Reed Ebbinghaus ENTS 310

The Future of Invasive Plant Management in Northfield

Managing invasive species is of special concern for Minnesota municipalities to address, as nonnative plants exert a variety of negative effects on economic productivity, landscaping objectives, and the integrity of natural lands. As the Northfield township currently has no consolidated institutional arrangement aimed at tackling the issue of invasive plant encroachment, this guide seeks to establish a coherent framework that can enable the municipality to successfully address the issue. In this paper, I identify the two major hurdles that any management plan must overcome, analyze the current management situation in Northfield, and then propose methods by which the municipality can overcome both hurdles and establish an effective invasive plant management plan 20 years into the future.

Literature Review: The Academic Foundations of Invasive Plant Management

The relevant literature on municipal invasive species control offers many insights that are important for a Northfield commission on invasive plant management to address. It can be divided into studies that attempt to define different approaches or styles of invasive plant management, and those which determine factors that improve or impede effective invasive plant management.

Approaches to Invasive Plant Management

Studies that categorize different approaches to invasive plant management are presented by Lenhardt (2017), Kellie (2015), Sheley et al. (2000), Buhler et al. (2000), and Graham (2019).

Michigan's Oakland County plan to control invasive species (Lenhardt, 2017) offers not only a coherent procedure to implement management, but also introduces notable case studies of

civic action that led to improved local results. It divides management priorities into six elements. *Organization structure, function and leadership* entails creating an appropriate information archive of important individual, NGO and agency contacts, establishing committee protocols, and conducting surveys of partner groups to determine their qualifications for aiding in management operations. *Funding and resource acquisition* includes forming a fundraising committee, establishing and sustaining contacts with partners (higher-level agencies, NGOs, community associations) and submitting grant applications for management projects. *Communication, coordination and data sharing* entails forming a work group focused on communications; *Education, outreach and messaging* entails forming an education-focused work group, coordinating periodic training of management staff and educating local residents, amplifying existing community outreach initiatives, and creating guides tailored to landowners. *Project planning and implementation* includes forming a project-planning work group and determining priority species and sites for control methods; *Policy and regulation* includes gathering and reviewing local laws pertaining to invasive species, promoting local awareness of such policies, and establishing training sessions for committee personnel related to future management operations.

Sheley et al. (2000) covered an approach known as Ecologically Based Invasive Plant Management (EBIPM), which could be useful for municipalities in implementing local policy, or in zoning decisions where community stakeholders are involved. The management process is stepwise and centered on property owners. First, a property owner completes a Rangeland Health Assessment (RHA), which includes a number of rangeland health indicators, including presence and abundance of invasive species. Next, a specific committee reviews the RHA to determine major problems caused by invasives on the property. They then link these findings to tools and

strategies for management, using ecological principles from scientific literature to guide their decision-making. Next, councilmembers determine proper removal and restoration strategies based on these ecological principles. Finally, with the aid of professional land managers, the committee sets up a site-specific management plan based on principles of adaptive management.

Ontario's provincial invasive species management guide (Kellie, 2015) is instructive in that it emphasizes an Early Detection and Rapid Response (EDRR) approach to controlling invasive plants. This kind of response requires "an extensive amount of effective and efficient coordination" (14). The guide also lays out non-regulatory and regulatory strategies for implementing invasive plant management. Non-regulatory strategies entail developing a watch-list of invasives for each district, incorporating invasive management into municipal land-use planning, integrating common mapping techniques into management practices, public outreach initiatives, enhancing collaboration between local government and NGOs, and fostering self-sustaining stewardship groups that aid in invasive plant management. Importantly, the authors emphasize education and training for management committee staff members. Regulatory strategies mainly consist of reviewing and passing by-laws which incentivize landowners to clear property of invasives.

Buhler et al. (2000) investigated tools to eradicate invasives under an IPM (Invasive Plant Management) approach and considers some of the challenges to achieving effective sustainable weed management. Some of these tools include biocontrol, computerized decision aid, physical/mechanical control, selective pesticide application, and (most importantly for this analysis) government policy. In attempting to understand the feasibility and difficulties of invasive weed management, the authors compared the practice to insect pest management; they concluded that while research on best management methods are sparse, weed management is

likely easier and less costly than the latter. However, they stress that more research is needed to determine which IPM approaches are optimal, including proper policy applications.

Graham (2019) analyzed forms of institutional cohesion in invasive plant management strategies. Under *Participatory Invasive Plant Management* (IPM), each actor manages for invasives individually on their property. *Linked IPM* is similar to the participatory approach, but actors do meet regularly to share information and skills regarding management practices; they sometimes synchronize management activities. *Collaborative IPM* entails the pooling of labor and financial resources to undertake more effective management operations, such as via routine community "weed pulls". The author recommends *Coordinated IPM* as a unique future management style, which entails regional government collaboration with municipalities to implement management operations.

The Efficacy of Invasive Plant Management

Studies that critically analyze factors that improve or impede effective invasive plant management are presented by Kettenring & Adams (2011), Lavoie & Brisson (2011), and Joshua & Sheley (2012).

Kettenring & Adams (2011) overviewed what can be learned from decades of invasive plant management strategies in North America, arguing that most invasive plant removal operations have enjoyed only moderate success. Removal, management and restoration successes are limited by a lack of emphasis on native plant restoration, "limited spatial and temporal scope of invasive plant control research, and incomplete evaluation of costs and benefits associated with invasive species management actions" (1). Common pitfalls of invasive plant control include unintended lack of target precision in herbicide treatments and inattention to new invasions following initial removal measures. Moreover, there remains a strong disconnect

between research and practical, on-the-ground conservation actions in the field. These challenges are all necessary for municipal invasive species management committees to consider in order to ensure that control measures are as effective as possible.

Lavoie & Brisson (2015) address a problem of coordination that has affected the approach to tackling weed invasions for many years; namely, the disconnect between scientists who study these invasions and the managers who attempt to prevent them. Managers all too often rely on local knowledge, other managers' expertise, and personal experience in controlling invasives, even though published information can convey highly valuable (and often novel) information about the natural history and problematic potential of certain species. Demonstrating the benefit of establishing these linkages, the authors established a training program in Quebec where land managers were introduced to recent biological information. Municipal plant management committees would do well to promote these linkages in order to ensure that management efforts are up-to-date and in accordance with sound scientific practice.

Joshua & Sheley (2012) investigated methods of achieving effective sustainable plant management on a site-by-site basis. It combines two approaches or frameworks, Ecologically Based Invasive Plant Management (EPIBM) and a comprehensive adaptive management approach. The former is utilized to design a successful invasive plant monitoring routine, which means 1) choosing the best treatment for the given location, 2) selecting appropriate plot sizes, 3) replicating the treatment at different times and locations, 4) randomizing treatments, and 5) using control plots. This system of monitoring can be especially useful for municipalities where information is needed on how quickly invasives are spreading and their interference with other flora and private property. The adaptive management plan has 8 steps, ranging from preliminary measures (setting measurable goals for the management cycle and collecting information on the

site proposed for management) to more advanced ones (incorporating stakeholder comments and implementing the management plan).

Laying the Foundation for an Invasive Management Plan: Assessing Local Conditions

Rationale

The Minnesota DNR defines an invasive plant as any species which "is not native to Minnesota *and* causes economic or environmental harm or harm to human health" (Hardel et al. 2020). This distinction separates invasives from the great variety of nonnative plants, such as garden ornamentals, which do not pose such threats. The extent of harm posed by certain invasives are wide-reaching and affect multiple social assets. For instance, a number of species pose direct threats to public welfare. Wild parsnip *(*Apiaceae: *Pastinaca sativa)* is the most notorious local invasive and among the few that has seen concerted, lasting removal efforts. This is mainly owed to the fact that its detrimental effects are obvious to the municipal or township councilor: it contains toxic sap that causes serious burns when handled (Hardel et al. 2020). Other species affect public welfare by complicating property-related issues in residential areas, as their overgrowth can extent onto neighboring properties; the knotweed (Polygonaceae: *Polygonum spp.*) is a poignant example in this regard (Hardel et al. 2020).

The most pressing threat of invasive species is to regional biodiversity. While many nonnative species can become naturalized and sustainably fill ecological niches alongside native plants, invasive species tend to exert a competitive advantage over indigenous ones, forming monocultures that fundamentally alter the structure of forests and prairies, ecosystems which harbor a diverse array of native plant species and by extension many native animals which rely on their ecological services (Pyšek & Richardson). In Northfield specifically, biodiversity is of

special import because of the area's cherished natural lands. Sites such as the Carleton College Cowling Arboretum and the Cannon River Wilderness Area are diligently managed to maintain a pre-industrial mosaic of broadleaf forest (the "Big Woods"), riparian forest, oak savanna, and prairie, whose natural characteristics are cherished by residents as symbolic of Northfield and the wider Minnesota region (FCRWA). Through their negative effects on native ecological dynamics, invasive species reduce the scenic and recreational potential of public lands. Understory species such as buckthorn (Rhamnaceae: *Rhamnus spp.),* for example, create thick stands that overgrow walking trails and render hiking through wooded areas all but impossible; buckthorn also provides forage for grazing mammals far in excess of natural supply, causing proliferation of White-tailed Deer which may overgraze private lawns, deplete native foliage, and increase erosion and thus affect water quality (Nancy Braker, pers. comm.). When popular local hobbies such as fishing and birding are considered, it is clear that these third-order effects of invasive plants on Northfield's natural lands must indeed be taken seriously.

However, invasive plants do not pose merely aesthetic risks. The global economic impact of invasive species is immense (USFWS, 2012), and while Northfield is not yet been particularly economically hard-hit by botanic invaders, it is worth noting that 1) locals are often unaware of the potential for economic harm many local species possess and 2) many economically-destructive species are well-situated to establish themselves in Rice County in future years. In Northfield environs, Canada thistle *(*Asteraceae: *Cirsium arvense*) invades cropland and reduces yield efficiencies (Hardel et al. 2020) and common tansy (Asteraceae: *Tanacetum vulgare)* frequents pastureland, removing forage for livestock (RSWCD, 2019). Because agriculture is a major industry in this region of Minnesota, it is imperative that a proactive approach be undertaken which anticipates yield-affecting species that might invade and which works to

prioritize removal of established species that could affect yields if allowed to proliferate. The cost of eradicating species that pose even minor risks to agriculture, and the bureaucratic burdens of working with neighboring municipalities and counties to keep track of new species appearances, would certainly pale in comparison to the economic damage of a future outbreak that severely decimates crop yields.

Conceiving a Municipal Invasive Plant Management Plan: Logistical Hurdles

An effective invasive management plan for any municipality inherently requires a two-pronged approach. On the one hand, institutional actors must be aligned in such a way that formulating and implementing management initiatives are rendered possible on a sustained, recurring basis, as noted by Kellie (2015) and Lenhardt (2017). This entails establishing partnerships within public associations (i.e. different levels of government) and between public and private association. This coordination must prioritize not only implementation itself but prudent, tried-and-tested implementation methods (avoiding the common pitfalls highlighted by Kettenring & Adams (2011)), thus necessitating a fusion of local and official knowledge. On the other hand, an effective management plan is unsustainable without meaningful public awareness, support, and active investment. As I shall make clear in the following sections, I consider the efficacy of municipal invasive plant management to be a function of how well the overall system is supported by 1) effectie institutional coordination and knowledge-sharing and 2) civic involvement. These are, in a sense, two logistical "hurdles" which must be overcome.

Hurdle 1: Applying proper control methods and coordinating management

The tools for running an invasive plant management system are distributed among different actors and stakeholder groups within society. It is inherently an interdisciplinary process, requiring the application of biological knowledge, translation of that knowledge into the

largely uncodified action of "removal" and "restoration", knowledge of and adherence to property rights (i.e. zoning regulations), implementing landowner outreach, navigating funding sources, and understanding, modifying, or adapting to social incentive structures. However, the most basic requirements for getting a working invasive management plan off the ground appears to be 1) obtaining adequate funding for management operations and 2) collaboration with stakeholder groups in order to harness ecological, management (i.e. implementation), and other logistical expertise (Lendhardt 2017; Kellie 2015). The *kind* of expertise harnessed through institutional arrangements is equally important. There is no "one size fits all" approach to invasive plant management, and supposedly intuitive methods to removal often prove highly counterproductive. The biology of each species—namely, its life stage and seasonality—largely dictates which removal methods are to be prioritized; and thus, since each invasive species has its own unique life history (in terms of both physical changes and time intervals between stages), a single eradication approach cannot be applied to all or even most species (Hardel et al. 2020). For instance, tackling the purple loosestrife *(*Lythraceae: *Lythrum salicaria)* infestation in inner Northfield green spaces requires careful discrimination, matching removal type to plant biology and site characteristics: seedlings can be treated with mowing, herbicide application, or prescribed burns; bolting stems and flowering adults can also be removed by excavation or clipping; and wilting plants cannot be removed at all (Hardel et al. 2020). Applying the wrong treatment (i.e. mowing plants in flowering stage or clipping wilting specimens) can in fact catalyze seed dispersal, and some very effective control methods (i.e. prescribed burns and controlled livestock grazing) are impractical for certain sites (i.e. small downtown parks). These realities of management require important professional local and academic knowledge from experienced land managers, and it is therefore imperative that a municipal management system

establishes linkages with actors and stakeholder groups that specialize in prudent removal efforts.

Hurdle 2: Garnering awareness, support, and involvement of civil society

The second major hurdle towards creating an effective invasive plant management system deals with the wider civilian population. Involving the public is implicitly important because the objective of controlling invasive plants is largely to improve public welfare. However, public involvement is also crucial for purely practical reasons; without it, the system I propose could not sustainably function. The process of removing invasive plants requires directly occupying or altering both public and private space within a municipality. This will inevitably interfere with citizen's lifestyles. As such, civilians must come to understand the rationale behind aggressive invasive plant management, from which point they might become incentivized to willingly aid and not resist management efforts. The most pressing area in which citizen support is needed is in the form of voluntary workers; eradication and restoration efforts tend to be labor-intensive and, given the size of our natural lands and the number of municipal green spaces, cannot be undertaken by a mere handful of professionals (Nancy Braker, pers. comm.).

Across regions, garnering public support for this issue is inherently difficult. Invasive species management is generally considered a low-priority issue relative to objectives such as affordable housing, transportation, and development, to the extent it is prioritized at all (Lubeck et al. 2019). Citizens generally lack awareness regarding the identity of invasive species and the empirically demonstrated harms they pose; for instance, most people do not know the difference between an invasive and a naturalized nonnative plant, much less how to identify and then prudently remove the former (Kapitza et al. 2019). However, mere education will not necessarily overcome the civic action hurdle and turn Northfield residents into ambitious identifiers and

eradicators of invasives. There is also the very real possibility of public resistance to plant removal mandates; because the identity and threat of invasives is widely unknown, citizens may react negatively to ordinances which require them to remove certain plants on their properties. As such, if a removal plan begins with a top-down regulatory approach, it could possibly foment enough local resistance to kill the plan in its inception.

Current State of Invasive Plant Management in Northfield

Regulations and Stakeholder Groups

The regulatory framework around invasive plant management in the region is at once rich in awareness of the issue, and weak in organization and implementation. The county level has in fact been most active in defining and mandating prerogatives. The Rice County 2020 General Noxious Weed Ordinance mandates the eradication of "noxious weeds" on all property within the county. It divides listed species into four categories based on removal priority, with different mandates for each. *Prohibited eradicate* species are those which are not yet widely established in the region, but have the potential to increase in number; these 16 species are mandated to be "fully destroyed" under MN Statute Section 18.78. *Prohibited control* species are those which are widely-distributed in the region; "efforts must be made" to "control" these 12 species under MN Statute Section 18.78. *Restricted* species are likewise widely-distributed, but so abundant that manual removal is impractical; rather, under MN Statue Section 18.82, persons cannot "transport, sell of import any of the propagating [reproductive] parts" of these 16 species. *Specially regulated* species denote any plant species, including natives, which "pose ecological, economical, or human or animal health concerns", yet regulations associated with these 4 species are species-specific and under the jurisdiction of the MN Department of Agriculture (McCorkell, 2020).

The Ordinance is vital in that it separates invasives into priority categories which regulatory bodies and removal groups can use in determining the species to which they might best allocated removal resources. However, the Ordinance is “toothless”, in a sense: it does not define what it means to put “effort” into removal, and it makes no systemic prescriptions. Individual landowners are merely expected to follow its rules, clearly disincentivizing property owners to care about illegal plants that are out of regulatory sight. Moreover, the Ordinance gives no information on prudent removal methods, and given the widespread lack of public knowledge on species-specific requirements for removal, could therefore promote the inadvertent propagation of invasive plants by well-intentioned landowners (McKorkell, 2020).

Rice County also runs the Rice Soil & Water Conservation District, a subsidiary organization of the county government which, among other services, provides technical assistance to landowners in need of invasive species management (RSWCD, 2019). Due to its wide reach, it is unlikely that management services provided by the RSWCD will be able to play a major role in alleviating invasive species concerns within Northfield specifically. However, it is undoubtedly an institution that any local-level invasive plant management program would do well to work with, given its knowledge base and history of interacting with landowners.

The township level has also made considerable strides in certain aspects of invasive plant management. The Bridgewater and Northfield Townships (in Rice County) and the Greenvale and Waterford Townships (in Dakota County) work together under the Cannon Valley Noxious Weed Collaborative Group to gather information and implement eradication at various sites across their pooled jurisdictions. The CVNW’s 2020-21 wild parsnip survey yielded important information regarding the species’ abundance within the greater Northfield area and took steps to

eradicate it under the guidance of local land managers, notably Nancy Braker of Carleton College and Neil Slifka of MN DNR (Bridgewater Township, 2021).

There are even larger regional-level organizations aimed at addressing conservation and restoration issues in the region. For instance, the Minnesota Board of Water & Soil Resources operates the Cannon River Comprehensive Watershed Management Plan (CRCWMP), a broad multi-stakeholder group that works to clean up and restore riparian, agricultural, and municipal areas to for the benefit of cleaner water, waste/runoff management, and biodiversity conservation. However, addressing invasive species, especially invasive plants, is not a priority for the CRCWMP and, given the myriad issues in which it specializes, is not likely to become a priority in the future (MBWSR, 2020).

In contrast to the township, county, and regional levels, the City of Northfield lacks a consolidated approach to invasive plant management. This is increasingly problematic as new invasives such as Amur corktree (Rutaceae: *Phyllodendron amurense*) begin spreading into city limits, and as established invasives such as purple loosestrife continue to use the largely unmanaged city as vector for outward dispersal (Nancy Braker, pers. comm.). The lack of any local body aimed at addressing the issue is quite evidently owed to the lack of personnel the City is able to recruit, and to the paucity of community awareness, interest, and support.

Inefficiencies in Invasive Plant Management within Northfield

As would be expected for a municipality with no consolidated system for tackling botanical problems, there are a number of factors that either impede the establishment of such a system, or which exist because of its absence. First and foremost, there exists no City Council committee tasked with overseeing invasive plant concerns. As stated previously, this is due to a lack of both qualified personnel and public awareness. The lack of public awareness is evident in

that invasive plant identification is not taught in K-12 institutions in Northfield, leaving young residents without the tools to recognize a growing threat to public, economic, and natural welfare. It is also evident in that residents ascribe positive qualities to all plants with aesthetic properties, and thus do not consider their destructive potential—this is certainly the case for purple loosestrife, whose showy purple blooms are certainly beloved by many residents (Nancy Braker, pers. comm.). Moreover, on the occasions where the City or supervisors of its natural lands do request managerial support for eradication, contractors tend to lack sufficient training in species identification and in application of prudent species-and-stage-specific eradication methods. For instance, managers have mistaken the highly invasive wild parsnip with the indigenous golden alexander (Apiaceae: *Zizia aurea*) (Nancy Braker, pers. comm.).

There also exist institutional constraints to implementing management in Northfield where property rights are concerned. The seemingly trivial strip of gardened land between a given residential sidewalk and a street is a somewhat radioactive issue for city councilors. This green space is municipal land; however, adjacent landowners are expected to manage it. Over time, however, the notion that landowners' sidewalk-edge plants are *their plants* becomes institutionalized. Over time, landowners develop strong connections to trees and shrubs on these strips as they come to embellish and define the aesthetic value of their property. As such, city councilors are unwilling to mandate that landowners remove "their" trees, regardless of the fact that these green strips often harbor invasives and appear to serve as vectors for the spread of recent invaders like Amur corktree (Nancy Braker, pers. comm.).

Creating and Implementing a Northfield Invasive Management Plan

The first step towards creating a management plan for managing invasive species in Northfield is overcoming the twin institutional hurdles laid out in the previous section. Some of these prescriptions are intuitive steps to establishing a very basic foundation for inter-stakeholder collaboration and civic involvement, while others require conceiving of novel solutions aimed at overcoming particular challenges unique to Northfield.

Overcoming Hurdle 1

Ensuring effective collaboration that harnesses accurate management methods first requires establishing a central decision-making authority. This entails forming a sub-committee in the Northfield City Council explicitly tasked with overseeing and implementing invasive plant management. The sub-committee should be headed by a paid coordinator who oversees the committee's progress, develops periodic work reports to the wider city government and the public, secures funding for a long-term management plan, and establishes partnerships with relevant partner organizations. Secondly, 1-3 land manager positions are required. These should be paid positions that are not necessarily permanent; the city can call in managers with certain expertise tailored to priority issues being undertaken at any given time. The other council positions should consist of volunteer councilors tasked with handling logistical issues, such as connecting with partner organizations, helping secure funding, and working on public outreach initiatives. The sub-committee's metric for determining species, and thus sites, of highest management priority should be based on listings in the 2020 Rice County General Noxious Weed Ordinance. Moreover, committee personnel should actively utilize EDD MapS software, a database that allows user to report and investigate invasive species abundance across sites, in order to further solidify decisions on priority sites and species for management efforts. Most importantly, the council should submit grant applications consistent with a 20-year management

plan. In Minnesota, such funding can come from state agencies such as the MN Department of Agriculture and the MN Board of Water & Soil Resources; the latter provides a "Cooperative Weed Management Area" grant which currently funds local townships under the Cannon Valley Noxious Weed Collaborative Group.

Second, the sub-committee must work to establish partnerships with local organizations that can help provide personnel, technical guidance, and local knowledge. The University of Minnesota can serve as an important partner institution in this regard. It operates the Minnesota Master Naturalist Program, a citizen science initiative which, if well-promoted within Northfield, can recruit residents into becoming "Master Naturalists" themselves. Disseminating information on Master Naturalist membership can help incentivize residents to become volunteers in management activities, since gaining higher membership status in the program entails participation in community conservation initiatives (University of Minnesota Extension, 2019). University of Minnesota personnel, such as invasive plant management experts, can also serve an important function, namely training for hired sub-committee land managers. While training for professional managers may seem superfluous, it is in fact highly beneficial under the logic of making management methods as effective as possible. While regional land managers tend to possess highly valuable local knowledge, they are often not familiar with current academic literature on highly relevant subjects such as best management practices for particular species; Lavoie & Brisson (2015) term this disconnect the *knowing-doing gap*. Establishing committee workshops in which experts from the University of Minnesota are paid to periodically introduce hired land managers to relevant academic knowledge can serve to ensure that management is comprised of a mix of local and official knowledge sources. Collaboration with outside sources of management knowledge can also help promote the widespread and growing emphasis upon

restoration instead of merely *eradication* in invasive species management approaches (Kettenring & Adams 2011). When managers emphasize replanting with natives after eradication of invasives, the opportunity for invasive recolonization could be significantly lessened.

The sub-committee should also work closely with more regional institutions, since their demonstrated experience serves as an important reservoir of local knowledge. The Cannon Valley Noxious Weed Collaborative, for instance, has learned important lessons from recent management activities that the City can adopt in order to avoid making the same mistakes. For instance, the Collaborative found that certain forms of mowing were ineffective at controlling for wild parsnip and in fact helped disperse parsnip seeds (Bridgewater Township, 2021); such valuable local knowledge is vital for the City to consider in order to make management as effective as possible. The Collaborative and the Rice Soil & Water Conservation District also have the opportunity to provide important technical knowledge on management methods and, in the case of the Collaborative, mobilize a volunteer base for City-led management projects.

Overcoming Hurdle 2

Establishing public awareness

Garnering public support must come through multiple avenues, and partner stakeholder activities are indispensable in this regard. In order to recruit a sizeable volunteer base that can provide for the logistics of invasive plant removal and restoration, sub-committee volunteers should coordinate with Minnesota Master Naturalist staff to conduct periodic information sessions aimed at the Northfield public. In these sessions, residents are introduced to the concept of invasive plants, proper identification and removal methods, and encouraged to become Master Naturalists and thus be ready to engage in upcoming restoration activities.

K-12 education is another sector of the public where the seeds of community activism can take root over time. The City Council should work with local school districts to draft programs as part of curricula aimed at familiarizing students with invasive plant identification and removal methods. Community service opportunities should serve as a necessary component of the education program, as this will give students hands-on management experience and help establish a sustainable local volunteer base into the future.

Changing incentive structures

In addition to laying the framework for public awareness and involvement in invasive plant management, the sub-committee must make efforts to incentivize residents to manage for invasive plant species. Ecologically-based Invasive Plant Management (EBIPM) is an approach originally designed for rangelands, yet which holds promise for municipal approaches. Under an EBIPM framework, a landowner submits a Rangeland Health Assessment to local government or an organization with management capabilities, essentially a survey that details the presence and extent of invasive plant infestation on property. With this information, the managing body can supply the landowner with guidance or, granted permission, directly administer control methods (Sheley et al., 2000). In the context of Northfield, I propose a modified version of EBIPM whereby a landowner completes a "Property Health Assessment" detailing the extent of invasive plant infestation on their property, including the identity of the invasives. The next step can take one of two forms: 1) the assessment information can be directly reviewed by the sub-committee, which then determines best management practices tailored to the specific species, growth stage, and extent of infestation on the property; however, it is unlikely that a landowner will possess the expertise necessary to give accurate information on the identity of invasive species, in which option 2) should be implemented wherein volunteer councilmembers (with landowner

permission) survey the property and report to sub-committee managers with detailed information. Depending on the landowner's management abilities and willingness to individually address the issue, the sub-committee may then 1) provide detailed instruction to the landowner on how to remove invasives on the property or 2) recruit volunteers (the size of the volunteer force being based on extent of infestation, difficulty of removal, and landowner request) to directly implement removal.

In addition to methods like EBIPM that directly connect landowners to the City's decision-making authority on invasive plant matters, identity- or membership-based initiatives may hold promise in incentivizing landowners to care about and manage for invasives. For instance, the City can implement an initiative that awards residents who 1) complete periodic Property Health Assessment surveys and 2) commit to planting native species with a special "Green Community Guardian" status that can be presented through such media as yard signs or bumper stickers. Green Community Guardian status would accord certain benefits to members, such as subsidized removal of invasives on property by sub-committee-appointed volunteers. The naming of the initiative is particularly relevant in that it emphasizes the concept of community stewardship, allowing residents to signal their commitment to helping stave off an increasing problem for local welfare. The logic behind this approach is supported by Lubeck et al. (2019), who found that communities are most likely to care about, and thus manage for, invasive plant species if the issue is framed as one that affects the community as a whole and which requires collective action to address.

Implementation

First 5 years

The first five years of a Northfield invasive plant management plan requires 1) establishing the institutional connections and 2) laying the foundation for public awareness and support which will allow for effective management in future years. It is in this formative stage of program development that a City Council sub-committee must be formed. Sub-committee personnel should quickly apply for funding sources to power the plan through its 20-year lifespan, reaching out to the MN Department of Agriculture and the MN Board of Water & Soil Resources. Concurrent with this institutional set-up should come the establishment of partnerships with the Cannon Valley Noxious Weed Collaborative Group, the Rice Soil & Water Conservation District, and relevant contacts at the University of Minnesota (including Master Naturalist program coordinators). An essential element of these partnerships should consist of collaborations between sub-committee land managers and administrative managers of partner institutions in order to facilitate knowledge-sharing and close the knowing-doing gap. With a satisfactory degree of inter-group collaboration, the City Council can induce local management groups such as the Cannon Valley Noxious Weed Collaborative Group to help provide a volunteer base to begin implementing low-scale removal efforts within the municipality.

Sowing the seeds of public awareness may take a considerable amount of time, given the paucity of current awareness and interest in invasive plant management among most Northfield residents. As such, the City Council should prioritize working with local K-12 institutions to implement programs that periodically introduce students to invasive plant identification, awareness of their threats, community service opportunities that instruct them in proper removal efforts. Not only will this approach help generate a student volunteer base relatively quickly, it will allow for greater awareness and interest in invasive plant issues as students disseminate knowledge with adults and become more involved in the community over time. However, in

order to generate a sustainable public volunteer base, the sub-committee must work with MN Master Naturalist personnel to host workshops open to the public. These workshops should attempt to be as inclusive as possible, directed at many social groups such as college students and low-income communities (with some bilingual sessions). The workshops should serve not only to spread awareness but also to convince attendants to become Master Naturalists themselves, which will incentivize them to attend periodic volunteer sessions.

5 years and beyond

After 5 years, new program actions will be implemented under the assumption that some form of increased awareness, and a concomitant volunteer base, has been established in Northfield. This heightened involvement will allow the City Council to institute the modified EBIPM approach and Green Community Guardian initiative to reach out directly to landowners. With a sizeable volunteer base composed largely of Master Naturalist members, the sub-committee should work closely with partners to determine site-specific eradication priorities and finally begin implementing large-scale intensive management. In the process, managers and volunteers should use ArcGIS methods and citizen science data to create a tiered list of priority green spaces within the municipality for invasive plant removal and subsequent restoration. These sites would be targeted for weekly manager-led, volunteer-supported restoration.

10 years and beyond

After 10 years, it is expected that public awareness will be established enough that the City will be able to mandate removal of invasive plants found on property. This approach would ensure that invasive trees and shrubs do not use privately-managed public land as vectors. Most importantly, however, this stage necessitates using a consolidated Northfield invasive plant management system to reach out to other municipalities and pressure regional government to

implement more stringent policy against invasives. The municipality should create a united front with neighboring cities (i.e. Faribault and Dundas) and already-established township- and county-level partnerships to pressure the MN Board of Water & Soil Resources for a Cannon River Watershed Invasive Plan Management Plan. This regional plan would ideally reduce management costs in Northfield by reducing the rate of invasions via such avenues as roadsides. Important in this approach would be the involvement of civil-society-based organizations, such as The Nature Conservancy, the Minnesota Land Trust, and the Minnesota Farmers' Bureau that would allow for sustained input from a variety of affected and implicated stakeholders. This approach would represent what Graham (2019) describes as a shift from *Collaborative IPM* (coordination of management between local institutions and the public) to *Coordinated IPM* (concerted management implementation resulting from cooperation between multiple levels of federal government).

Conclusion

While Northfield currently does not have a consolidated approach to invasive plant management, the presence of guiding regional institutions and the possibility for employment of managerial expertise hold great promise for an effective municipal plan. Likewise, the provision of public workshops, educational programs, and EBIPM-related incentives may well garner a significant degree of public awareness, support, and volunteering that would sustain management operations well into the future. It is my hope that this analysis and plan may aid Northfield policymakers in the continued struggle to tackle the problem of invasive plants in the city, with councilors accounting for the two proposed logistical hurdles and working diligently to address them.

Works Cited

Buhler, Douglas D., et al. “Theoretical and Practical Challenges to an IPM Approach to Weed Management.” *Weed Science,* vol. 48, no. 3, 2000, pp. 274–280.

“Cannon River Comprehensive Watershed Management Plan.” *Minnesota Board of Water and Soil Resources,* 2020, < http://www.riceswcd.org/wp-content/uploads/2020/10/CANNON-RIVER_1W1P_DRAFT_FINAL_CLEAN_04132020_ApprovedCover.pdf>.

“The Cost of Invasive Species.” *U.S. Fish and Wildlife Service,* 2012, <https://www.fws.gov/verobeach/PythonPDF/CostofInvasivesFactSheet.pdf>.

“FCRWA: Join/Get Involved.” *Friends of the Cannon River Wilderness Area,* 2020, <https://www.friendsofcannonriverwildernessarea.org/join-get-involved/>.

Graham, Sonia. “Coordinating Invasive Plant Management among Conservation and Rural T Stakeholders.” *Land Use Policy*, vol. 81, 2019, pp. 247–255.

Hardel, Mari, et al. “State of Minnesota: Tactical Invasive Species Management: Regional Prioritization Plan 2020.” *State of Minnesota*, 2020, <www.mda.state.mn.us/sites/default/files/docs/2020-09/Tactical%20Plan%202020_4.pdf>.

“Invasive Species and Noxious Weeds.” *Rice Soil and Water Conservation District,* 2019.

Kapitza, Katherina, et al. “Research on the social perception of invasive species: a systematic literature review.” *NeoBiota,* vol. 43, 2019, pp. 47-68.

Kettenring, Karin M., and Carrie Reinhardt Adams. “Lessons Learned from Invasive Plant Control Experiments: A Systematic Review and Meta-Analysis.” *Journal of Applied Ecology*, vol. 48, 2011, pp. 970–979.

Lavoie, Claude, and Jacques Brisson. “Training Environmental Managers to Control Invasive Plants: Acting to Close the Knowing–Doing Gap.” *Invasive Plant Science and Management,* vol. 8, no. 4, 2015, pp. 430–435.

Leffler, A. Joshua, and Roger L. Sheley. “Adaptive Management in EBIPM: A Key to Success in Invasive Plant Management.” *Rangelands,* vol. 34, no. 6, 1 Dec. 2012, pp. 44–47.

Lenhardt, Susan, et al. “Strategic Invasive Species Management Plan: A Strategy for Collaboration in Oakland County Michigan to Prevent, Contain, and Mitigate Damage Caused by Invasive Species.” *Oakland County Cooperative Invasive Species Management Area*, 2017.

Lubeck, Alice A., et al. “Collective Factors Drive Individual Invasive Species Control Behaviors: Evidence from Private Lands in Montana, USA.” *Ecology and Society,* vol. 24, no. 2.

McCorkell, Trent. “2020 General Noxious Weed Ordinance.” *Minnesota Department of Agriculture,* 2020.

“Minnesota Master Naturalist: About Minnesota Master Naturalist.” *University of Minnesota Extension,* 2019, <https://www.minnesotamasternaturalist.org/about/>.

Nancy Braker, personal communication.

Pyšek, P., and David M. Richardson. “Invasive Species, Environmental Change and Management, and Health.” *Annual Review of Environment and Resources,* vol. 35, pp. 25-55.

Sheley, R., et al. “Applying Ecologically Based Invasive-Plant Management.” *Rangeland Ecology and Management,* vol. 63, no. 6, 2010, pp. 605–613.

Sherman, Kellie. *Creating an Invasive Plant Management Strategy: A Framework for Ontario Municipalities*. Ontario Invasive Plant Council, 2015.

“The Township vs. Wild Parsnip: 2020-21 Report by the Cannon Valley Noxious Weed Collaboration.” *Bridgewater Township,* 2021.