several publications. Yet, before diving into the realm of urban forestry, it is beneficial to make the distinction between *empowered* and *empowering*.

Empowerment is a conceptual construct on multiple levels; state, community, organization and individual. It is the organizational and individual levels that are considered within this project. Both the organizational and individual levels are interconnected. Individuals influence organizational constructs occurring within a community, creating an empowering organization and / or an empowered organization. Zimmerman (1995) distinguishes between the two in the following manor.

> *"Organizational empowerment includes processes and structures that enhance members' skills and provide them with the mutual support necessary to effect community level change (i.e. empowering organization). He also points out that it refers to improved organizational effectiveness by effectively competing for resources, networking with other organizations, or expanding its influence (i.e. empowered organization)."*
>
> (Zimmerman, 1995)

The ability of an organization to achieve an empowering or empowered status is integral to individuals' sense of control over their environment. Both of these words (*empowered and empowering)* hold root in the idea of psychological empowerment (PE). PE is an analysis of empowerment at a singular level, i.e. the individual (Zimmerman, 1995). This can be accounted for in a combination of perceptions; "personal control, a proactive approach to life, and a critical understanding of the sociopolitical environment," along with "increased mastery and control, increased skills, access to resources and ties within and outside the community," (Westphal, 2003; Perkins and Zimmerman, 1995). Zimmerman's approach to empowerment created a new working definition which delineated among the different ways of psychologically analyzing and interpreting the behavioral changes and intentions of individuals. An individual becomes *empowered* when they, "show mastery of skills, control over aspects of their environment, and an ability to make changes that lead to a higher quality of life for themselves (and sometimes others)," (Westphal, 2003). An individual's actions may influence another group or person to also become empowered; i.e. the individual is said to be *empowering* another. This multilevel view to empowerment allows projects and organizations to tailor approaches to achieve the greatest maximum potential. When participation and PE are used in concert, creating participatory approaches which promote and enable individual empowerment, the outcome results in increased community capacity translating into an ability to support and build stronger community infrastructure (Fraser et al., 2006; Prestby et al., 1990; Fawcett et al., 1995; Gittell and Newman, 1998).

A Focus on Urban Forestry

Similar to engagement studies of participation, very little research has been conducted on empowerment in U&CF programs. The two most common areas of technical assistance, tree planting and inventory, uphold the greatest ability to incorporate a wide range of participants and involve the aspects of engagement and empowerment. It also happens that these two forms of technical assistance create the majority of literature within U&CF for analyzing these psychological traits.

Non-profit and community organizations thrive on tree-planting activities. These are the desired hands-on approaches for most grant funding opportunities in U&CF. Tree planting activities are successful events which can involve youth to adult. This can be the impetus for introducing youth to the outdoors and at the same time providing an opportunity for adults to act as role models. Westphal (2003) correctly identifies that not all projects produce the desired outcome of empowerment. With the invigoration of participatory approaches, it is easy to portray many projects as achieving a level of individual empowerment yet this claim is not a sustained form of capacity building. For example, community tree planting events which consist of volunteers, a brief demonstration on correct planting tips, and a social event of basic labor, are one of the most common methods believed to provide support and engagement techniques. These once or twice a year activities are limited in their ability to obtain commitment and provide further defined needs of the volunteers; *information exchange, education, support building, decision-making supplement, and representational input* (Glass, 1979).

A shift in funding has restricted these programs since many of them are supplemented through state U&CF funding. Although tree planting programs are still important, fewer communities can afford to maintain the trees they plant along with conducting seasonal forestry activities such as pruning, watering, mulching, trimming, and tree removals. As evidenced by the difficultly of communities dealing with emerald ash borer, municipal staff is overloaded by removals and seek contractors to complete the work or municipalities refrain from planting trees due to the current stress and declining budget (Adams, 2012). By developing a method of engaging a resident to not only plant a tree but also maintain it is critical for the future of urban forests. Adjusting programs to ensure the needs of volunteers are met, Glass (1979) attempts to create a fundamental attitude shift that will impact future behaviors. Through the tentacles of citizen networking and focused programing, momentous attitude and behavior change can readily take place.

Attitudes and Behaviors

Attitudes concerning natural resources have been an important component of sustainability and capacity; (Hauer, 2006; Chaskin, 2001; Dwyer and Schroeder, 1994; Green et. al., 1998; Summit and Sommer, 1998; Tarrant and Cordell, 1997; Werner et al., 1995; De Oliver, 1999; Chess, 1999). Attitudes toward an object affect behavior regarding that object, i.e. a positive attitude toward urban trees is associated with a person's behavior of planting trees within their yard or community. The relationship between attitude and behavior has been a substantial focus of social psychology (Eagly and Chaiken, 1993).

In the late 1960s, Alan Wicker (1969) published an extensive empirical review of attitude-behavior research. He claimed there was "little evidence that people possess stable underlying attitudes that influence their overt behavior," (as cited in Eagly and Chaiken, 1993, p. 155). During this same time Martin Fishbein published a process in which "attitudes might serve as causes of behavior" (Eagly and Chaiken, 1993, p. 168). This process was later called the *theory of reasoned action* and published by both Fishbein and Icek Ajzen in 1975. Their theory hypothesized that, "People are assumed to behave as they intend to behave. They intend to behave in ways that allow them to obtain favorable outcomes and that meet the expectations of others who are important to them," (as cited in Eagly and Chaiken, 1993, p. 173). Unfortunately, this theory was restricted in its ability to incorporate external variables that may inhibit one's behavior (later known as perceived behavioral control), e.g. a person may have the intention to plant a tree, but is restricted in their ability to carry out this action due to monetary or time constraints. In attempts to enlarge the model provided by the *theory of reasoned action,* Ajzen and Fishbein proposed a simplified and revised theory for behaviors which are not under volitional control, the *theory of planned behavior*.

The theory of planned behavior provided a new theoretical framework approach to behaviors, see Figure 3 (Eagly and Chaiken, 1993; Ajzen, 1991). There are three latent predictors of behavioral intention: attitude toward the behavior, subjective norm (influence others have) and, perceived behavioral control. The major difference in this model, compared to its predecessor, is the last predictor. Perceived behavioral control can affect behavior in two ways: “It influences intention to perform the behavior, and it may have a direct impact on behavior,” (Eagly and Chaiken, 1993, p. 187). Assuming both

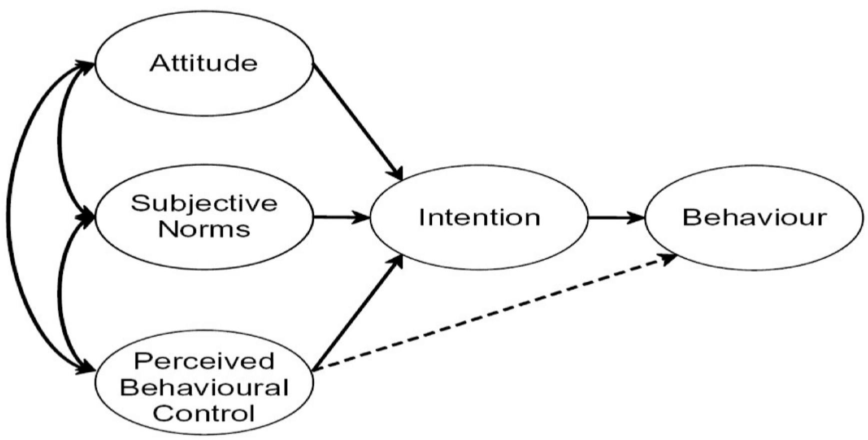


Figure 3. Diagram of the theory of planned behavior (Borgida and Spring, 2011).

the attitude and subjective norm are favorable, with respect to the behavior, the greater the perceived control over the behavior. This is theorized to lead to an increased intention to act on the behavior, or as in the previous example, to plant a tree (Ajzen and Driver, 1992). The theory of planned behavior allows researchers to understand what variables affect a community’s willingness to volunteer or pay for nonmarket goods or services.

Incorporating new variables such as group cohesion, which would create internal pressure to conform to the group norm, and increased education and awareness of the direct relationship urban trees have on daily life, may provide a strong enough influence to increase the intention to act on a specific behavior. Combined with an empowering atmosphere, individuals would have the opportunity to build the capacity of their community for U&CF programming.

Physical Infrastructure

Physical infrastructure in a community can be just as important as social infrastructure. The physical infrastructure in a community is defined for the purposes of this paper as the quantitative or tangible aspects of urban forestry within a community. These aspects can include; funding, equipment, stock, trees and personnel for the community. Out of these different physical infrastructure categories, funding can be a key for change in any of the other areas. Different funding levels impact the amount and type of equipment a community owns or rents, the number of trees a community can buy, and the amount of maintenance/management provided to planted trees.

In a typical municipal fiscal year, tree planting and maintenance are two of the main budgeted expenses. The number of trees a community can plant should be planned around the ability of personnel and funding to adequately care for "x" number of trees. By exceeding the ability of a community to care for its trees, the urban forest in the community suffers through lack of pruning, watering, mulching or siting and removal of hazard trees. Ironically, many communities face the opposite issue of not being able to plant enough trees due to budget constraints. In the case of the research presented in this thesis, increasing the number and quality of trees a community was able to plant through the use of new 'equipment' without adjusting their annual planting budget allowed communities to counter the effects of EAB on their urban forest. Consideration for future maintenance and personnel was determined by each individual community thus allowing the communities to assess their own capacity to maintain and care for the increased number of trees they were able to plant.

Tree Stock Production and Harvesting

There are three common types of tree stock; bare-root, container-grown, and balled-and-burlapped (B&B). Bare-root trees are field grown trees which, when harvested are dormant and all soil is removed from the root system. These trees are generally smaller in caliper and easier to handle due to their light weight. A significant limitation of bare-root trees is these trees are best planted when trees are dormant or before bud-break. This means that most bare-root trees must be planted in the early spring and cannot be kept for planting later in the season. In bare-root harvesting it has been observed that 200% more roots are left intact than in B&B harvesting methods (Buckstrup and Bassuk, 2000). Trees harvested in this method are pulled from the field in the fall once the trees have gone dormant and they are placed in cold, high humidity storage over the winter. Trees are graded and tagged during the winter months and then sold for spring planting in the dormant state. Some trees, many of the oak species, require a 'sweating' period prior to planting. Sweating is a process of rehydrating the root system and warming the plant out of deep dormancy or more specifically endodormancy, dormancy that results from "physiological factors inside the affected structure" (Pallardy and Kozlowski, 2008, pg.43). Although the species may vary, nurseries generally advise sweating of many bare-root plants for a successful transplant.

B&B trees are field grown and harvested with large field equipment, generally a tree spade. Although, these trees can be hand-dug the process is quite arduous and intensive compared with the advancements in technology. Once a tree is spaded from the ground with a ball of soil surrounding the root system, the soil-ball is then enfolded in burlap or other material and typically a wire basket is wrapped on the outside to support the shape of the soil-ball during transport. These trees require multiple people to move and/or heavy equipment due to the preferred large caliper of B&B trees and the increased ball of soil that must accompany the increased tree size. B&B trees are harvested throughout the season, but care must be taken to ensure a structurally sound soil-ball to prevent damage to the root system. It is recommended that B&B trees be harvested early spring and late fall to decrease transplant stress (Watson and Himelick, 1997). During harvesting of the root ball in the B&B method more than 95% of the root system can be left behind at harvest sites (Harris and Bassuk, 1993; Watson, 1987).

Container-grown stock is not a harvesting method but rather a production method. This production method can be popular for nursery business models due to its independence from field production methods that require specific site requirements (Watson and Himelick, 2013). Container-grown stock are produced in pots and transplanted several times throughout nursery life to avoid stress and limiting growth factors. These container-grown trees are easy to handle and transport due to their smaller caliper size and uniform spacing. Trees container-grown retain 100% of their root system as it is completely contained inside the pot or bag used for growing. This provides certain advantages when transplanting trees compared to B&B stock, but due to the lighter growth medium used in the pots increased care is needed to ensure the roots stay adequately moist. Another concern with container-grown stock is the risk of pot-bound root systems. These are root systems that have out-grown their pot, by reaching the edges of the container. If pots are not up-sized or if root growth is not altered by a method such as air pruning, they will begin to circle the edges of the pot causing significant malformations that can result in numerous issues including instability, poor growth and stem-girdling roots (Johnson and Fallon, 2007).

There are several advantages and disadvantages to each type of stock. To summarize the main points, the table below has been developed.

	Bare-root	B&B	Container-grown
Advantages	• Large percentage of root system remains • Easily handled • Minimal Equipment • Root defects can be detected • Least expensive of all stock types	• Large size trees are easily attained • Traditional harvesting method for nurseries • Soil-type can be matched for greater success • High transplant success rate	• 100% of root system • Planting season extended • Easily handled • Minimal Equipment • Moderate to high transplant success rate
Disadvantages	• Sweating required for many species • Best transplant success when trees are dormant/bud enlargement (early spring) • Moderate transplant success rate • Roots require constant moisture	• Loss of 95% of root system • Equipment and personnel needed for transport and planting • Expensive production method • Increased ability to plant tree too deeply	• Potential for de-formed root systems • Increased nursery production cost • Frequent irrigation and care during and after transplant

Table 3. Comparison of three common stock types (Watson and Himelick, 1997; Harris and Bassuk, 1993).

Once a specific stock type is chosen, or a combination of stock types, tree planting is the next step. Practicing good planting techniques such as planting a tree in the proper place, at the proper depth and with the proper follow-up care, creates the least amount of stress possible on a tree which aids in the transplant success of a tree (Harris and Bassuk, 1993; Watson and Himelick, 2013; Santamour, 2004).

Planting

Urban soils are notorious for being poor sites for tree growth and survival (Watson and Himelick, 2013; Nowak et al., 2004). Compounding the survival rate of urban trees are the preparations taken prior to placing a tree in the ground. Both B&B and container-grown stock require personnel to find the proper planting depth and ensure roots are in adequate shape so as not to begin the formation of encircling the tree trunk. Although much of this responsibility should fall back onto the nurseries in growing and harvest, this is not typically the case. The improper depth of root systems greatly inhibits the growth and vigor of trees. The susceptibility of tree species to planting depth can vary but a higher mortality rate has been noted in many studies (Watson and Himelick, 2013; Arnold et al., 2007).

Bare-root stock avoids both of these problems by the first order root being clearly visible along with the root system structure (Buckstrup and Bassuk, 2000). Unlike the prior stock types bare-root trees have no protection for the delicate root hairs and apical cells. Damaging these tissues of the root can cause transplant shock as discussed in this following section. To prevent this type of damage, bare-root trees require roots to be continually moist. One artificial way of preventing desiccation is through the application of an antitranspirant of a hydrogel dip. Failure to comply with the needs of each stock type during plant out can result in tree mortality through desiccation or transplant shock (Buckstrup and Bassuk, 2000; Watson, 1987; Struveet. al., 2005; Watson, 1986).

Transplant Shock

Struve et al. (2000) describes transplant shock as, "a temporary condition of distress resulting from injuries, depletion, and impaired function [of a tree]." This condition is primarily due to the significant removal of fine roots during harvest and transportation of a tree (Watson, 1985; Gilman et. al., 1998). These fine roots are responsible for the absorption of water and nutrients (Kozlowski and Davies, 1975). Other factors affecting transplant shock have been hypothesized and identified as planting conditions, handling, provenance, type of root system, species, time of transplant, etc… yet, the amount of root system removed or displaced during transplant is directly associated with the vigor of the tree following transplant (Watson, 1985; Lauderdale et al., 1995). Roughly 15-5 percent (Harris and Bassuk, 1993) or less of a B&B tree root system remains following harvest (Watson and Himelick, 1997; Watson, 1987). Bare-root trees by comparison retain "200% more roots" than B&B (Hillman and Bassuk, 2009).

The size of tree has also been identified as a factor for transplant establishment. Several studies have compared the length of time it takes a tree to become "established," producing growth similar to that of an un-harvested and transplanted tree (Watson and Himelick, 1997; Watson, 1985; Gilman et. al., 1998; Lauderdale et al., 1995). This establishment period has been defined by the density of the root to achieve a pre-transplant root system, roots typically have to grow to a distance equal to "three times the diameter of the canopy width" (Watson, 2005). Although root systems of smaller and

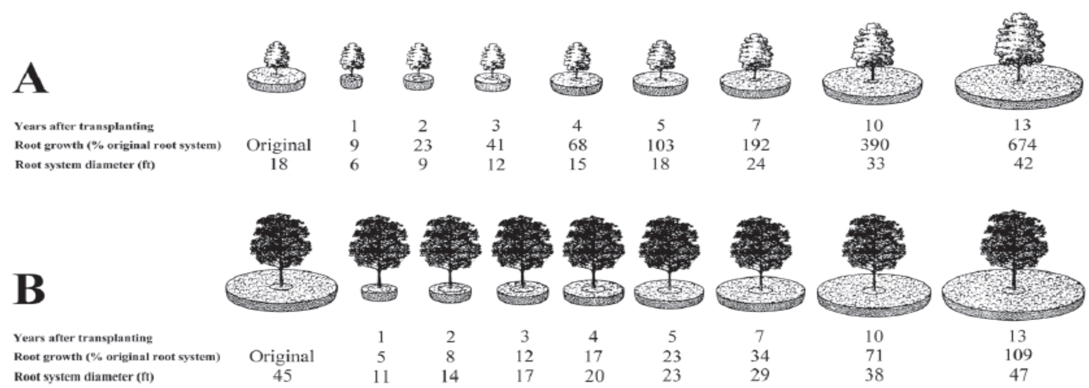


Figure 4. Relationship with size of tree and growth after transplant (Watson, 1985).

larger trees elongate at the same rate, it takes a smaller tree less time to reach the required spread than a larger volume tree (Watson, 1985). Thus a smaller tree will begin to put on regular, established growth far earlier than a larger tree planted at the same time, see Figure 4.

Survivability & Cost

Survivability and cost are two major factors when considering the type of stock to plant. Balled-and-burlapped trees are 50-70 percent more expensive to purchase than their bare-root counterparts (Buckstrup and Bassuk, 2009). Despite this price difference B&B trees are still purchased and used in urban planting. In a reversed review, a study conducted by Cool (1975) compared bare-root and B&B stock costs and concluded that the total costs for a bare-root tree was 2.5 times the calculated cost of a B&B tree. This was due to the significant mortality rate associated with bare-root trees. Since his study, there has been an increase in directed education regarding proper planting practices. Harris and Bassuk (1993) have provided significant insight to the correct planting of bare-root trees to minimize the risk of transplant mortality. They identified several planting considerations when handling bare-root material: prevention of planting too deeply, root desiccation and most importantly, "seasonal restraints", which followed when bare-root stock should be dug and planted for best survival rates, primarily viewed as spring.

A more recent attempt at circumventing seasonal restraints and improving the root system of bare-root stock has been with the development of gravel bed systems. Starbuck et al. (2005) bucked the traditional planting season for red oak and green ash by utilizing a Missouri gravel bed system, also known as a community gravel bed. Starbuck et al. heeled in the trees during the spring months to reduce transplant shock. By invigorating the root systems and increasing the number of fine roots, the trees were successfully transplanted in the summer and displayed fewer symptoms of transplant shock and recovered in a shorter period of time. In Minnesota, this same method of heeling in bare-root stock has been used throughout the state to increase the survivability of bare-root material, therefore decreasing the cost. By combining bare-root stock with gravel bed systems, communities can increase the number of trees they plant, remove the limitation of planting season for bare-root and decrease their over-all cost due to the low cost of bare-root stock and higher rates of survivability.

Research Outline

Since the last state funded survey of U&CF activities, Hauer (2001), the economic ability of communities to support their programs and activities has declined dramatically. It is necessary to determine the worth of technical assistance projects in building social and physical infrastructure in a community. The value of such assistance as cited by Hauer can have more significant impact than funding on capacity building in U&CF programs. A federally funded project was used as the impetus of measuring and assessing technical assistance to Greater Minnesota communities. Six communities throughout Minnesota were specifically invited to participate in the Emerald Ash Borer: Rapid Response (EAB:RR) project, which was used expanded upon the results of Hauer's 2001 U&CF programming survey.

Two components of the project were assessed for their ability to affect U&CF capacity. The first section was manipulating the presentation of technical assistance in relation to social capacity of a community. Component (I) dealt with empowering and engaging community members in U&CF activities, specifically inventory techniques. There were two divisions representing empowerment and engagement within each community: 1) a lead volunteer coordinator, city department, governing body or official that empowered citizens of the community and was responsible for organizing community volunteer activities, and 2) the community volunteer structure, consisting of citizens who were trained in tree inventorying and emerald ash borer management by the University of Minnesota's urban forestry technical assistance team.

The second section of the project focused on the increase in physical U&CF infrastructure within the communities. Component (II) used the efforts of reforestation due to the threat of EAB to measure the benefit of using a community gravel bed system (CGB). By assessing the use of this system as a cost effective method of purchasing, holding and improving species diversity for public spaces within a community, more trees would be planted without adjusting the budget of a U&CF program. Many programs lack a dynamic structure to allow sustainable and long-term work. Both components used in this study were viable for sustainability and continued progress towards goals.

Technical assistance is a common and relatively open term which obstructs the identification of specific actions that lend to engaging and empowering projects. By comparing and contrasting the impacts of technical assistance given to a community through the project to that of typical federal or state technical assistance programs, i.e. control communities, the significance of indicators used in assessing the success of the technical assistance provided begins to take shape. These impacts in turn provide the stimulus for improving community capacity. By using previous research in community capacity, along with integrated indicators created for this research the ability of this new mode of technical assistance is tested.

The following research questions were created to understand the effect of technical assistance on urban and community forestry capacity.

1) Did involvement in the EAB:RR project affect the urban and community forestry capacity through the technical assistance provided?

2) Are the impacts and characteristics of the social or physical infrastructure for urban and community capacity sustainable?

Based on the review of literature and project model, the following hypothesis was created:

---

1) *Did involvement in the EAB:RR project affect the urban and community forestry capacity through the technical assistance provided?*
   Ho: Involvement in the EAB RR project had no effect on the urban and community forestry capacity.

   Ha: Involvement in the EAB RR project had a noticeable effect on the urban and community forestry capacity through the technical assistance provided.

Materials and Methodology

Using quantitative data collection methods, two questionnaires and one data collection sheet were developed to address and answer the research questions and hypothesis. These data tools were used in the context of the grant project described below.

In 2009, an appropriation from the state legislature allowed the creation of a joint project through the Minnesota Department of Agriculture, Minnesota Department of Natural Resources, the University of Minnesota Extension, and the University of Minnesota Department of Forest Resources, to provide training and assistance to communities across the state of Minnesota. This project was implemented by the working group known as the Community Engagement and Preparedness Team, housed under the University of Minnesota Department of Forest Resources.

Several communities were preselected for participation in the EAB:RR project. Communities were distributed geographically throughout the state and represented population classes ranging from less than 1,000 inhabitants to 25,000 or more. These population categories reflect the similar style of governance and budgetary constraints for that population size within the state of Minnesota.

Upon initial contact communities were provided with information regarding the project and were able to self-select for participation. In 2009-2010, a total of six communities were identified as participates in the EAB:RR project: Crookston, Hendricks, Hibbing, Hutchinson, Morris and Rochester.

Each community selected a coordinator or government official that provided a contact for all information dispersal and communication. The communities self-advocated this project to their residents and gathered a group of 6 to 25 volunteers to participate in the first project objective, conducting an inventory. Each volunteer was required to participate in a 10-12 hour training session which occurred the spring months of 2010. Once the training was complete, volunteers conducted a “mock inventory block” with the project leaders from the University of Minnesota team and were then given the leeway to continue the rest of the inventory on their own. When questions arose from the communities, a team member either responded to the community via email or traveled to be on-site within the community. Four of the six communities completed their inventory before the winter of 2010 and two communities finished by June of 2011.

Another eight communities were identified as participants in the 2011-2012 round of the EAB:RR project. Four of these eight communities completed a pre-assessment survey discussed below: Bemidji, Royalton, Starbuck and St. Cloud.

Survey Development and Assessment

Five surveys were developed to assess various aspects of the project. All five surveys were reviewed, and field tested prior to use. Professor Mary Ellen Murphy, of the Humphrey School of Public Affairs, University of Minnesota, provided significant input in the validity of the questions for evaluation purposes. Participants were pre-identified and contacted due to the small population applicable to complete each survey. One of two methods were employed in filling out the survey: on-line or by paper. SurveyMonkey® survey tool was used to create, fill and analyze the data. Paper copies of surveys were a printable format from SurveyMonkey® and entered back into the on-line database for storage and comparison.

Message Subject	Send Date	Number Sent
Community 6 Tree Inventory Volunteer Survey	Mailed on June 17, 2011 8:55 AM	11
Community 5 Tree Inventory Volunteer Survey	Mailed on June 17, 2011 8:27 AM	13
Community 4 Tree Inventory Volunteer Survey	Mailed on June 7, 2011 9:43 AM	8
Community 3 Tree Inventory Volunteer Survey	Mailed on February 16, 2011 1:01 PM	20
Community 2 Tree Inventory Volunteer Survey	Mailed on February 16, 2011 9:55 AM	10
Community 1 Tree Inventory Volunteer Survey	Mailed on February 16, 2011 9:35 AM	16

Table 4: Post inventory survey delivery schedule using SurveyMonkey®.

The first pair of surveys were pre-training and post-inventory surveys of volunteers within participating communities, see Table 4. The objective of these questionnaires was to collect data on the level of activity and present attitudes of volunteers before and after completion of the EAB:RR project. Forty-seven surveys were collected in all for the project-community volunteers. Attitude and behavioral questions were used to assess the changes over time from engaging in the EAB:RR project. Post inventory surveys focused on behavioral intent as an identifying factor for significant change. Fifty-one volunteers from project communities completed the post project survey. The survey field tests were conducted on January 25, 2011 with five Minnesota Tree Care Advisors using computers for the sample survey. Comments received from the field tests were reviewed and the surveys revised. Due to the small subsample size and direct relationship with each volunteer, it was identified that further prior action was not required before sending out the questionnaire. Any 'un-responded' volunteer two weeks following the initial email, also received an email reminder. Volunteers provided with paper copies were given the survey on the first day of inventory training and asked to fill the survey out prior to beginning the training. Surveys were collected and training proceeded. Due to the differences in community project start and finish dates, surveys were provided at different times to each subset of the population sample. The volunteer survey was analyzed using a mixed model for the fixed effect of pre and post treatment with the random effect of community. Due to the limited questions and responses, further testing was done using the Bonferroni/Holm correction for multiple comparisons (Oehlert, 2000).

$$p(j) \leq \frac{\varepsilon}{K - j + 1} for\ all\ j = 1, \ldots, i.$$

The second pair of surveys were developed to assess the change of community U&CF programs one year following their participation in the EAB:RR project. A comparison survey was provided to selected communities who did not participate in the EAB:RR project as a base model for the analysis. For the control group of non-project communities, similar traits of populations and location were used for a more reliable comparison. If a community declined to participate, a secondary community with similar attributes was contacted.

Survey Title	Send Date	Sent
Reminder - Sustainability Survey	Mailed on June 5, 2012 7:46 AM	2
Sustainability Survey	Mailed on May 30, 2012 6:31 AM	6

Table 5. Project community survey delivery schedule using SurveyMonkey®.

The data from these two surveys adds to the understanding of urban forestry program status and sustainability over time within and between communities whom participated and did not participate in the project. Questions for the Community Sustainability survey were generated in part from previous questionnaires developed by the Minnesota Department of Agriculture and Natural Resources, specifically questionnaires used during the years 1987, 1989, 1990 and 1996 along with data collected in 2001 in a joint effort between the University of Minnesota and the Minnesota Department of Natural Resources. All previous project communities were contacted via phone prior to the survey to ask for their participation. An email reminder was provided the day before the link to the on-line SurveyMonkey® survey was sent.

Message Subject	Send Date	Sent
LAST CALL for U&CF Surveys - Please Act Now	Mailed on July 17, 2012 9:36 AM	2
Urban and Community Forestry Survey	Mailed on July 13, 2012 10:06 AM	1
Reminder- Urban and Community Forestry Survey	Mailed on July 9, 2012 7:37 AM	1
Reminder - Urban and Community Forestry Survey	Mailed on July 9, 2012 7:36 AM	2
Urban and Community Forestry Survey	Mailed on June 27, 2012 7:00 AM	1
Urban and Community Forestry Survey	Mailed on June 26, 2012 7:00 AM	2
Reminder – Urban and Community Forestry Survey	Mailed on June 5, 2012 7:56 AM	2
Urban and Community Forestry Survey	Mailed on May 24, 2012 9:54 AM	1
Reminder - Urban and Community Forestry Survey	Mailed on May 24, 2012 9:47 AM	4
Urban and Community Forestry Survey	Mailed on May 17, 2012 12:48 PM	6

Table 6. Non-project community survey delivery schedule using SurveyMonkey®.

If communities had not responded within two weeks, a secondary email through SurveyMonkey® was sent to remind participants of the link, see Table 5. If a community had not responded with the first prompt, a second prompt was sent with a reminder and link four weeks following the original attempt. A final prompt was sent to all outstanding surveys roughly eight weeks after the original survey was sent, see Table 6.

The community capacity survey was relatively simplistic in that most questions were binary in nature and thus a test of proportions was able to be run for statistical significance. Non-project communities, as a control, were compared to project communities that were identified as a treatment group. For questions with more complex Likert scale responses, Wilcoxon tests were run due to the small sample size and non-normal distribution of the data. This allowed for a nonparametric alternative to the two-sample *t*-test.

Physical Infrastructure Development and Assessment

Each community had trained volunteers to complete an urban forestry assessment, and each community located and built a community gravel bed for the use of holding bare-root trees for spring, summer and fall planting. These gravel beds were constructed to assess the feasibility of utilizing bare-root nursery stock to increase the planting capacity of each community. Communities were provided up to $1500.00 reimbursement for materials used to build their gravel bed. Assistance was provided, if requested, with the siting and construction of the gravel bed. Materials used in the construction process varied but all beds contained 3/8th inch, or similar sized gravel to a depth of 8-12" with structural siding providing a defined area for the bed. Irrigation methods for the beds varied along with irrigation timing. Due to the difference in design and materials for each community the base cost of building a gravel bed was considered $1500.00. This one-time fee was added to the cost of gravel bed planting stock ordered in for the study in 2011.

Community	Date of Stock Installation	Date of Stock Harvest
Crookston	5/18/11	8/24/11
Hendricks	5/17/11	10/21/11
Hibbing	5/25/11	10/6/11
Hutchinson	4/28/11	7/25/11
Morris	4/26/11	10/26/11
Rochester	5/9/11	9/30/11

Table 7: Community installation and harvest dates for recorded gravel bed stock.

Upon completion of the bed, participating communities purchased bare-root stock from their preferred nursery, and once received between the months of March and early May, placed stock into the gravel bed for holding. Prior to the installation of trees into the gravel bed, measurements were taken according the best measurement method developed by the University of Minnesota Urban Forestry Outreach, Research, and Extension field nursery. Data points included; species, caliper, visual evaluation of the tree and a photo of the root system on a 4 foot x4 foot square board with 3 inch x3 inch grid markings. The length of time plant stock was held in the gravel bed varied by community, see Table 7. The technical assistance team was notified of plant-out and assisted the community by repeating the measurement process. In Hendricks and Hibbing, assistance was provided in the planting process as well. In addition, assistance was provided during installation and harvest, and project team members were available for questions, concerns or problems that arose during the season. Communities were asked to provide updates ongoing throughout the season of the stock being held in the bed. Response and success of updates ranged from weekly emails to bi-monthly communication initiated by the project team.

Additional information was collected from four nurseries, one wholesale, and three retail. Bailey's, Cross, Jim Whiting and Sargent's nurseries all have a variety of nursery stock and ready listings for their prices. Using their 2011 price guides, five common tree species were selected for comparison; *Acer platanoides, Quercus bicolor, Tilia americana, Picea glauca,* and *Gleditsia tricanthos.* An average cost was calculated for each nursery stock type using the same 1-2" caliper as used in the gravel beds, see Figure 5. Using the calculated average for each nursery stock type, 37.49 dollars for bare root stock, 93.83 dollars for container-grown, 195.80 dollars for balled

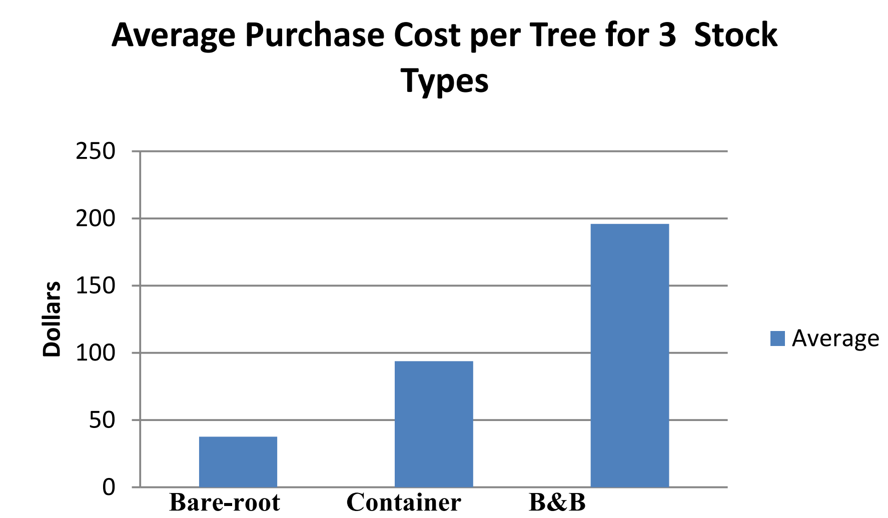


Figure 5. Average cost comparisons for nursery stock type.

and burlapped stock, the number of trees a community was able to purchase was determined.

The size category was determined based on the typical caliper size used in street tree plantings and recommended for the gravel bed (Starbuck, C. personal interview, January 14, 2010). As impetus for the study was emerald ash borer, the number of ash trees estimated for public property in each community was used as the replacement factor. This meant that the total cost for each nursery stock type to replace the estimated number of ash trees in the six communities is shown in Table 8.

Bare-root	Container	B&B
$436,271.13	$1,091,899.71	$2,278,524.60

Table 8. Nursery stock replacement for ash trees.

Results

Attitudes and Behavior Survey Results

The average volunteer was Caucasian, between 50 and 70 years of age, and has lived in their community for more than 10 years with the majority of volunteers having lived in their community for 20 years or more. Males and females were equally likely to volunteer and was considerably more stratified by the individual community than as an over-all sample. Although these demographic variables were collected, analysis did not identify any association between demographic variables and responses. There was,

	Strongly disagree	Moderately disagree	Moderately agree	Strongly agree
I value the work our City Forester/Tree Board does.	2.2%	0.0%	22.2%	75.6%
Trees were the reason I volunteered to participate in the inventory.	4.4%	4.4%	35.6%	55.6%
I would like to see more trees planted in my community.	0.0%	0.0%	31.1%	68.9%
I now think twice before moving firewood from one location to another.	0.0%	0.0%	26.7%	73.3%
Participation in the EAB project has caused me to become engaged in sustaining my community forest.	2.2%	6.7%	46.7%	44.4%

Table 9. Post inventory survey attitude responses. N=45

however, evidence of statistically significant changes (p = <1e-04) in basic attitudes and knowledge of emerald ash borer, moving from relatively basic knowledge of knowing what EAB stands for to feeling comfortable informing others how to control EAB, see Figure 6.

Marked differences in pre training and post inventory knowledge were noted in questions regarding volunteers understanding of emerald ash borer and the role of their city's forester. Emerald ash borer knowledge reflected the most significant change with a p-value of 5.95e-08 (adjusted <1e-04) and a standard error of .22. There was no variation of this effect among communities however there was a potential effect amongst individuals. Greater comprehension of the role of the city forester or tree board was demonstrated by a slightly lowed difference with a significant p-value of 1.54e-06 (adjusted <1e-04), but more interestingly there was potential variation among communities (SD =.232) as well as individuals in responses (SD =.602). Shifts in attitude were also noted along with behavioral intent differences, see Table 10.

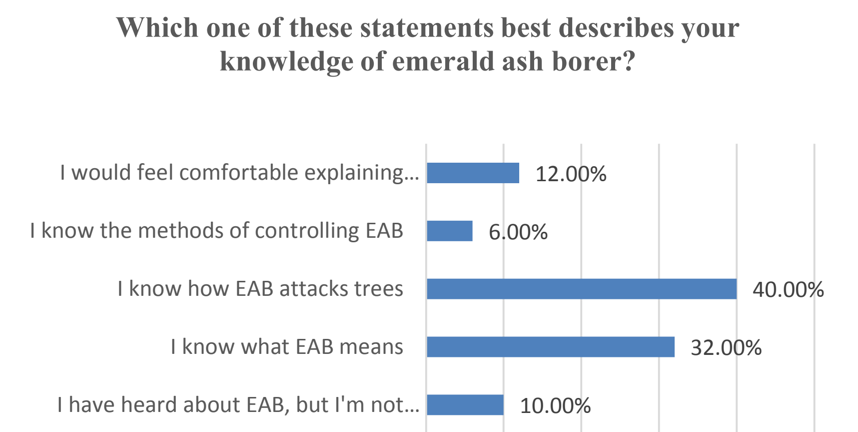


Figure 6. Pre-training survey knowledge of emerald ash borer, n= 50

Question	Y2-pre	Y1-post	t value	p.value	p.adjust
EAB Knowledge	3.220	2.022	-5.420	5.95E-08	<1e-04
Understanding Forester Role	2.224	1.301	-4.806	1.54E-06	<1e-04
Government Involvement	2.460	1.591	-5.435	5.48E-08	<1e-04
Valuing City Forestry	1.674	1.289	-3.026	0.002474	0.0322
Engaged in Sustaining Community Forestry	2.064	1.667	-2.317	0.02052	0.2462

Table 10. Pre and post survey comparison, statistically significant or nearly significant questions.

Volunteers felt significantly more involved in their local government (adjusted p-value of <1e-04) from pre to post training. This difference was notably the second highest difference within the survey questions with a standard error of .16. The value volunteers placed on their city forester was also increased (p-value of .002, adjusted .03). An additional question of interest, although not statistically significant, was the response of volunteers in relation their feelings of engagement in sustaining their urban forest (p-value of .02, adjusted .25).

	Yes	No	I plan on doing this in the future
I have talked about EAB with a neighbor or friend since participating in the EAB RR project.	95.6%	4.4%	0.0%
Participation in the EAB RR project spurred me to plant a tree(s) in my yard.	42.2%	42.2%	15.6%
Participation in the EAB RR project has caused me to talk to someone about moving firewood.	71.1%	24.4%	4.4%

Table 11. Behavioral intent and action from post inventory survey, n= 45.

Marked changes were noted in questions relating to urban tree perception as volunteers viewed their community's trees with a more structured eye. The shift moves from the majority of responses viewing seventy percent of their trees in excellent condition to thirty percent of community trees in excellent condition.

Behavioral intention was noted in response from pre-inventory participation and was validated through the behavioral action of sharing information with others as measured in the post inventory survey. Only thirteen percent of volunteers responded that they had not shared tree identification information with

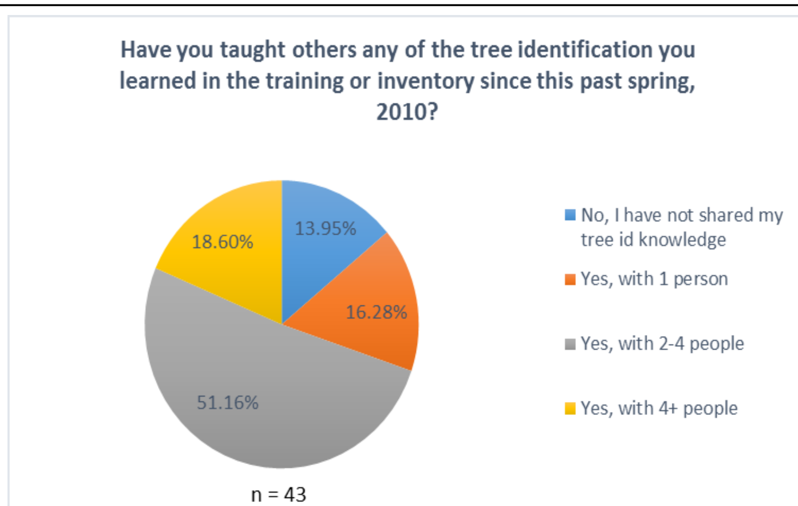


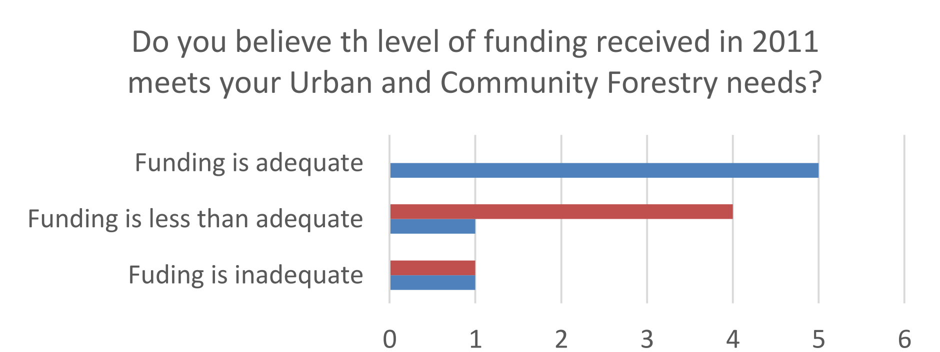
Figure 7. Number of people taught by volunteers using the learned skills from inventory participation.

others, see Figure 7.   Opportunities for additional behavioral actions appeared to be negligent as only twenty-four percent of volunteers had participated and sought out additional learning and volunteer opportunities in natural resources.

Community Participation Comparison

Prior to participation in the Emerald Ash Borer: Rapid Response Project, half of the project communities had an inventory with the oldest being completed in 2004. Five of the six communities had a tree ordinance and four of the six, a tree board. In 2011 the urban forestry budget for these communities ranged from two percent to less than one percent of the total municipal budget. All treatment respondents indicated that this funding level for their urban forestry program was less than adequate for their forestry needs. Funding allocation between the treatment, project communities, and control group, non-project communities, was suggestive, but not significant with a p-value of .065.

Sixty percent of respondents agreed that participation in the project allowed them to enhance their community forestry program. Sixty-two percent of non-project communities had an inventory at the time of the survey with three conducted in 2010 or 2011 and the oldest inventory completed in 2000. Unlike prior inventories from the project communities, two of the non-project communities included residential or private property within their prior inventories. Six of the eight



	Fuding is inadequate	Funding is less than adequate	Funding is adequate
Treatment	1	4	0
Control	1	1	5

Figure 8. Adequacy of funding for communities.

communities had an ordinance and budgets varied from seven percent to less than one percent of total community budget. Unlike the project communities, seventy-one percent of respondents thought their current community forestry budget was adequate, see Figure 8. Overall, the forestry responsibilities in both subgroups fell primarily to the public works department with only one community indicating the individual in charge of forestry related activities had a forestry degree either two or four year. Despite these observations of the data, analysis showed that none of the variables between the treatment and control group, for capacity were significant at a .05 p-value.

Physical Infrastructure Analysis

Although all communities reported their gravel bed stock orders, not all costs were relayed, however the harvest data was used to confirm that number of dead or nearly dead trees, i.e. those trees ranking a 1 or 0 using the University of Minnesota Field Nursery assessment guide, see Appendix B.

	2010 GB stock order Expense	Number of GB stock ordered for 2011	Total cost of trees including replacement for dead or nearly dead trees
Crookston	N/A	28	1349.64
Hendricks	600	33	1424.62
Hibbing	1385	24	1274.66
Hutchinson	4405	75	3411.59
Morris	N/A	79	2961.71
Rochester	11670	28	1124.7

Table 12. Community gravel bed orders and replacement costs.

Using the estimated price for a bare-root tree the cost of replacement for those dead or several declined trees was able to be calculated.

Table 13 provides the number of publicly owned ash trees inventoried in each community. Taking the number of ash trees in each community, the replacement cost for bare-root, container-grown and B&B stock was calculated.

	Number of ash trees in the community
Crookston	220
Hendricks	658
Hibbing	3772
Hutchinson	1551
Morris	1169
Rochester	4267

Table 13. Inventoried ash from communities.

When calculating the replacement for all six communities using container-grown trees, the cost estimate raises to over a million dollars, B&B trees over two million dollars, see Table 14.

This base cost of replacement does not take into account possible transplant mortality or other issues resulting in a tree's failure to thrive. An average of twenty-three percent of trees used in the 2010-211 community gravel bed were not able to be transplanted out into the field due to poor or dead condition. A mortality replacement cost was calculated at varying rates, 0-40%, using the total cost of replacing all six communities with bare-root stock, see Table 15.

	Bare-root	**Container**	**B&B**
Crookston	$8,247.80	$20,642.60	$43,076.00
Hendricks	$24,668.42	$61,740.14	$128,836.40
Hibbing	$141,412.28	$353,926.76	$738,557.60
Hutchinson	$58,146.99	$145,530.33	$303,685.80
Morris	$43,825.81	$109,687.27	$228,890.20
Rochester	$159,969.83	$400,372.61	$835,478.60
Total Cost	**$436,271.13**	**$1,091,899.71**	**$2,278,524.60**

Table 14. Replacement cost of ash trees in each community.

To consider cost of using community gravel bed trees for ash replacement, the cost of initial construction fees, $1500, was added to the cost of purchasing forty-five trees bare-root-- this was the average number of trees purchased for gravel beds during 2010-2011. Within the first year, gravel bed stock would be cost $3562 compared to $1687 for bare-root. Spreading the $1500 for gravel bed construction over five years, $300 per year, creates a more competitive price for gravel bed stock at $1987 per year when compared to $1687 for bare-root stock. Taking the higher of the two prices, $1987 per year, bare-root trees become uneconomical when mortality raises to over forty percent in a given year.

0% Replacement	5%	10%	15%	20%	25%	40%
$436,271.13	**$458,084.69**	**$479,898.24**	**$501,711.80**	**$523,525.36**	**$545,338.91**	**$610,779.58**

Table 15. Mortality replacement cost.

Discussion

Community Attitudes and Behavior

It is evident from the pre and post surveys provided to inventory volunteers that understanding and knowledge of urban forestry topics increased. This is to be somewhat expected as the volunteers self-selected for participation in this project and thus were already engaged in the topics or projects. An unexpected, but positive change was the view of volunteers feeling engaged in government. This change is an indicator of the success of using the project engagement technique to increase volunteers' perception of urban forestry and their involvement in it. Attitude transition related to urban forestry topics, although not statistically significant compared to engagement or knowledge changes, was noted through several of the questions indicating that a change in behavior would be plausible, see Table 16.

What was not expected however was the absence of further behavioral change regarding the continued participation in high engagement activities such as buckthorn *(Rhamnus cathartica)* pulling, tree board participation or furthering education by becoming a Master Naturalist or Gardener. This void could be due to the difference in subgroups which may be related to location of opportunities or further time commitments. As a limitation in this study, due to the funding structure and time constrains of working across two grants, the ability of working with the same subgroup should be focused on in future surveys. The consistency in subgroup surveys would potentially confirm the tendency of behavior and attitudes in volunteers. It is noted that the pre-survey group from the eight communities in the second round of funding did have the ability to complete both a pre and post volunteer surveys, yet, were restricted in time and follow-up was not an option. The one

Statement Question	Strongly Disagree	Disagree	Agree	Strongly Agree
I now think twice before moving firewood from one location to another.	**0.00%** 0	**0.00%** 0	**26.67%** 12	**73.33%** 33
Participation in the EAB project has caused me to become engaged in sustaining my community forest.	**2.22%** 1	**6.67%** 3	**46.67%** 21	**44.44%** 20

Table 16. Post inventory survey question 16, empowerment responses, n=45.

community of the second round funding that was able to finish prior to final data collection and thus was given both pre and post surveys, did display a slight shift in their behavior by fifty-five percent of respondents seeking additional learning opportunities, yet only one of the respondents sought out additional natural resources volunteer activities.

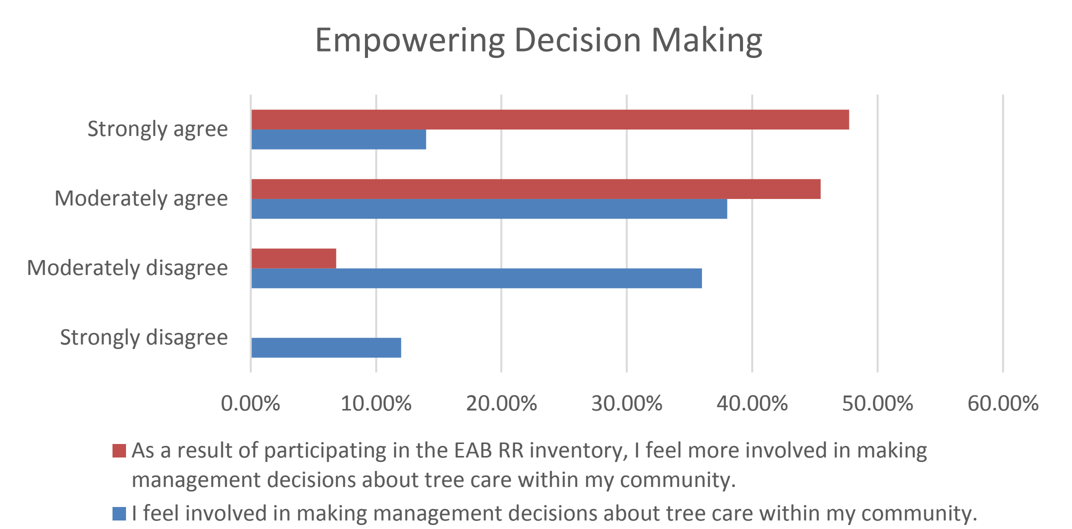


Figure 9. Post inventory survey responses for involvement in decision making within volunteer's

Despite the apparent lack of effect in intensive, physical behaviors, such as volunteering for other natural resource projects, simpler behaviors, information sharing through verbal or electronic communication, was apparent. Virtually all volunteer respondents indicated that they had shared information learned through participation in the inventory project with another person. Furthermore, many of the volunteers displayed indications of empowerment through their responses providing information on their directed actions and involvement in sustaining their community forest, see Figure 9.

This indication of empowerment provides future incentive to continue engaging volunteers in sustained and prolonged activities to create a social framework of support for their community forest. It should be noted that all communities contained at least one empowered decision maker within the municipal government structure. Although some communities were more successful at empowering volunteers, overall, the technical assistance provided through the project did appear to be an effective method of empowerment. More research is needed to understand the length of this effect. Overall, less physically intensive activities and interactions appear to be highly susceptible to change, which is an initial step towards more intensive behavioral shifts. Provided with increased opportunity and ease, volunteers may have more indicative behavioral responses to future similar projects.

Measuring Capacity and Change

Current measures of capacity are static and dismiss the dynamic nature of forestry, municipal staff and budgeting. The federal capacity measurement, Community Achievement Reporting System (CARS), used to distribute earmarked urban and community forestry funding to the states, is antiquated and needs to be updated to adequately capture progress and change in urban forestry. The current structure relies upon meeting four individual elements per selected community. Does the community have: a management plan developed from professional resource assessments to actively manage treed areas, professional forestry staff (degreed or certified), an ordinance reflecting the governance of treed areas in the community, and an advisory organization for tree topics?

Communities are divided into two groups, developing and managing. Developing communities have met one of the key elements in CARS, while managing communities have met all of the key elements in CARS. Yet, the difficulty with this system is once a community is marked as meeting a requirement, there is little continued follow-up. A community may have created a management plan one year and was counted as meeting that requirement but the next year there is no evidence of having utilized the management plan. In this case, has the community actually accomplished anything beyond a lengthy document? As states are encouraged to check off each of these goals for communities to retain and build state funding it is not in their benefit, or capacity, to annually recheck each community to ensure continued cooperation. The potential of communities is accounted for using the grouping of developing communities. Communities meeting the four elements are likely to have a potentially successful urban and community forestry program, but, unfortunately these goals used by the U.S. Forest Service provide very little insight into the ability to have a community have a successful U&CF program. Reviewing and altering what elements are critical to building capacity of a community would be a far better measure for U&CF program sustainability long term within the U.S.

The ability of a community to have a successful U&CF program relies on their capacity to implement program requirements. This capacity is hinted at by communities employing a professional staff person and advisory group, but whether these individuals have the necessary funding, equipment and education to further the program and complete U&CF activities is not clear. Very little research has been done with relation to U&CF program capacity or capacity modeling as discussed above. This project was one attempt to gain a better perspective in some of the key elements to address not only what components create capacity in a community, but also which elements are directly related to a change in capacity features.

The EAB:RR project did have two definitive impacts on participating communities: they each received an inventory and were able to alter their urban forest through plantings using the community gravel bed. The project moved fifty percent of participating communities from not having an inventory, a capacity indicator, to attaining one. An updated inventory provides all of these communities that ability to make strategic management decisions, especially with relation to emerald ash borer as intended by the project. However, this indicator of capacity as discussed above does not truly appear to be significant gauge of U&CF capacity. As a static standard, it will be necessary to follow-up with these communities to determine how they have used the inventory data to improve their forestry programming and management.

Despite the lack of statistically significant variables between project and non-project communities, there was a perception by project communities of U&CF programmatic impact by participating in the EAB:RR project. Sixty percent of project communities felt that the project did enhance their programs although it was not determined in what aspect this was done. Thirty-three percent of the project communities were unsure if there was an enhancement made to their program with one of the communities indicating they believed the resources, beyond funding, were inadequate for program enhancement.

Continued study is needed to understand the limitations and exact elements of effective change for U&CF programming. This may include additional site visits and a repeat of the sustainability survey to gauge whether a shift in programming as occurred either with to management and planning or with assistance in education and volunteer utilization. Unlike CARS, the EAB:RR project worked on the theory of engaging volunteers to become not only part of the social infrastructure available to U&CF programs, but also part of the interworking's of U&CF programs in an opportunity to be empowered. With the knowledge that federal funding is decreasing and finical assistance is limited, volunteer groups have the potential to fill this gap, by providing physical as well political power to move U&CF programs to the forefront of communities. This alters Hauer's capacity model from federal and state funding and technical assistance to local ways of achieving funding, and through the project, intense, directed technical assistance.

The EAB:RR project built this base infrastructure, a volunteer group and basic inventory knowledge, to improve the capacity for these communities. These inputs ideally would lead to an increase in U&CF capacity as outputs of tangible measures: increased tree longevity, increased tree canopy, greater diversity, citizen participation, human health and well-being, etc…. As it stands, neither the current CARS capacity model nor the suggested elements in the EAB:RR project are relevant predictors of output indicators for sustainable capacity building, although continued surveys within project communities may indicate the opposite. To determine the future effects of the EAB:RR project, Hauer's capacity model, see Appendix A, should continue to be considered for its array of inputs that align with key elements likely to produce the desired outputs for measuring change in U&CF programming.

Bare-root (BR) vs. Balled-and-Burlapped (B&B)

To gain a better understanding of the use of bare-root vs. B&B trees, an informal survey developed on December 20, 2011, was distributed to thirteen Minnesota metropolitan communities who were Arbor Day Foundation, TreeCity USA status recipients and thus tracked their tree planting as one of the requirements in the 2010 TreeCity USA application. Within this survey a question was asked to each community about the type of planting stock it used in 2010, BR, B&B or container-grown, see Figure 10. Twelve out of the thirteen communities' plant B&B trees, nine out of the thirteen communities' plant container-grown trees and only seven plant bare-root trees. When asked why, responses varied from soil type to availability to survival success to budget size. At the March 2012 Northeastern Municipal Foresters (NEMF) Meeting held in Mount Prospect, IL, an informal inquiry on the primary type of nursery stock planted was asked of those municipal forester present, roughly 25 attendees. The responses were consistent with responses from the metropolitan Minnesota communities but were far more weighted towards B&B plantings due to availability stock size.

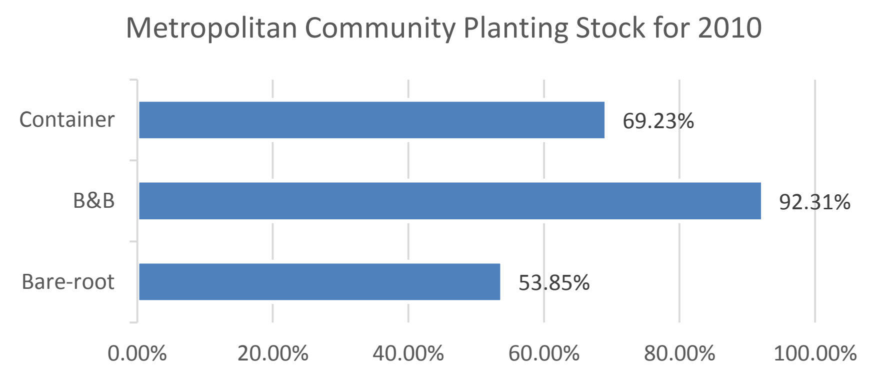


Figure 10. Planting stock type purchased for use in 2010, n=13.

The idea of a larger tree in an urban setting is appealing to not only residents but also urban foresters as they struggle to fulfill the demands of their communities' needs. Yet, despite consistent research supporting the planting of smaller bare-root trees, there continues to be an abundance of B&B stock purchased and planted every year. Community budgets are shrunk to unbelievably small proportions when only B&B stock is used for replanting, e.g. a budget of $10,000 purchases only 51 trees compared to 266 bare-root trees. Even at 40% replacement rate, the highest bare-root mortality rate noted by Minnesota communities in the informal planting survey, it is still far more economical to use bare-root trees than either container or B&B, $610,779.58 compared to over $2 million. Due to the continued underfunding of U&CF programs across the country, diversification in stock type is necessary to maintain a healthy and balanced urban forest.

By diversifying stock type, communities are also able to diversify their species selection as B&B and container-grown retailers are selective in what they carry to ensure there is no profit due to carrying over unsold and expensive nursery stock. Although gravel bed bare-root trees are more expensive then the common bare-root nursery stock, both types still outcompete the pricing of container-grown and B&B stock and provide the greatest diversity of species. Utilizing both gravel bed stock and bare-root nursery stock provides the opportunity for summer and fall planting as well as spring planting. The ability to plant late summer or fall can help avoid heavy spring rains or droughty summers, which have a significant impact on transplant survival. The added cost of gravel bed trees can be offset by the increased benefits of this stock type: flexibility in planting schedule --which increases the diversity of tree species available, increases root mass which may decrease transplant mortality (Watson, 2013). Regardless of bare-root or gravel bed bare-root, the savings allows communities to increase the number of trees planted, growing their over-all green infrastructure.

Other considerations affecting the price point between gravel bed and nursery bare-root trees include the use of volunteers. In many of the project communities the additional $1500 required for the building of gravel beds was mitigated by reusing materials and volunteer labor, rather than city employees, for installing, harvesting and caring for the trees when in the gravel bed. Not only does volunteer labor affect the cost of nursery stock, but this also results in a pronounced attitude shift. Volunteers who participate in tree planting events gain a stronger relationship to the trees they planted. This is not just an individual benefit but a group and community-level benefit as well. Volunteer tree planting fosters a sense of community and ownership of trees as a common-owned resource. It is more likely for individuals to also volunteer care and maintenance for these trees when this actively involved in the planting process (Westphal, 2003; Dwyer et al., 1992).

Although labor is an important component in the comparison of gravel bed vs. nursery bare-root trees, for the purposes of this study was not incorporated due to the major differences in community planting programs. However, how labor is addressed in communities should be considered due to the increased number of intensive hours to install and harvest stock from the gravel beds. This additional time can vary based on the number of employees and the number of trees being used. When community programs choose to use volunteers the size and weight of a tree make a difference in ease and ability of planting. Compared to 2” caliper bare-root tree, a 2” caliper B&B tree can weigh close to 300 pounds (Relf, 2009). This difference increases the time, energy, equipment and man power needed to plant a B&B tree.

The effect of gravel beds in the project communities is unknown at this point. The $1500 provided to each community certainly increased their planting budget for 2010-2011, especially in communities where volunteers and recycled materials were used for building and maintaining the gravel bed. Continued follow-up is needed to track the planting and mortality of trees in project communities in future years to analyze the cost benefit. The continued use of gravel beds in these communities is a suggestive indicator of capacity as planning, labor, and organization are highly integrated to obtain cost effective results.

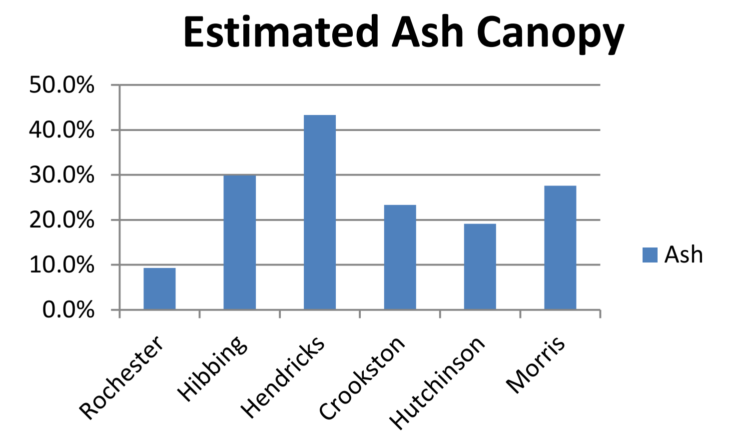


Figure 11. Estimated ash canopy of entire community inventory.

Based on the experience of the EAB:RR project, communities should be evaluated as those that utilize volunteers to plant trees versus those that use only in-house labor or contracted labor to plant trees, to include and track the effect of labor as a variable in planting program increase and/or success. As each community had a different percentage of ash in their urban forest, see Figure 11, the need and urgency to plant varies among communities. With proper use and planning, gravel beds could increase the physical infrastructure of communities and allow communities to reforest from the effects of emerald ash borer far faster than using traditional nursery stock such as B&B, container-grown or bare-root. One other interesting possibility arose with the use of gravel beds in communities, the ability to offer trees to homeowners and thus affect the potential diversity of trees on private as well as public property. In either a cost-share program, the resident pays for half of the tree, or in an outright sale of trees to community residents, the ability to offer select species greatly impacts and could improve the genetic and age-class diversity at a broader scale than publically owned property.

Conclusion

Similar to engagement studies of participation, very little research has been conducted on empowerment in U&CF programs. The two most common areas of technical assistance, tree planting and inventory, uphold the greatest ability to incorporate a wide range of participants and involve the principle aspects of engagement and empowerment. Unlike both technical assistance and tree planting, engaging volunteers in the inventory practice provides a method which may lead to empowering volunteers. Behavioral changes although not as significant as desired through this project, are suspected to be increased when further study is completed with matched surveys.

Based on the results of this study, it is unclear how great an impact the technical assistance provided was able to affect communities' U&CF programs. The increase in social capacity provided by the use and engagement of volunteers has the potential to be a significant input into the capacity model for U&CF programming but relies on other equally significant inputs of dedicated staffing, education and funding. The service of the volunteers provided a critical component to urban forestry management simultaneously increasing the likelihood of communities completing other urban forestry management tasks: maintenance, tree planting, ordinance renewal, budgeting... etc. Yet, without the proper staffing to utilize, organize and incentivize volunteers the social infrastructure created in these communities through the EAB:RR project is not sustainable.

The physical infrastructure provided did allow communities many benefits of longer planting season, larger root masses on nursery stock and the ability to increase their planting efforts and decrease their costs potentially aiding their program budgets. Long-term studies need to be applied to gravel beds to determine the success of bare-root stock from these beds once planted. The mortality rate and establishment of gravel bed stock may suggest a benefit for communities building and utilizing the gravel bed, but caution should be taken however as a strong community program is needed to maintain current and newly planted trees as well as the gravel bed itself. The management of gravel beds and planting stock can easily be done by volunteers increasing the value of the beds tremendously. Providing volunteers an opportunity to manage the care and planting of trees also increases their sense of engagement and empowerment within the community aiding an urban and community forestry program as a whole. The physical infrastructure of gravel beds relies heavily on volunteer or community staff to ensure the health and vigor of their trees even after plant out. This type of ownership should be heavily considered by municipalities with decreased budgets. It is also clear that whether a community utilizes gravel bed stock or traditional nursery bare-root stock they will increase their number of trees obtained by their planting budget which increases the urban forest.

Both the physical and social infrastructure inputs were not enough to create a significant change in project communities' capacity for urban and community forestry. Some communities adapted recommended changes by continuing the use of gravel beds and working on EAB management plans. One community even set aside current funding for future use with regards to EAB. The communities that appeared successful require continued follow-up to determine the actual change achieved within the community. Technical assistance in this project was a boon to all the communities' involved, but may be a crutch when communities' lack funding and staffing support. Staffing turnover can have devastating impacts on U&CF programs which can cause the collapse of organized social infrastructure inputs along with a gap in knowledge and education. Future studies should incorporate a more detailed look at staffing in combination with infrastructure inputs.

References

Ajzen, I. 1991. The theory of planned behavior. *Organizational Behavior and Human Decision Processes* 50 (2): 179-211.

Ajzen, I., and BL Driver. 1992. Contingent value measurement: On the nature and meaning of willingness to pay. *Journal of Consumer Psychology* 1 (4): 297-316.

Anagnostakis, Sandra L. 1987. Chestnut blight: The classical problem of an introduced pathogen. *Mycologia* 79 (1) (Jan. - Feb.): pp. 23-37, http://www.jstor.org/stable/3807741.

Arnold, M. A., G. V. McDonald, D. L. Bryan, G. C. Denny, W. T. Watson, and L. Lombardini. 2007. Below-grade planting adversely affects survival and growth of trees species from five different families. *Journal of Arboriculture* 33: 64-69.

Arnstein, S. R. 1969. A ladder of citizen participation. *Journal of the American Institute of Planners* 35 (4): 216-24.

Austin, M. E. 2002. Partnership opportunities in neighborhood tree planting initiatives: Building from local knowledge. *Journal of Arboriculture* 28 (4): 178-86.

Brasier, C. M. 2000. Intercontinental spread and continuing evolution of the Dutch elm disease pathogens. *The Elms: Breeding, Conservation and Disease Management*: 61-72.

Buckstrup, M. J., and N. L. Bassuk. 2009. *Creating the urban forest: The bare root method.* Ithaca, New York: Urban Horticulture Institute, Department of Horticulture, Cornell University.

Buckstrup, M. J., and N. L. Bassuk. 2000. Transplanting success of balled-and-burlapped versus bare-root trees in the urban landscape. *Journal of Arboriculture* 26 (6): 298-308.

Cavaye, J., and Queensland. Dept. of Primary Industries. 1999. *The role of government in community capacity building,* Queensland Dept. of Primary Industries.

Chaskin, R. J., and University of Chicago. Chapin Hall Center for Children. 1999. *Defining community capacity: A framework and implications from a comprehensive community initiative,* Chapin Hall Center for Children at the University of Chicago.

Chaskin, R. J. 2001. Building community capacity. *Urban Affairs Review* 36 (3): 291.

Chess, Caron. 1999. Public participation and the environment: Do we know what works. *Environmental Science Technology* 33 (16): 2685-92.

Clark, J. R., N. P. Matheny, G. Cross, and V. Wake. 1997. A MODEL OF URBAN FOREST SUSTAINABIL1TY. *Journal of Arboriculture* 23: 1.

Cuthbert, RA. 1975. *Relative importance of root grafts and bark beetles to the spread of Dutch elm disease*. Vol. 206Northeastern Forest Experiment Station, Forest Service, US Dept. of Agriculture.

De Oliver, M. 1999. Attitudes and inaction. *Environment and Behavior* 31 (3): 372.

Dwyer, J. F., D. J. Nowak, and M. H. Noble. 2003. Sustaining urban forests. *Journal of Arboriculture* 29 (1): 49-55.

Dwyer, J. F., and H. W. Schroeder. 1994. The human dimensions of urban forestry. *Journal of Forestry* 92 (10): 12-5.

Dwyer, J.F., E.G. McPherson, H.W. Schroeder, and R.A. Rowntree. 1992. Assessing the benefits and costs of the urban forest. *Journal of Arboriculture* 18(5): 227 – 234.

Eagly, A. H., and S. Chaiken. 1993. *The psychology of attitudes.* Harcourt Brace Jovanovich College Publishers.

Elmendorf, W. F., V. J. Cotrone, and J. T. Mullen. 2003. Trends in urban forestry practices, programs, and sustainability: Contrasting a Pennsylvania, US, study. *Journal of Arboriculture* 29 (4): 237-48.

Fawcett, S. B., A. Paine-Andrews, V. T. Francisco, J. A. Schultz, K. P. Richter, R. K. Lewis, E. L. Williams, K. J. Harris, J. Y. Berkley, and J. L. Fisher. 1995. Using empowerment theory in collaborative partnerships for community health and development. *American Journal of Community Psychology* 23 (5): 677-97.

Florin, P. R., and A. Wandersman. 1984. Cognitive social learning and participation in community development. *American Journal of Community Psychology* 12 (6): 689-708.

Francisco, V. T., S. B. Fawcett, J. A. Schultz, B. Berkowitz, T. J. Wolff, and G. Nagy. 2001. Using internet-based resources to build community capacity: The community tool box. *American Journal of Community Psychology* 29 (2): 293-300.

Fraser, E. D. G., A. J. Dougill, W. E. Mabee, M. Reed, and P. McAlpine. 2006. Bottom up and top down: Analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. *Journal of Environmental Management* 78 (2): 114-27.

French, D. W. 1993. History of Dutch elm disease in Minnesota. *Minnesota Report (University of Minnesota Agricultural Experiment Station) (USA)*.

Gibbs, J. N. 1978. Intercontinental epidemiology of Dutch elm disease. *Annual Review of Phytopathology* 16 (1): 287-307.

Gilman, E. F., R. J. Black, and B. Dehgan. 1998. Irrigation volume and frequency and tree size affect establishment rate. *Journal of Arboriculture* 24: 1-9.

Gittell, M., and K. Newman. 1998. Empowerment zone implementation: Community participation and community capacity. *Second Year Report to the MacArthur Foundation and the CUNY Collaborative Research Program, New York, Howard*

Samuels State Management and Policy Center at the Graduate School and University Center of the City University of New York.

Glass, J. J. 1979. Citizen participation in planning: The relationship between objectives and techniques. *Journal of the American Planning Association* 45 (2): 180-9.

Green, T. L., T. J. Howe, and H. W. Schroeder. 1998. Illinois small community tree programs: Attitudes, status, and needs. *Notes*.

Haack, R. A., and J. F. Cavey. 1997. Insects intercepted on wood articles at ports-of-entry in the United States: 1985–1996. *Newsletter of the Michigan Entomological Society* 42 (2-4): 1-6.

Haack, R. A., K. R. Law, V. C. Mastro, H. S. Ossenbruggen, and B. J. Raimo. 1997. New York's battle with the Asian long-horned beetle. *Journal of Forestry* 95 (12): 11-5.

Haight, R. G., F. R. Homans, T. Horie, S. V. Mehta, D. J. Smith, and R. C. Venette. 2011. Assessing the cost of an invasive forest pathogen: A case study with oak wilt. *Environmental Management*: 1-12.

Harris, J. R., and N. L. Bassuk. 1993. Tree planting fundamentals. *Journal of Arboriculture* 19: 64-.

Hauer, R. J. 2006. Urban forestry capacity building and models. Paper presented at Proceedings of the 4th International Conference on Environmental Management for Sustainable Universities, June.

Hauer, R. J., and G. R. Johnson. 2008. State urban and community forestry program funding, technical assistance, and financial assistance within the 50 United States. *Arboriculture and Urban Forestry* 34 (5): 280-9.

Hauer, Richard J., Gary R. Johnson, and Michael A. Kilgore. 2011. Local outcomes of federal and state urban & community forestry programs. *Arboriculture & Urban Forestry* 37 (4) (07): 152-9, http://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=64467066&site=ehost-live.

Hauer, Richard James. 2005. Urban forestry and urban forest capacity: Defining capacity and models of capacity building. Thesis (Ph. D.)--University of Minnesota, 2005. Major: Natural resources science and management.

Hinds, David G. 2008. *Building community capacity: Environment, structure, and action to achieve community purposes.* Madison, WI: Cooperative Extension Publishing, G3840.

Horton, D. 2003. *Evaluating capacity development: Experiences from research and development organizations around the world*.

Hulme, P. E. 2009. Trade, transport and trouble: Managing invasive species pathways in an era of globalization. *Journal of Applied Ecology* 46 (1): 10-8.

Jackson, S. F., S. Cleverly, B. Poland, D. Burman, R. Edwards, and A. Robertson. 2003. Working with Toronto neighbourhoods toward developing indicators of community capacity. *Health Promotion International* 18 (4): 339.

Johnson, G. R., and D. Fallon. 2007. *Stem girdling roots: The underground epidemic killing our trees,* University of Minnesota.

Kozlowski, TT, and WJ Davies. 1975. CONTROL OF WATER BALANCE IN TRANSPLANTING TREES. *Journal of Arboriculture* 1 (1).

Lauderdale, D. M., C. H. Gilliam, D. J. Eakes, GJ Keever, and AH Chappelka. 1995. Tree transplant size influences post-transplant growth, gas exchange, and leaf water potential of 'October Glory' red maple. *J. Environ. Hort* 13 (4): 178-18.

Liebhold, A. M., J. A. Halverson, and G. A. Elmes. 1992. Gypsy moth invasion in North America: A quantitative analysis. *Journal of Biogeography*: 513-20.

Lyons, T., and B. Reimer. 2006. A literature review of capacity frameworks: Six features of comparison. Paper presented at National Rural Research Network Conference.

Mazullo, J. 2011. Ithaca and other cities diversify their urban forests. *Cities Going Green: A Handbook of Best Practices*: 121.

Milgroom, Michael G., Kerong Wang, Yang Zhou, Susanne E. Lipari, and Shigeru Kaneko. 1996. Intercontinental population structure of the chestnut blight fungus, cryphonectria parasitica. *Mycologia* 88 (2) (Mar. - Apr.): pp. 179-190, http://www.jstor.org/stable/3760921.

Moskell, C., S. Broussard Allred, and G. Ferenz. 2010. Examining volunteer motivations and recruitment strategies for engagement in urban forestry. *Cities and the Environment (CATE)* 3 (1): 9.

Neely, D., and EB Himelick. 1963. Root graft transmission of Dutch elm disease in municipalities. *Plant Dis. Rep* 47 (2): 83-5.

Newton, L., G. Fowler, A. N., R. S., Y. Takeuchi, and S. P. 2011. Thousand cankers pathway assessment: Movement of *geosmithia* sp. and *pityophthorus juglandis* from the western into the eastern united states. In: McManus, K. A.; Gottschalk, K.W., eds. 2010. Proceedings. 21st U.S. department of agriculture interagency research forum on invasive species 2010; 2010 January 12-15; Annapolis, MD. gen. tech. rep. NRS-P-75. Newtown square, PA: U.S. department of agriculture, forest service, northern research station: 112. *Notes*.

Nowak, David J., Miki Kuroda, and Daniel E. Crane. 2004. Tree mortality rates and tree population projections in Baltimore, Maryland, USA. *Urban Forestry & Urban Greening* 2 (3): 139-47.

Oehlert, G. W. 2000. *A first course in design and analysis of experiments*. New York: W.H. Freeman and Company.

Pallardy, S. G., and T. T. Kozlowski. 2008. *Physiology of woody plants.* Academic Press.

Perkins, D. D., and M. A. Zimmerman. 1995. Empowerment theory, research, and application. *American Journal of Community Psychology* 23 (5): 569-79.

Poland, T. M., and D. G. McCullough. 2006. Emerald ash borer: Invasion of the urban forest and the threat to North America's ash resource. *Journal of Forestry* 104 (3): 118-24.

Prestby, J. E., A. Wandersman, P. Florin, R. Rich, and D. Chavis. 1990. Benefits, costs, incentive management and participation in voluntary organizations: A means to understanding and promoting empowerment. *American Journal of Community Psychology* 18 (1): 117-49.

Santamour Jr, F. S. 2004. Trees for urban planting: Diversity uniformity, and common sense. *The Overstory Book: Cultivating Connections with Trees*: 396.

Schlarbaum, S. E., F. Hebard, P. C. Spaine, and J. C. Kamalay. 1997. Three American tragedies: Chestnut blight, butternut canker, and Dutch elm disease. *Notes*.

Simpson, L., L. Wood, and L. Daws. 2003. Community capacity building: Starting with people not projects. *Community Development Journal* 38 (4): 277-86.

Still, DT, and HD Gerhold. 1997. Motivations and task preferences of urban forestry volunteers. *Journal of Arboriculture* 23: 116-29.

Struve, D. K., C. Starbuck, and H. Mathers. 2005. Bareroot and balled-and-burlapped red oak and green ash can be summer transplanted using the Missouri gravel bed system. *Hort. Technology* 15 (1): 122-7.

Summit, J., and R. Sommer. 1998. Urban tree-planting programs--A model for encouraging environmentally protective behavior. *Atmospheric Environment* 32 (1): 1-5.

Tarrant, M. A., and H. K. Cordell. 1997. The effect of respondent characteristics on general environmental attitude-behavior correspondence. *Environment and Behavior* 29 (5): 618.

Verity, F. 2007. *Community capacity Building - A review of the literature.* South Australia Department of Health.

Watson, G. W. 1987. The relationship of root growth and tree vigour following transplanting. *Arboricultural Journal* 11 (2): 97-104.

Watson, G.W. 1986. Cultural practices can influence root development for better transplanting success. *J. Environ. Hort* 4 (1): 32-4.

Watson, G. W., and E. B. Himelick. 2013. *The practical science of planting trees*, ed. E. Hargrove. Champaign, Illinois: International Society of Arboriculture.

Watson, G. W. 1997. *Principles and practice of planting trees and shrubs,* International Society of Arboriculture.

Watson, G.W. 1985. Tree size affects root regeneration and top growth after transplanting. *Journal of Arboriculture* 11.

Watson, W. T. 2005. Influence of tree size on transplant establishment and growth. *Hort. Technology* 15 (1): 118-22.

Werner, C. M., J. Turner, K. Shipman, F. Shawn Twitchell, B. R. Dickson, G. V. Bruschke, and W. B. von Bismarck. 1995. Commitment, behavior, and attitude change: An analysis of voluntary recycling. *Journal of Environmental Psychology* 15 (3): 197-208.

Westphal, L. M. 2003. Urban greening and social benefits: A study of empowerment outcomes. *Journal of Arboriculture* 29 (3): 137-47.

Westphal, L.M. 1993. Why trees? Urban forestry volunteers' values and motivations. *Managing Urban and High-use Recreation Settings. General Technical Report NC-163.US Department of Agriculture, Forest Service, North Central Forest Experiment Station. St. Paul, MN*: 19-23.

Zimmerman, Marc A. 1995. Psychological empowerment: Issues and illustrations. *American Journal of Community Psychology* 23 (5): 581-99.

Appendix A

Project	Formative	Developmental	Sustained
Mature Tree Care			
Reactive removal of hazard trees	Periodic care of significant trees in community or upon request	Cyclical maintenance program for entire community	Cyclical maintenance and young tree training program
Conserving and Protecting Existing Canopy			
None	Town has zoning bylaw &/or subdivision regulations that protect trees	Town is purchasing land or easements to protect forest	Town actively manages forests for other econ. & environ. benefits
Planting Programs			
No planting program	Occasional planting in high visibility areas	Annual planting program	Planting > removed, throughout comm.
Community Capacity			
No current capacity for tree management	Active Tree Warden / Tree Crew	Tree Warden / Department with training and experience	Certified Arborist and fully trained crew
Legal and Policy			
Not currently following existing state laws	Enforcing state and other applicable laws	Local ordinance building on laws to protect public trees	Advanced ordinance adding private tree protection, etc.
Managing through Partnerships			
Occasional partnerships on specific projects	Citizen involvement in U&CF through tree board or other	Ongoing partnership with utilities and /or other U&CF mangers	Tree Board and ongoing partnerships with various mgmt. agencies
U&CF Education and Awareness			
No educational programs	Annual awareness event such as Arbor Day	Some information materials distributed to citizens	Ongoing education programs for youth and adults
Funding U&CF Program			
Some local funds for emergency tree care	Minimal local funds for basic tree care along with some grants	Sufficient local funds along with occasional grants and private donations	Mix of local funds, grants and private money, enough for management plan

Urban and community forestry capacity model adapted from Massachusetts State U&CF Program. (Hauer, 2005, pg. 36).

Appendix B

Best Practices of Data Collection

“Best Practices of Data Collection”
Introduction

This document is to be used as a component of the data collection sheets your community’s gravel-bed project received. If your community has already installed your bare-root gravel-bed stock, don’t panic! Caliper and stem/crown health data are also very important. This manual has been provided in the hopes that by observing “best practices” in data collection, we can strengthen your community’s commitment to achieve long-term and financially sustainable solutions to meet your growing public/street tree needs. This program was developed through a MN. Dept. of Natural Resources grant to The University of Minnesota’s Department of Forest Resources. It was given as a response to the threat of Emerald Ash Borer to increase biodiversity in tree species and offer new solutions for post E.A.B. reforestation.

CONTENTS

*Accompanying materials and tools should include the following:

- Gravel Bed data sheets (hand writable)
- Digital calipers (“loaners” or to keep)
- cm measuring tape
- Camera (loaner), if one is not accessible
- Dry-erase board (“white board”) and markers
- 4x4 gridded plywood
- Tree tags, if not accessible

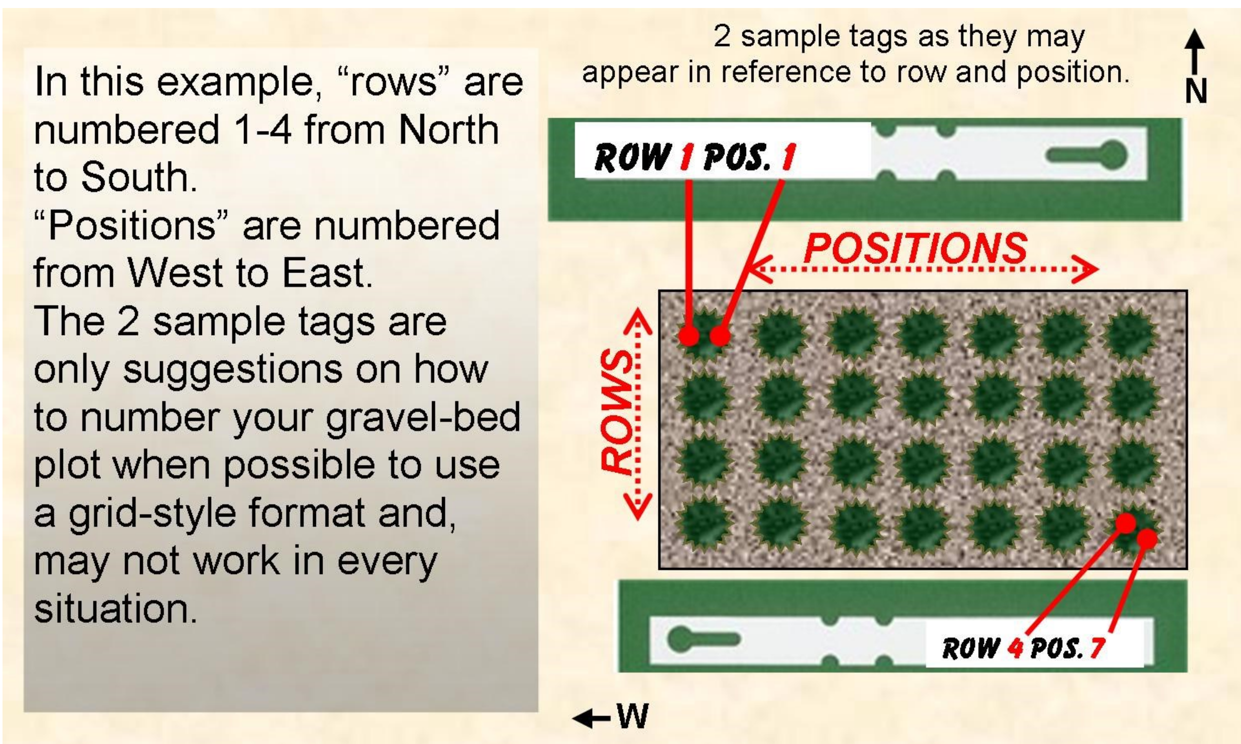
Recording of Species & Tagging and/or Numbering Stock

This is done prior to any data collection, these are some of the reasons accurate data collection is important to your community:

- To give more quantifiable answers to questions regarding species suitability to your specific bio-region.
- To correlate gravel-bed data with long term tree health data after transplant into your parks and boulevards (if we cannot locate the trees, follow-up visits become impossible).
- To address the financial impact within your community of "buying-in" and planting of more "traditional" type nursery stock.

Though, trees can be tagged and numbered as you wish, the following illustration gives you an idea of how a typical experimental nursery may tag their trees. The example, is based on a "row & position" system. Every row and position recorded on your data sheet should also correspond to a specific trees species on your data sheet. ******If your city/community already has a system for tagging and numbering stock, you may simply record that tree-tag # in <u>either</u> the row or position box of the data collection sheet.***

Hand written tags should be written legibly in permanent marker for photo. documentation (next page).



Collecting Root Data

The collection of the root condition data needs only 2 (digital) photographs per tree. The first is an identifier photo, which helps us track this particular tree's performance. The second is of the root system, which helps us independently put a numerical rating on the trees health from the ground down. This rating is very species specific and, is based on 4 specific root classifications which all tree species fall into as defined by Mn/DOT's "Inspection and Contract Administration Manual for Mn/DOT Landscape Projects" 2008 Edition.

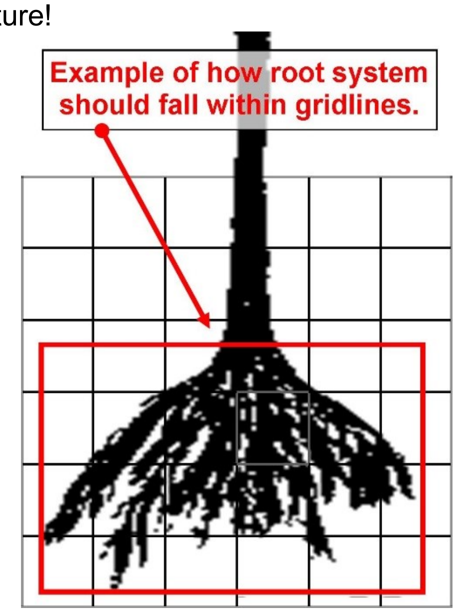
Protocol for Photographing Roots

*Prior to beginning this part of the data collection process you'll want to make sure:

- All your trees are labeled clearly as specified in the "Recording of Species & Tagging and/or Numbering Stock" section of this manual.
- *Set your camera for maximum resolution is for the purpose of computer aided photo analysis. Photos of lesser resolution will still be valuable for visual analysis and rating.*

1. Clearly photograph tree tag or whiteboard with row and position clearly written in dark colored marker. If your current gravel-bed set-up does not allow for clear row/position numbering, an individual tree # will suffice as long as it corresponds to species on your data sheet.

2. Hold the tree stem (outside grid) so the root system rests lightly against the grid and is visually within the perimeters of your 4x4 ft. gridded plywood whilst in camera view frame. Stem should be positioned parallel to the angle of the plywood. Camera should be positioned similarly as not to distort uniformity of gridlines. Take picture!



Above Ground Condition

The above ground condition rating is meant to reflect stem and crown health of a tree. This rating system may seem an arbitrary and subjective measure as two condition ratings may be different depending on two different opinions on what is healthy or unhealthy for any particular tree species. That being said, **it is wise to have two persons cooperate on this task**. This will help assure confidence and greater observance and accuracy within the data-set. It is preferable to choose individuals who will be available to collect follow-up condition ratings upon harvest from gravel-bed and potentially annual data one year after transplant.

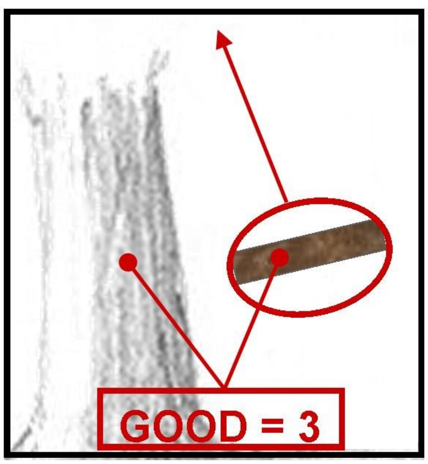
Like species* should receive *like ratings* for *like conditions.

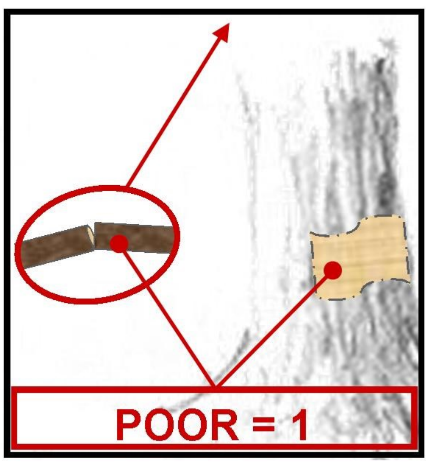
- Establish a mental "baseline" for each species & review your ratings throughout the process. Ask yourself "When compared to like species, do different ratings reflect observable differences within that species?"

- It is more important that the data stay accurate within it's data-set than, reflect a concise and defined criteria or concept of what is or is not "healthy".

The Ratings Should Be Recorded To Your Data Sheet As Follows:

0=DEAD 1=POOR 2=MODERATE 3=GOOD





Caliper Measurement

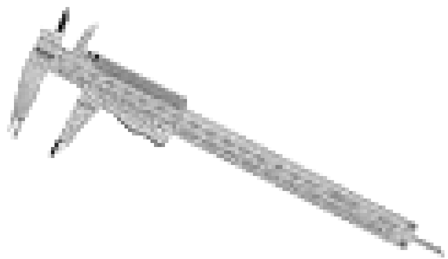
Caliper measurement, when accurate, is perhaps the best measure of the vigor and health of juvenile or recently transplanted trees. In the experimental nursery setting, this data is generally collected after stock has been planted or in this case, installed in gravel-bed. Unlike root data, this data can be collected indefinitely throughout the life of a tree. In the interest of time management of those directly involved in the data collection process, as well as to maintain consistency of collection within the set population, it is usually good to retrieve this type of data by **no more than two persons** (one to collect, one to record). Much valuable data has been lost due to a discrepancy in collection and variances in "note" taking styles (i.e. terminology, alternate use of abbreviations etc..). Also, it is good to have 1-2 persons who can clarify any questions that may arise in this process.

There are two basic types of calipers most appropriate for collecting measurements of trees the size of which were selected for this project. Digital calipers offer extreme ease of use, are very accurate and easy to read.

Calipers measure the diameter of a tree directly. They are comprised of a fixed arm, scale and moveable arm. There are a wide variety of calipers available. The most widely used type is the light, metal alloy caliper. These can be either digital which, is ideal for accuracy, speed and ease of reading or, traditional non-digital which, can be more difficult to read however can prove more durable and are less likely to fail due to weather (rain or extreme cold specifically). Most often people find calipers self explanatory; however, it is a good idea to read the accompanying owners manuals for specifics (especially for digital models).

All measurements ideally will be taken in millimeters (mm) to the second place after the decimal (hundredths of mm). For example they should be written as 65.43 or 58.76 versus 65.4 or 58.7. Trees with a caliper or circumference greater than 80 mm tend to be more difficult to get an accurate measure due to the depth of the caliper jaws.

Note: *If you find it difficult to accurately measure some larger species, a simple metric measuring tape (provided) can be wrapped completely around the stem at designate measuring point to obtain circumference in centimeters.*

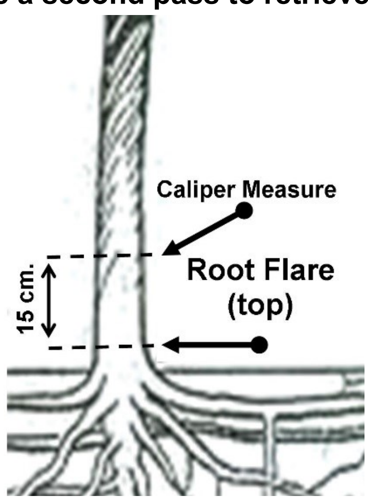


CALIPER MEASUREMENT STEP BY STEP

1. **Locate the root flare** (sometimes called trunk flare or root collar). We can define root flare roughly as the point at which the stem tissue (above the ground) swells at the base of a tree and begins to make a "visual transition" to the below ground root tissue (diagram below). Do not mistake this for the "graft union" which can be found at anywhere from 5-20 cm. above the root system on the stem.

2. **Measure 15 cm** (diagram below) from the "top" or beginning of this transition. If you wish, mark this point with a horizontal line with a permanent marker, latex type outdoor paint (using an artist brush) or alternatively, you may choose a latex (preferred only) paint marker which are less cumbersome, dry faster and can be purchased at most art stores. This process will make any follow-up measures much easier. Consider making your marks facing the same direction, this will make any follow-up caliper measurements easier, as the trees will be "pre-marked" at 15 cm.

***If you choose to mark, it will usually be more efficient to mark ALL your trees at once, AND THEN make a second pass to retrieve the caliper measurements.**



3. **Take Caliper Measurement**

- Place fixed arm and scale flush against the tree perpendicular to the tree axis, at 15 cm.
- Adjust the moveable arm until it is flush against the trunk.
- Read the scale.

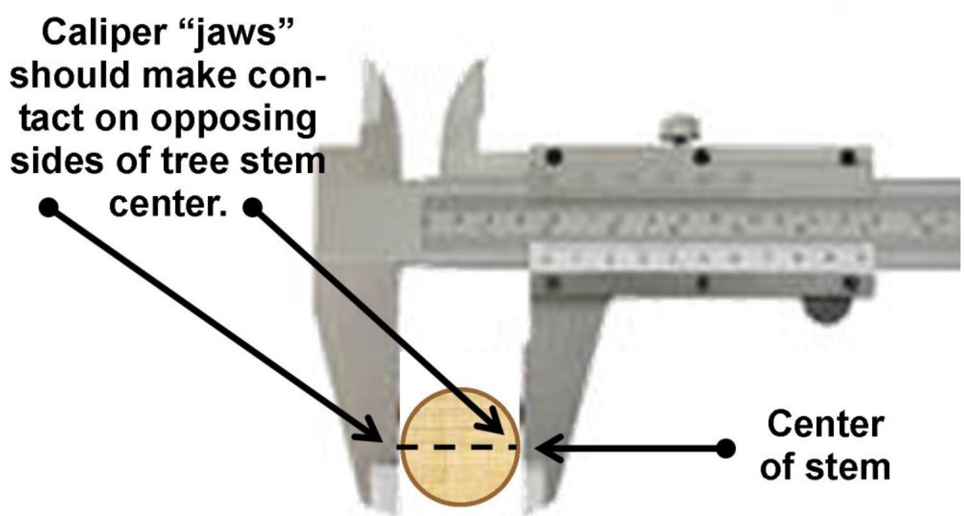


Photo: top view

****In the instance you need to obtain the measure from an elliptical (more oval or not truly round due to stem injury etc..) shaped stem you will need to take 2 separate caliper measurements:***

- Your first measure done as above.
- Turn caliper ¼ turn (90°) take second measure.
- ***Record both measures****;* be sure to clearly note the reasoning for 2nd measure in the "Notes" portion of your data collection sheet. No excessive detail is needed; you may simply note "not round", "damaged stem" or something similar based on reasoning of measure*.*