Volunteer Expert Technical Response Summary

Stormwater Utility Vegetation Plan

April 2024

City of Madison Engineering Division

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Background

Development of the stormwater utility vegetation management plan includes evaluating vegetation-specific stormwater management goals such as stabilization, groundwater recharge, and improved water quality, as well as multiple ecosystem services to address other ecosystem services and environmental concerns.

As part of this plan development, the City of Madison Stormwater Utility solicited volunteer assistance responding to land management questions from > 180 academics and professionals in the fields of stormwater engineering, lake and water quality, soil science, climate, urban heat islands, pollinators and wildlife, forestry, ecology, and land conservation.

Approximately 40 experts provided responses to these questions. Questions were catered to specific areas of expertise. Volunteer responses varied in depth and position, and responses back were variable across fields of study.

The specific questions asked are included in Attachment A.

Overall Findings

Responses varied and, in many cases, conflicted, showcasing an overarching theme that we live in an increasingly complex world that includes a variety of complex environmental issues.

This report provides a general summary of the feedback received in the technical responses. It is intended to identify large, broad themes and key findings. Each specific response includes nuances that are important to consider. It is highly recommended that this report is read in conjunction with responses of questions in Attachment A. Summaries of questions that had few responses were not included in this report but are included in the Attachment.

1.0 Priorities and Solutions Differ Amongst Technical Experts

Like many highly technical, scientific fields there are diverse opinions on solutions, best practices, and priorities related to vegetation. These varying opinions can be seen in the responses to almost every question including use of pesticides, accommodating migration shift, the tolerance of specific invasive species, down to specific mowing practices.
For example, experts in ecological restoration and conservation may prioritize native ecosystems, whereas experts in urban forestry may prioritize urban forest diversity including exotic species. Similarly, invasive species management experts may consider pesticides an appropriate tool to promote plant biodiversity whereas others strongly advise against any form of pesticide use because of the potential implications to pollinator biodiversity and health.

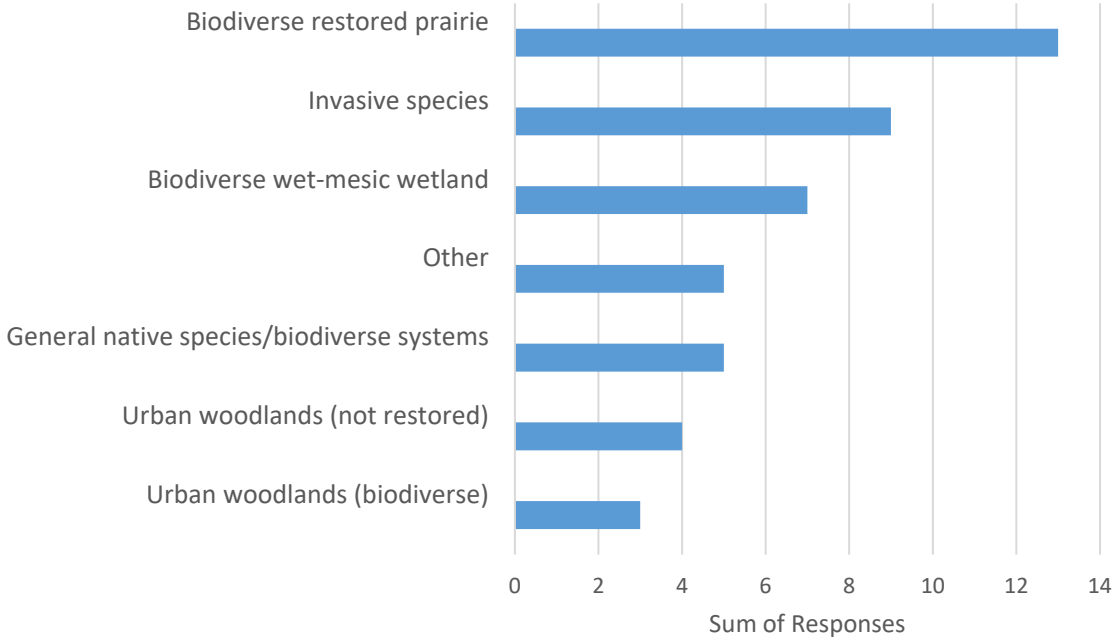
2.0 Resiliency is Complex with often Competing Solutions

Vegetation systems can rarely meet all the ecological/environmental/social solutions for resiliency. The term resiliency often oversimplifies the complex interaction of soils, hydrology, carbon storage, biodiversity, invasive species, pollinator habitat, climate change, and the increasingly complex ways that vegetation impacts these variables.

For example, wetlands providing a great example of the complexity of vegetation and their ecosystem services. Wetlands can be most resilient to flooding regimes and have the highest stocks of carbon, because decomposition of organic matter is so slow in anerobic environments. They also exhibit minimal tree cover and (in our region) are typically unable to meet the percentages of canopy cover that provide maximum heat island benefits. Wetlands are also incredibly susceptible to invasion by reed canary grass and hybrid cattails. These highly invasive species are particularly resilient to fluctuating water conditions but create systems lacking in biodiversity and offering few pollinator or wildlife habitat opportunities. Additionally, these invasive species are extremely resource-intensive to eliminate, requiring intensive grading, hydrological alterations and/or pesticide applications to control.

The below chart is an oversimplification of responses from experts but shows that generally experts acknowledge the adaptability of restored native ecosystems as well as their susceptibility to invasive species. No expert was recommending invasives species, just noting their highly adaptable characteristics to impacts like flooding, drought, species competition, disturbance, etc.

Figure 1: Most Resilient to Climate Change



Sample Quotes

- *"Unfortunately, degraded wetlands have proven themselves to be the most resilient. The most frightening aspect of climate change is the introduction of new, previously intolerant species to southern Wisconsin. This does not mean that the city should give up on restoration as the degraded wetlands are inferior to natural plant communities in every way except resilience."*
- *"The extensively studied Faville prairie example suggests that wetland-tolerant native prairie plants are resilient in the face of flooding events. Increased frequency of flooding would be an anticipated impact of climate change; thus, the biodiverse wet-mesic wetland would be expected to be the most resistant to climate change."*
- *"Unfortunately, degraded RCG or cattail monocultures are probably the most resilient. They have the broadest tolerances in terms of water quality or disturbance while also being widely distributed throughout the state. Although, existing wet-mesic wetlands may also be high on that list, if protection efforts are established. If those communities still respond and adapt to the natural hydrological disturbances they're accustomed to, it may be that those community compositions change over time based on temperature changes, but still retain the wet-mesic wetland designation. Urban woodlands may also be high on that list too, but over time they may be supplanted by the invasives currently existing in those areas."*

3.0 Native Plants with Deep Root Systems Provide Stormwater Benefits, which in-turn provide Lake and Water Quality Benefits

Experts in various fields noted the importance of native plants – or plants with deep root systems providing stormwater benefits including reducing soil erosion, increasing infiltration, reducing water velocity. Native plants with deep root systems were consistently identified as a method to reduce soil erosion.

Sample Quotes

- *"My experience is that deep-rooted native plants are best at withstanding urban flows and should be accompanied by turf reinforcement mat in most cases to provide resiliency as well as appropriate toe protection. Shoulder or flank areas with lower velocities and shears can transition to no-mow or turf areas to offer a more manicured look if desired. One approach in the design of waterways or open channels is to provide different levels (i.e. low flow channel with "shelved" channel section) of vegetation based on the frequency and inundation time. This could be established based on stormwater H&H modeling results for different rainfall events at different frequencies to determine the water levels in the channel. The appropriate vegetation can be selected at different elevations along the channel based on this analysis. This approach could provide a comprehensive restoration plan that incorporates numerous plant species and supports diversity throughout the greenway."*
- *"Invasive plants are prone to creating environments dominated by single-species monocultures. These monocultures may have shallow root systems or have other features that are not as effective at slowing, infiltrating or filtering runoff. They are also*

more susceptible to die-offs due to disease or other environmental stresses that can create openings in the protective blanket that would otherwise cover the soil."

- *"Soil erosion is significant and disproportionate problem related to any area of disturbance or exposed soil surfaces. In our urban areas, it is mostly related to construction sites where there is a failure to maintain adequate erosion control measures. It can also be associated with erosion of urban stream banks due to excessive streamflow flashiness, inadequate floodplains, sparse or shallow-rooted bank vegetation, and/or adjoining high-runoff surfaces and stormwater discharge points."*
- *"Infiltration does occur during flashy periods but to gain a significant increase there would need to be a greater effective infiltration area and additional area may be limited in urban areas, especially existing developed areas."*
- *"While soil erosion is a natural process along waterways, it is exacerbated by the hydromodification effect discussed herein. As such, as a water resource engineer attentive to the issue, I often witness eroded streambanks throughout the Madison area and surrounding communities. It seems a daunting task to address on a large scale, though in some cases invasives such as reed canary grass do a formidable job of populating these disturbed areas. While that is the case, they also can tend to mask the severity of the erosion by draping over areas of vertical erosion during growing months only to be revealed as problems in the winter. Laying back slopes (where space allows) with turf reinforcement mats/native vegetation and some level of toe protection could go a long way as a cost-effective means of stemming erosion and thus increasing biodiversity. Likewise, soil erosion in an urban area can result in sediment being transported to storm sewer systems that eventually drain to a stormwater BMPs or natural waterbodies. This can result in more frequent maintenance of BMPs for private landowners or the city and also result in a higher pollutant loading to natural water bodies."*

4.0 Areas of General Consensus

In general, there are a few areas where many experts seemed to agree. This includes:

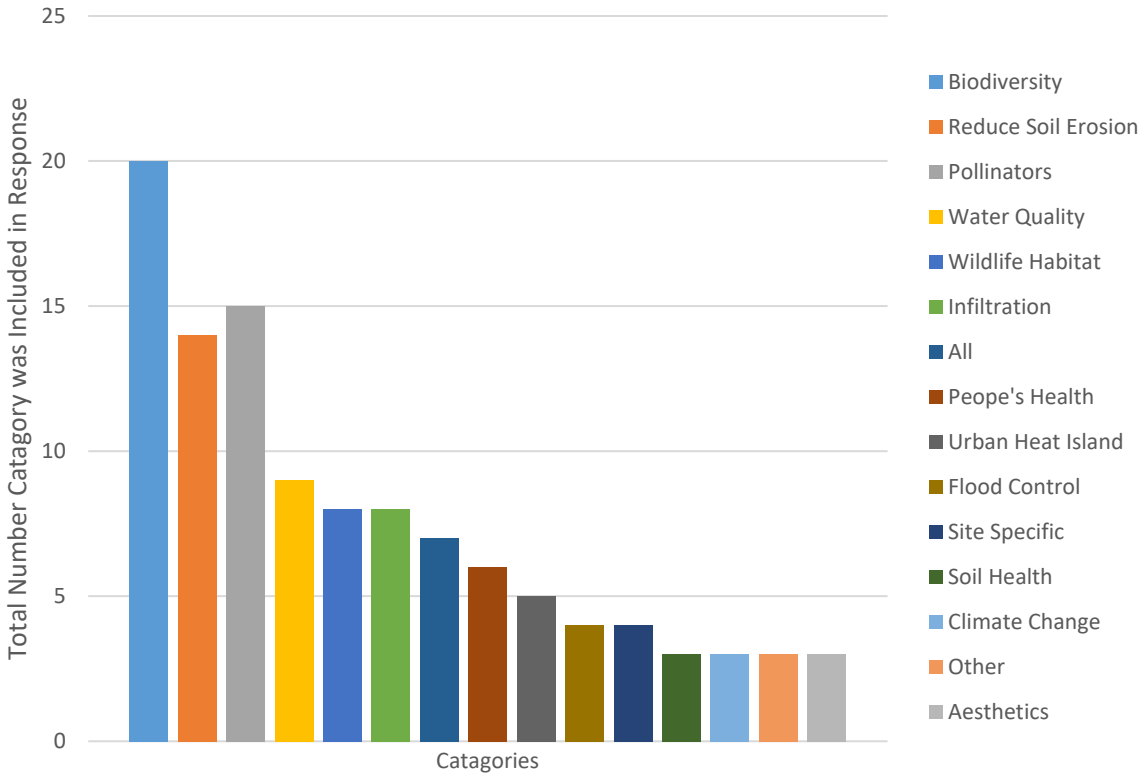
- **Top Ecosystem Services:** At the minimum biodiversity, soil erosion, and pollinator habitat should be priority ecosystem services that compliment stormwater management goals.
- **Top Ecosystem Threats:** There is a general consensus on the devasting impacts of reed canary grass in Wisconsin's wetlands.
- **Invasive species management is an important goal on public lands:** Native ecosystem restoration and native aggressive species management is more complex.
- **Include Integrated Pest Management as part of strategies for invasive species that includes prescribed burning and some pesticide use.** The majority of experts recognize the importance of herbicides and incorporating prescribed burns as part a comprehensive approach.
- **Native Plants in urban areas contribute to supporting pollinators and other species:** There are meaningful opportunities in small urban plantings to improve pollinator habitat, and potentially threatened or endangered species.

Within these topics there were variations of approaches and priorities, but largely there is consensus that biodiversity is extremely important; invasive species need to be managed on public lands; reed canary grass and hybrid cattails are a daunting threat to native ecosystems, IPM is critical to land management; and native plants play an important role for other species.

4.1 Top Ecosystem Concerns are Promoting Biodiversity, Reducing Soil Erosion, and Addressing Pollinator Impacts

Most respondents recognized that the top three ecosystem services that stormwater vegetation should provide include biodiversity, pollinators, and reducing soil erosion, but this was noted as not a "one size fits all" approach.

Figure 2: Top ecosystem services that stormwater utility vegetation should provide.



Example Responses:

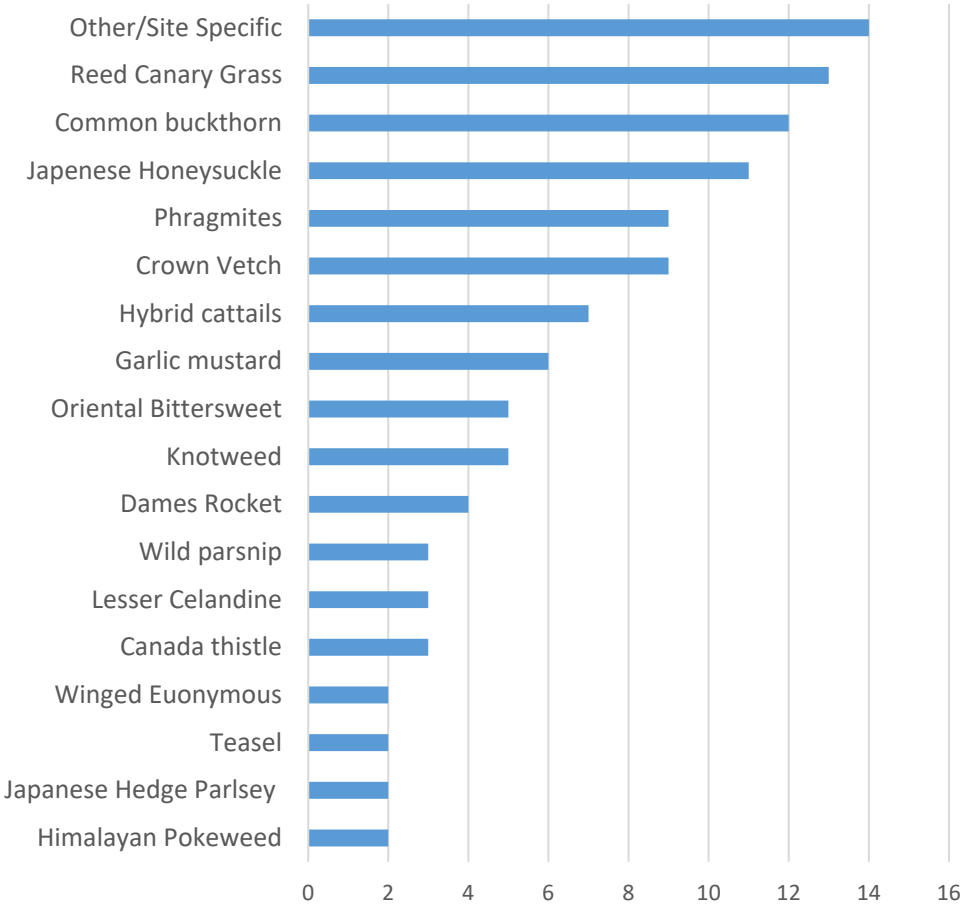
- *"My opinion is that these areas have the biggest impact/benefit on soil erosion and runoff management. When soil is bare, it is at higher risk of erosion and carrying other nutrients with it. Greenway vegetation gives the opportunity for water to infiltrate into the ground and slow runoff. With the increasing risk of flooding due to climate change, these areas can help build flood resiliency."*
- *"All of these are important, but given their size and common locations, I would rank soil retention, erosion, and biodiversity highest."*

- *"Biodiversity, urban heat island minimization, aesthetics (wild greenspace), soil retention/erosion minimization."*

4.2 Reed Canary Grass in a top ecosystem threat, but there are multiple other species.

Reed canary grass was identified as likely the invasive species most likely to impact habitat, biodiversity, etc. It is also recognized as incredibly prevalent and time-intensive to eradicate. Reed canary grass is a particular challenge to stormwater property since it thrives in moist soils and frequently flooded areas. It is also incredibly resource-intensive to eradicate as noted by many.

Figure 3: Invasive Species that Pose the Greatest Threat Today and In Future



Example Responses:

- *"Common buckthorn and reed canary grass, today and in the future."*
- *"Phragmites, Cattails, and Crown Vetch. Followed by humans. The impact of careless individuals littering, planting, spraying, transporting seeds on lawn equipment, etc. cannot be overstated."*
- *"Two characteristics are especially challenging: Legumes with hard seeds and long dormancies, and rhizamatous clones which resprout from small root*

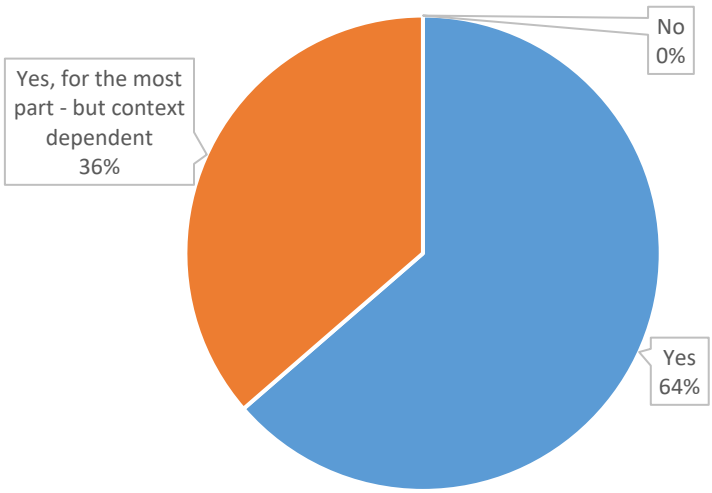
fragments not reached by herbicides. Or they have both characteristics like crown vetch. And in a changing climate? All the new invasives within 200 miles south of our climate zone may get here eventually with climate change. We should watch for them and eradicate their populations early when small, if possible."

- *"It depends on the species, the density and coverage of the species, and what the overall goals of the public land management are. Large, dense patches of invasives (like Phragmites) can take many years to control and may never fully be controlled. If the goals of a particular project are to increase diversity and native habitat, then invasive species removal should be included, but know that time, funding, and capacity may potentially have to stretch across many years."*
- *"Unfortunately, degraded RCG or cattail monocultures are probably the most resilient. They have the broadest tolerances in terms of water quality or disturbance while also being widely distributed throughout the state. Although, existing wet-mesic wetlands may also be high on that list, if protection efforts are established. If those communities still respond and adapt to the natural hydrological disturbances they're accustomed to, it may be that those community compositions change over time based on temperature changes, but still retain the wet-mesic wetland designation. Urban woodlands may also be high on that list too, but over time they may be supplanted by the invasives currently existing in those areas."*
- *"My experience is mostly related to phragmites, reed canary grass, buckthorn, and honeysuckle management. To the extent that species can be removed and then managed in quality stands of native vegetation, I strongly support the eradication in these areas and then management to keep them out. Without adequate funding to manage expansive stands of these species, they appear to otherwise provide stabilization of potentially erosion-prone lands and thus could have some surface water quality benefit, ecological biodiversity harm notwithstanding."*

4.3 Invasive Species Management is Important Goal on Public Lands

To some degree, all respondents agree that invasive species management on public lands is an important goal. However, less agreement amongst experts about removing aggressive native species as part of ecological restoration goals, which is discussed further in this report.

Figure 4: Should Invasive Species Removal be included in Public Land Management Goals?



Example Responses:

- *"Absolutely, while removing invasive species on public lands can be controversial. It creates opportunities to educate the general public on the reasoning behind the need for land management and its practices. Education can help to build support and possibly volunteers to help accomplish the daunting task of managing public lands."*
- *"Yes, within reason. Often for established invasive species, absolute removal is not practical or possible. The goal is to manage the invasive species, not necessarily remove every single stem. The exception might be for novel invasives for which, with quick action, one might prevent the invasive from gaining a foothold in the area of interest."*
- *"Yes, invasive by definition means that they will spread if not controlled. 1-Eradicate small patches. 2-Prevent larger patches from seeding or spreading vegetatively. 3-Use managed native competition to reduce them to minor components of plant communities. "*

4.4 Integrated Pest Management Should Include Prescribed Burning and Evaluate Sparingly Use of Pesticides

Ecologists and land managers almost unanimously agreed that fire is an important tool for land management, as well as sparingly use of herbicide is a necessary tool of integrated pest management. Fire was noted to have practical limitations of its use in urban landscapes but should be incorporated where logical. Regarding herbicide, most respondents acknowledged that its use should be limited, geared towards only specific situations, but is necessary for eradication of some species and for management with limited resources. However, some respondents cautioned against using pesticides, specifically neonicotinoids because of their impacts to pollinators. Note, that the Stormwater Utility does not use neonicotinoid herbicides or plant any species treated with neonicotinoids.

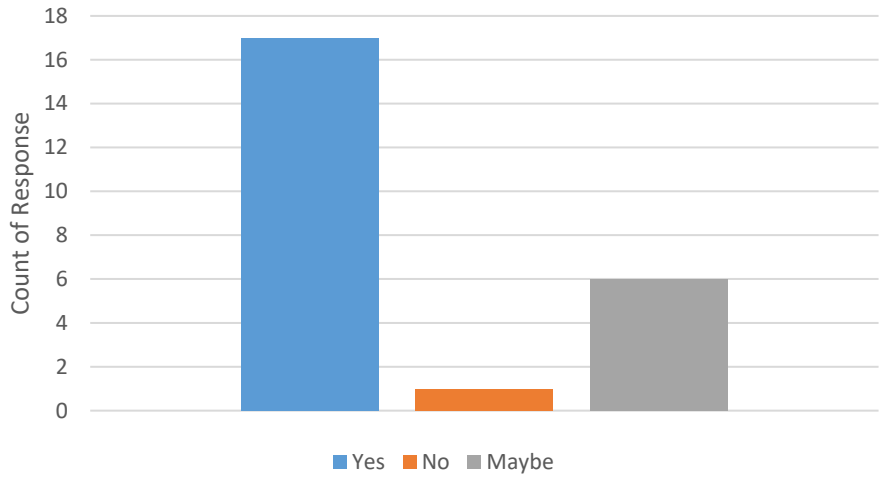
Example Responses:

- *"Reintroduction of fire in natural landscapes can have great positive impacts. The logistics of doing burns in an urban setting may be more challenging, but as a learning experience, volunteer experience or for demonstration purposes, burning could be just as important of an educational practice as an ecological one."*
- *"Reintroducing fire into non-urban and urban native landscapes is critical to restoring the native vegetation that once dominated the Madison area pre-settlement times. Removing fire from the landscape has played a role in invasive species population growth, our fire-adapted native vegetation species can withstand fire, while many invasive species cannot."*
- *"Most importantly, removal of pesticides - recent studies show pesticides such as neonicotinoids contaminate water, soil, plants, kill pollinators outright, sicken wildlife and birds, and are found in animal and human tissue. Plant for biodiversity and resilience. Use of cover crops, smother crops, companion plants, grazing, prescribed fire, and interseeding are preferred methods for pollinators. Interseed and/or overseed at regular intervals."*
- *"Given the acreage involved, herbicides can become even more important to utilize especially as monetary and labor resources begin to get stretched thin. Tactic changes may also be necessary depending on available resources. One such tactic could be focusing most management on remnant habitat and high quality plantings, and outside of that using herbicides to push satellite populations toward main populations working from the high quality areas towards the low quality areas. "*
- *"Herbicide seems like a necessary evil. There are certain species (e.g., reed canary grass, cattail) that manual removal doesn't make much sense at a large scale and there are others that can get so dense (e.g., garlic mustard, parsnip) that manual control would be too labor intensive to make a dent."*

4.5 Native Plants in Urban Areas Contribute to Supporting Pollinators and other Species, but not a Guarantee all Species will Benefit from Urban Native Plantings.

Responses generally indicated that native plantings in urban areas provide beneficial insect habitat but impacts to larger wildlife populations might be limited. Responses varied and included strong support in urban areas to improve pollinator habitat, included endangered species. However, many respondents indicated that larger tracts of preserved habitat in rural areas are more beneficial to larger wildlife.

Figure 5: Urban Land May Provide Meaningful Opportunities for Habitat for Uncommon Species and Pollinators



Example Responses:

- *"Yes. Absolutely and without a doubt small, urban native plantings totally provide benefits for pollinators and other wildlife. Period. Rusty Patched Bumble Bees have been well documented across large and small native plantings in the Madison and surrounding areas. Planting and restoring native habitat to provide for more spring blooming flowers and shrubs may be especially crucial to sustaining their populations, as well as those of other pollinators: including dutchman's breeches, virginia waterleaf, virginia bluebells, shooting star, currants, plums, serviceberry, and gooseberries. You can find a list of plants that the Rusty Patched Bumble Bee favors via the USFWS, this academic article by WI entomologists, or in Judy Cardin's publication."*
- *"In short, yes. Urban native plantings have been short to provide essential resources for native species including species like bats, arthropods(including plant pollinators), amphibians, birds, and other invertebrates. If we provide space in our community for these native species community members, they can be provided the opportunity to thrive along with us."*
- *"In terms of threatened or endangered species, the opportunities for habitat for these species is probably limited. Most of these species either have very specific*

niches, need a lot of area, or are sensitive to degraded systems, all of which may have been consequences of increased urbanization. Small plantings can potentially provide areas for pollinators but its important that they don't create habitat islands which may not provide long-term support for these pollinator species."

5.0 Areas of General Conflict

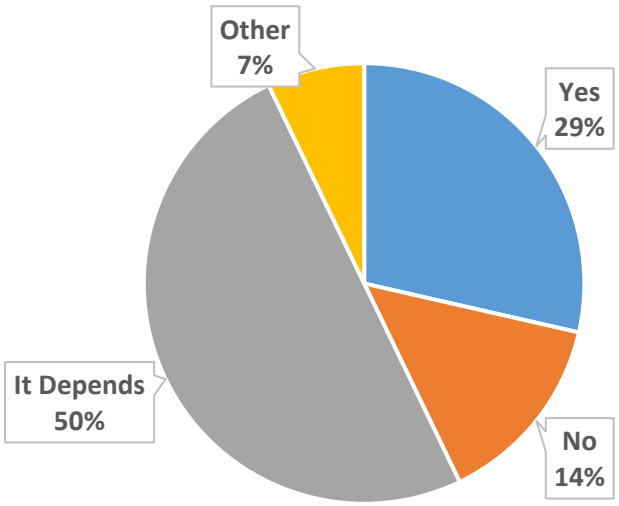
Areas of general conflict focused more on the nuances and prioritization of specific practices for invasive species removal. However, given a specific site, larger plan goal, and more time, it is anticipated that responses would likely be more aligned with more specific details and resources to answer the long list of questions they volunteered for. This includes:

- **Differing Views on Aggressive Native Species Removal:** The responses provided a broad depth and diversity of species that should be removed.
- **Different Perspectives on the Impacts of Mowing.** The majority of experts recognize the importance of mowing, herbicides and incorporating prescribed burns as part a comprehensive approach.
- **Opinions Vary on Assisted Migration**

5.1 Differing Views on Removing Natives that are not part of the Original Ecosystem.

Responses had vast differences in opinions on removing natives. However, many of them shared values that removing aggressive natives or other nonnative trees should be based on larger management goals and resources. For Stormwater Utility land, this is an important consideration where resources are limited – and management techniques like prescribed fire are limited based on the type of plants present.

Figure 6: Should Native Species Not Part of the Original Ecosystem Be Removed



Example Responses:

- *"Mesophication or the encroachment of native woody species that prefer shadier more moist environments or cannot tolerate repeated fire events within multiple years (i.e. maples, slippery elm, poplars, birch, and cherry) is one of the greatest threats to community health and diversity within wooded communities. It shades out the groundlayer and overtime starves the vegetation of the amount of sunlight it requires to grow."*
- *"Interesting question that restoration ecologists grapple with all the time. It depends upon what the goal of the management unit is. If the goal is to create a replica of the pre-settlement ecosystem down to the last species, then the manager might be justified in removing a box-elder or maple from a prairie restoration. If scientific replication of a native community is not the goal then why not leave the non-native species alone, all other factors being equal (see answer 3A). If, on the other hand, the management goal is to create or re-establish a particular ecological function, such as nutrient retention, or flood control, or erosion control, carbon sequestration, then the removal or retention of existing non-native trees should be justified on the basis that they hinder or help in achieving the management goal."*
- *"I think that removing some successional native species can be a good goal for some landscapes and locations for a similar reasoning as question 1. By reducing or removing some of these native species we are creating a space for the other native species that are adapted to open light regimes or regular disturbance like low intensity fire which provides much needed habitat for these disturbance adapted species thereby increasing the community diversity and resilience into the future."*
- *"By "original ecosystem" you probably mean the ecosystem prior to European invasion, which was managed with fire by indigenous humans. Without fire,*

more mesic trees will be more "natural" on wet and mesic sites (cherry, walnut, hackberry). It may be difficult and unwise to try to exclude them all forever from a natural succession. However, the species you cite are all floodplain species famous for invading bare soil anywhere, so I would try to control them in stands mixed with oak woodland diversity. Especially thin them out when competing directly with better oak woodland species, e.g. in the woodland fringe east of the Hanson Road ponds. "

5.2 Timing and Method of Mowing in Herbaceous Communities is Site Specific.

Respondents in conservation land management had varied opinions on mowing herbaceous ecosystems for management. The majority of the responses were in favor of mowing, but noted some concerns with a general approach compared to specific spot mowing – dependent on the specific site.

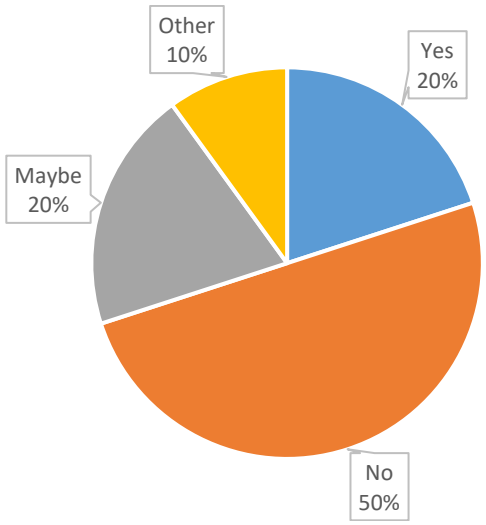
Example Responses:

- *"Mowing a newly planted prairie has been shown through research and on the ground practice to be an effective way to suppress annual and biennial weed species during the first 2 years after a prairie is planted with native Wisconsin species. The mowing is completed usually a few times per growing season for the first two years and a high blade height of about 10 inches to reduce the seed production of weed species while the prairie species are still short and putting most of their energy into below ground root system establishment. Mowing where there is a mix of cool season non-native and warm season native grasses present, mowing after the first couple of years after planting may inhibit the continued growth and survival of the warm season grasses while not negatively affecting the cool season grasses that can persist under more consistent herbivory or mowing events. This may then provide conditions in which the cool season grasses have an advantage and can outcompete the warm season grasses.*
- *"Spot mowing is not an issue. Broadcast mowing can be an issue if a large thatch layer is developed, potentially smothering native plants and creating cooler soil temperatures that will promote non-native cool season grass establishment."*
- *"Depends upon what the management goals are (grassland birds, species diversity, etc.) and on when the mowing is done. Take into account the needs of the species being managed for and time the mowing and its frequency to be beneficial or have the least impact. For grassland birds, one would not mow during the spring and early summer nesting season, for example."*

5.3 Differing Ideas Related to Assisted Migration for Climate Change Related Ecosystem Shifts

Assisted migration as part of stormwater utility land management includes encouraging establishment, typically of species native to North America, but native to floras south of our region. Such species were typically not historically present in pre-European settlement within public lands. The goal of assisted migration is in-part to proactively address warming climates and potential species migration. Most of the respondents were skeptical about this management strategy as a goal within stormwater management, but some cited potential benefits and examples.

Figure 7: Should public lands encourage ecosystem shifts related to climate change?



Example Responses:

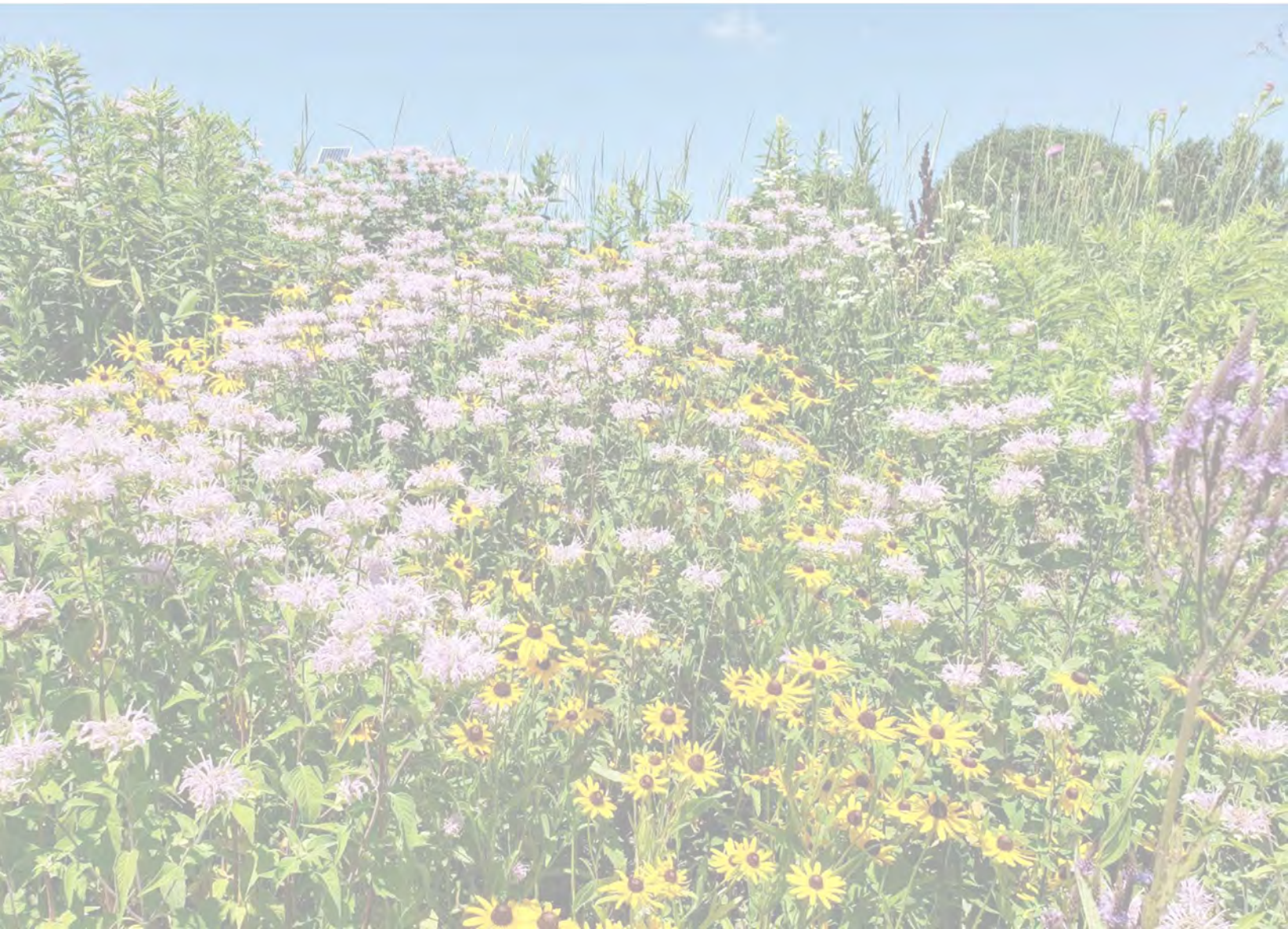
- *"I believe that it is pretentious to think that we know how to do this. We do not know how insect populations will be able to adapt to the "assisted" species nor how these species will affect native plants. Mostly what I have observed of southern species introductions is negative - aggressive species that out-compete native plants."*
- *"At this time, I would caution against introducing native vegetation species found south of the Wisconsin border into local Madison ecosystems, unless we understand or know that each individual species introduced will not have a negative effect on local vegetation and wildlife."*
- *"Assisted migration is a powerful strategy that is being studied and implemented on a number of levels by agencies including the US Forest Service. It is likely to be a key tool in the climate adaptation toolkit. For example, species at their northern range limits in Wisconsin are successfully used as street tree plantings, such as sycamore; and species that don't quite make it to Wisconsin as native species, are doing very well here, including redbud, Osage orange, tulip tree, and even bald cypress. These species may prove increasingly hardy and adaptable in the future, while native species like eastern hemlock and white pine, decline."*

Attachment A – Technical Responses

Stormwater Utility Vegetation Plan

April 2024

City of Madison Engineering Division



Contents

Overall Questions

1. While pond and greenway vegetation primarily serve stormwater management purposes, it also plays a role in carbon storage, urban heat island, biodiversity, pollinator habitat, soil retention and erosion, etc. Based on your expertise, what are the top ecosystem benefits or services these lands should provide?

Responses

1. Connective corridors of biodiversity. Top ecosystem benefits are habitat corridors that allow movement of wildlife between suitable habitats, and pollinator/insect habitat. We lose so much biodiversity due to habitat fragmentation and habitat loss, and the loss of insects is accelerating the loss of other species like birds. All of these smaller patches of greenway would be a lot of habitat and habitat connection if they were maintained with native plants instead of choked with invasive brush. Habitat corridors that are not invaded and support our native species will provide the above-mentioned purposes. That is what healthy ecosystems do. The key point is education to the public so people know what they are actually looking at.
2. All of the above, plus providing a place for passive recreation.
3. biodiversity
4. biodiversity usually has more resilience.
5. Biodiversity will help provide other ecosystem functions and services such as carbon storage, pollinator habitat, soil erosion and other features.
6. Biodiversity, pollinator/wildlife habitat, soil retention, capture of pollutants and trash and preventing them from moving downstream, water infiltration, beautification.
7. Biodiversity, urban heat island minimization, aesthetics (wild greenspace), soil retention/erosion minimization.
8. Currently they are managed primarily for stormwater purposes. I believe they could be, and should be, managed for multiple values and co-benefits, that improve our environment, benefit residents and the community, promote biodiversity, and help adapt our landscape and ecosystems to a changing climate. These are all important values that can be achieved and are complementary to stormwater management. Due to the limited available land for ecosystem restoration and public recreation in an urban area, it is important to maximize ecological, recreational, and watershed benefits from these public lands.
9. Erosion control, biodiversity, and pollinator habitat.
10. Evidence continues to pile up about the profound effect that nearby nature has on people's mental and physical health. Though hard to quantify, these services might be the greatest benefits of urban vegetation. However, these lands could provide all of the above and likely do so in a synchronous manner depending on the management goals and the means that support those goals.
11. Groundwater filtration, erosion control and shoreline stabilization, bird and pollinator habitat, support biodiversity, clean water and soil health, aquatic animal habitat, carbon sequestration - which all contributes to environmental health and thus human health.
12. I have limited education or professional training on this subject and can only offer an opinion based on my experience. I feel that one of the main secondary benefits of ponds/greenways is simply to insert some greenspace in an otherwise dense urban environment. Ideally there would be development and preservation of drainage/stormwater management corridors that would provide for a larger connected area of these kind of features.

13. I recommend using native species and plant communities native to the area in order to maximize carbon storage, water retention and infiltration, and benefit to native biodiversity, especially pollinators.
14. I would agree that all of the mentioned benefits are desirable and should be readily achievable. Out of all of them, the net carbon storage may be the most complicated in terms of being certain of its effects. It depends somewhat on what the alternatives are - e.g., removing the vegetation will definitely result in C losses, but there may be other uses that would store more C than vegetation for stormwater management - e.g., if being very wet means they are often releasing methane. That said, certainly these ecosystems contain C, and minimizing soil disturbance is typically the best decision from a C standpoint.
15. In my experience working with the UW-Madison Arboretum, Madison, and throughout the Midwest, the top ecosystem benefits are biodiversity, pollinator habitat, and erosion control for greenway restoration projects. Pond projects would also have biodiversity and pollinator habitat benefits but also a crucial role in keeping stormwater pollutants out of Madison's lakes. To the extent that pretreatment (potentially in the form of hydrodynamic separators, sumps with SAFL baffles and/or snouts) can be incorporated upstream of greenways and ponds, the community can benefit from trash and floatable control as a proactive maintenance provision to maintain the desired aesthetic though promoting greenway/pond cleanup days would have a similar effect while engaging the public.
16. Madison being an expansive urban wildland interface within the majority of multiple lakes watersheds has a great impact on the overall health of these watersheds. Reducing the impacts of erosion, and sedimentation by slowing down and/or holding water may be two of the most important ecosystem benefits that can be gained by stormwater utility managed lands. However, utilizing native species within these areas allows for the near equally important services of pollinator habitat and diversity hotspots to provide much needed respite for migratory species and potential habitat for species of concern.
17. My opinion is that these areas have the biggest impact/benefit on soil erosion and runoff management. When soil is bare, it is at higher risk of erosion and carrying other nutrients with it. Greenway vegetation gives the opportunity for water to infiltrate into the ground and slow runoff. With the increasing risk of flooding due to climate change, these areas can help build flood resiliency.
18. In my experience it's less about what these systems should provide and more about they are able to provide. Green spaces of any kind will help to offset the heat island effect. If a wildflower mix that includes species blooming throughout the growing season is sowed on the pond berm (for example) AND is maintained, then the diversity of pollinators and other insects can be high. If they are not maintained the only real benefit, they might have is plant biomass (likely non-native species like cattail or reed canary grass). This still provides cover and habitat for some generalist species, but not much more.
19. Pond and greenway vegetation should aim to provide the following services, in order of importance: soil retention and erosion services from upstream stormwater flows, pollinator habitat, biodiversity, urban heat island, and then carbon storage.
20. SM land can simultaneously offer water quality improvement, surface-water infiltration, carbon sequestration, wildlife and pollinator habitat, and biodiversity support.
21. The primary purposes of stormwater infrastructure are to a) minimize non-riparian flood damage to private and public property, and b) reduce the amount of sediment and phosphorus entering lakes and streams from urban catchments. Other ancillary benefits such as: groundwater recharge, carbon storage, urban heat island mitigation, biodiversity, pollinator habitat, human amenity, etc. should be

pursued when they do not pose a risk to the primary purpose, and are affordable. Though one questions how much impact the small area of stormwater utility land can have on these issues.

22. The stormwater management function of our greenways should be compatible with many benefits that green spaces provide in the City. Diverse ecosystems are inherently aesthetically pleasing- I believe in our neighborhoods these greenspaces provide a welcome relief from pavement and provide shade, recreational space, bird and wildlife habitat. If a greenway is determined to have inadequate ability to convey stormwater then engineered conveyance such as storm sewers; additional upstream storage, flumes, swales etc. should be considered before trees and vegetation would be permanently removed from the green space for the sake of stormwater management. The primary concern is that minimum impact alternatives are developed when changes are deemed necessary. Avoid placing new pavement in stormwater management areas.
23. There is really no reason why they can't simultaneously provide all of those listed benefits without the need to prioritize them. Regardless, my top two would be: 1) soil health (both erosion protection and infiltration); and 2) pollinator habitat & biodiversity.
24. These areas can also serve as valuable sinks for phosphorous, sediments, and nutrients damaging to downstream waters. Healthy waters contribute the most to healthy plants, soil, and ultimately wildlife. While these areas can serve as valuable small habitat parcels, their wildlife benefit could be increased by being connected via habitat corridors to other areas.
25. These ecosystem services will vary by facility and location, but in general stormwater mitigation or buffering, biodiversity, pollinator habitat, and soil retention and erosion are likely benefits common throughout most facilities. These benefits can be assessed using tools like ENCORE or InVEST if the City would like to explore further.
26. Vegetation buffers not only provide capacity for stormwater purposes, but also play a role in water quality: slowing and cooling water before it returns to its associated waterbody or returning to ground water reserves. The other services listed above are also beneficial, but urban heat island mitigation, pollinator habitat, soil retention, etc. may be more appropriate in particular contexts. Similarly, a third bundle of services that are also important (though maybe not in this context) are the aesthetic and educational opportunities these buffers provide. Educational signage is always helpful, not only to describe the goals of stormwater management, but also how that management uses natural solutions to achieve additional goals.
27. With changing climate and more extreme weather events, effective stormwater management could help with the other benefits mentioned as it may help prevent damage to other nearby areas providing ecosystem services. I also feel that these areas can provide a lot of benefits towards biodiversity and pollinator conservation.

2. In Madison, stormwater land spans a variety of ecological conditions and natural communities, such as: biodiverse restored prairie,biodiverse wet-mesic wetland,degraded reed canary grass and/or cattail monocultures, urban woodlands with a combination of mature oaks, invasive trees, and shrub species. Of these and other southeast glacial plains ecological communities, which do you see as being the most resilient to climate change?

Responses

1. Likely a diverse restored prairie.
2. Wetland plants are already predisposed to tolerate a wide range of moisture regimes. Biodiversity is so important, and we already know that aggressive species do not necessarily do what we were hoping (for instance, reed canary grass was planted for erosion control but actually provides poor

erosion control). Any biodiverse native plant community is going to have more of a chance to weather the changing climate because there are more species in it.

3. A dense and longer vegetative cover (not short or short cut) is better at limiting erosion by lowering energy immediately at the ground surface. Deeper rooted vegetation tends to support greater infiltration.
4. Again, I have limited education or professional training on this subject. I'm also not sure I entirely understand the question, but by observation I seems to see more and more stormwater features become overgrown with cattails. It would seem that they are the most resilient to all the factors that may be affecting them.
5. Although all plant communities are suffering as a result of climate change - established biodiverse prairie seem to be slightly more resilient. Invasive species also seem to thrive in atrophic environments.
6. Biodiverse prairies, wetlands and woodlands are going to be the most adaptable because they have a greater number of species. They will also be the best suited for wildlife habitat. Non-natives and invasives may be resistant to climate change, but they are not very desirable to start with.
7. Biodiverse restored prairie
8. Biodiverse restored prairie and urban woodlands. While degraded monocultures of invasive plants might be resilient to climate change, they have negative impacts on the resiliency of nearby ecosystems, so should be avoided.
9. biodiverse restored prairie
10. Experience tells me that the weedy reed canary grass and hybrid cattail monotypes are most likely to prevail in areas that receive stormwater runoff; it's obvious that they are thriving in disturbed areas under SM. They are thus "resilient" meaning able to resist or bounce back from disturbance. They are extremely competitive, but could be outgrown by tall woody plants in areas that dry periodically in unusual years. I think it's a mistake to consider vegetation as being constant in composition and abundance. It's also unwise to expect that just because we plan a particular assemblage for a specific site that it will establish and persist at that site.
11. I believe that biodiverse restored prairie and biodiverse wet-mesic wetland ecological restorations will be the most resilient to climate change. However, I believe that seedings and plantings conducive to a specific moisture regime should overlap to provide a seed bank that is more resilient to climate change as a restored area gets drier or wetter over time.
12. I can't comment on which will be the most resilient to climate change. More work has been done to identify the risks that climate change can cause to our ecosystem. I would refer to the Summary of Issues and Impacts that is outlined by the Wisconsin Initiative on Climate Change Impacts(WICCI)—Plants and Natural Communities Working Group the impacts outlined are more broad and will depend on specific properties and ecosystems. Another research brief authored by the WICCI Plants and Natural Communities Working Group shows that wetland restoration can be a very effective tool in increasing flood resiliency.
13. I don't really know how to answer this. Resilience is somewhat arbitrary, and I don't know how to compare these conditions/communities to one another
14. IMO, none of these habitats are "resistant to climate change" in the context of stormwater vegetation. If increased rainfall intensity and volume, alternating with increased drought and high temperatures, becomes the norm for the upper midwest, each of these communities will be challenged to "adapt".
15. In my opinion, this question is flawed. Obviously, novel ecosystems may be more able to adapt to climate change but that doesn't mean we should let invasive species dominate our landscapes.

16. Most resilient: restored prairie, urban woodlands. Slighly less resiliency for wet-mesic wetlands (prairies?) due to potential for invasive by reed canary grass.
17. My expertise is not really in this area.
18. Native grasslands, prairies, and degraded Reed Canary Grass monocultures will prove to be the most resilient to climate change.
19. WICCI has evaluated the climate change vulnerability of Wisconsin's natural communities and published a list here: https://uwmadison.app.box.com/s/rmsiursbljwnnhrq92c3rquxc0tanut6. Based on these results, I would order the communities noted in order of most-to-least resilient as follows. Communities already degraded, having more resilient hydrology, or established vegetation are generally more resilient to change: degraded reed canary grass and/or cattail monocultures, biodiverse wet-mesic wetland, urban woodlands with a combination of mature oaks, invasive trees, and shrub species, biodiverse restored prairie,
20. Per Wisconsin Initiative on Climate Change Impacts (WICCI)'s climate change vulnerability assessments of the natural communities of Wisconsin, mesic and wet-mesic prairies should be moderately resilient to climate change--biodiverse upland and lowland prairies are highly tolerant of a range of extremes from droughts to floods, fire, wind, etc. but they are vulnerable to invasion of aggressive, non-native species that thrive on high nutrient levels and frequent disruptive disturbance. Degraded RCG and cattail monocultures are probably going to increase at the expense of more diverse natural communities, due to the disruptive effects of increasingly large flood events, that bring with them excessive loads of sediment, nitrogen, and phosphorus enrichment. Woodlands are going to be increasingly vulnerable to changes in climate, hydrologic extremes (flood, drought) and introduced insects and pathogens. Fire suppression has led to a loss of oaks and oak regeneration is not at a sustainable level, while invasive species have increased.
21. Prairie once being the most expansive of these southeast glacial plains ecological communities allowed for individual species to inhabit ranges that crossed multiple states. Exposing them to different micro and macro climates and influencing genetic diversity that can tolerate a diverse range of climatic conditions. The interconnectedness of this community across its historical range (seed spreading via mammals, wind, and anthropogenically) helped to spread some of this tolerance to differing climates into most of the entire community over thousands of years. Building in a sort of base resilience to changing climatic conditions, which other communities lack as they generally sit in more ecologically distinct areas that did not allow for the same inherent genetic diversity. Prairies of today however are greatly fragmented and need a little intervention to replace the interconnectedness of history. Focusing first on utilizing native wisconsin species that are at the northern end of their range within the state will help to establish a core level of diversity that is resilient to the changing climatic conditions. Outside of those species utilizing seeds of the same species (same scientific name) found within Wisconsin's ecological communities from areas that Wisconsin's climate is predicted to shift towards, or as far south as possible if the species range does not include the area Wisconsin's climate is predicted to shift towards. Should help to ensure that our native ecological communities have the genetic diversity to remain diverse and resilient in the face of climate change. The regular application of prescribed fire within the communities that had a frequent fire return interval is another key to ensuring the stability and diversity of these communities into the future to weather the upcoming climatic changes. Regular application of prescribed fire will stimulate greater diversity within the whole community. Increasing its ability to act as a carbon sink through the increase of aboveground biomass actively uptaking more carbon. If done on a large enough scale this practice could help play a large part in slowing down or mitigating climate change.

22. Prioritizing native biodiversity of plant species that have evolved in this geographic region and that are selected to thrive in a given soil type, moisture regime, and sunlight exposure will lead to more resilient and stable ecosystems.
23. Resilience to climate change is hard to quantify and I don't believe is a primary driver of urban habitat shifts. That is due to direct human disturbance, land use histories, and lack of stewardship. We also have little idea on how individual plant species (populations) may respond to changes in snow cover, temperature, or precipitation patterns (drought, rains, winter rain, etc.). In general, native habitat that meets the following is likely to be more "resilient" to the effects of climate change: a) the are many different plant species (high species richness), b) plant species are balanced in their representation (i.e. not dominated by a single or select few species), c) habitat area is larger in size, d) habitat is actively stewarded, and e) habitat is protected from unplanned, extreme hydrological shifts (i.e. a wet area becomes dry or vice versa). The reed canary grass and urban woodlands are feasibly the most resilient habitat even though they don't meet any of the above criteria. Shows how much we know…
24. The biodiverse restored prairie and the biodiverse wet-mesic wetland
25. The extensively studied Faville prairie example suggests that wetland-tolerant native prairie plants are resilient in the face of flooding events. Increased frequency of flooding would be an anticipated impact of climate change; thus the biodiverse wet-mesic wetland would be expected to be the most resistant to climate change.
26. Unfortunately, degraded RCG or cattail monocultures are probably the most resilient. They have the broadest tolerances in terms of water quality or disturbance while also being widely distributed throughout the state. Although, existing wet-mesic wetlands may also be high on that list, if protection efforts are established. If those communities still respond and adapt to the natural hydrological disturbances they're accustomed to, it may be that those community compositions change over time based on temperature changes, but still retain the wet-mesic wetland designation. Urban woodlands may also be high on that list too, but over time they may be supplanted by the invasives currently existing in those areas.
27. Unfortunately, degraded wetlands have proven themselves to be the most resilient. The most frightening aspect of climate change is the introduction of new, previously intolerant species to southern Wisconsin. This does not mean that the city should give up on restoration as the degraded wetlands are inferior to natural plant communities in every way except resilience.
28. Well, that is the question isn't it? Difficult to answer because we don't yet know the full range of climate change impacts of the future. Probably best to have a range of natural ecological communities and stormwater vegetation types across the City to cover as many possible future scenarios as possible.

Land Group Questions

3. Should invasive species removal be included on public land management goals? What are your thoughts on restoring native ecosystems as part of public land management?

Responses

1. Certainly, a worthwhile endeavor and something that should be done on public land. Every little bit helps.
2. Good goal, keeping in mind restoration may look different than in more intensively managed conservation parks.

3. Madison being an expansive urban wildland interface within the majority of multiple lakes watersheds has a great impact on the overall health of these watersheds. Reducing the impacts of erosion, and sedimentation by slowing down and/or holding water may be two of the most important ecosystem benefits that can be gained by stormwater utility managed lands. However, utilizing native species within these areas allows for the near equally important services of pollinator habitat and diversity hotspots to provide much needed respite for migratory species and potential habitat for species of concern.
4. Restoring native ecosystems is a normal aspect of public land management. The Wisconsin Department of Natural Resources works to manage and restore hundreds of acres annually on properties across the state. It is important to realize that there is a specific connotation to using the terms “management” versus “restoration”. Management infers that an ecosystem must continue to receive inputs by human intervention in order for the ecosystem to retain its current state. Restoration infers that an ecosystem has returned to a self-organizing, and self-sustaining state after human intervention and that further human interventions are not required. Public land management will require more “management” than “restoration” as these ecosystems are not of sufficient size and scale to allow for self-perpetuating states. Not all greenspaces, ponds, and other stormwater areas will be suitable for restoration, these areas will be better served as management areas.
5. This is a critical effort in creating habitat corridors for native flora and fauna. Restoring native ecosystems provides the critical and (now) scarce habitat that native birds, mammals, herps, pollinators, and plants NEED to continue to survive. Restored lands are not only beneficial to wild beings, but human beings as well. Native plants, for example, work better together to mitigate flooding, cycle nutrients, and create a beautiful landscape we can all enjoy for generations.
6. When possible invasive species should be removed. This is a complex question since there are hundreds of non native species in a variety of situations. Is it important to remove burdock from a stand of reed canary grass?No. But what about crown vetch or birds foot trefoil starting in a planting of prairie wildflowers….yes because those invasives will kill all the wildflowers and destroy diversity. One size does not fit all, the decision making is an art advised by science for each specifically defined situation. In Madison area the greatest threat to prairie wildflowers is Crown Vetch. The seeds will last in the soil for 30 years and a single seed will expand into a single species patch killing all other plants. A crown vetch patch doubles in size every few years and can only be killed with herbicide or smothering with carpet or dense landscaping fabric left on for several years that encourages seed germination./
7. In deciding what to manage you look at what will give the biggest bang for the buck in other words you triage the landscape. Hey it would be great to control hybrid cattails and reed canary and then establish diversity, but would the same resources do for a more easily managed plant community such as a prairie meadow or an open oak woodland.

4. Should invasive species removal be included on public land management goals?

Responses

1. Yes; remove invasives. Yes. If invasive species aren’t managed there is no chance of creating biodiverse landscapes. Invasive species create monocultures which provide the least usable habitat. Absolutely yes.
2. Absolutely, While removing invasive species on public lands can be controversial. It creates opportunities to educate the general public on the reasoning behind the need for land

management and its practices. Education can help to build support and possibly volunteers to help accomplish the daunting task of managing public lands.

3. As for climate change…what is your definition of climate change…just getting warmer, longer growing season, drier because it is warmer. The goal of urban area plantings is appropriate diversity that can be managed with minimal available resources. In terms of presettlement vegetation Dane county has much more tree and shrub vegetation because fires used to burn all of Dane county except for limited protected areas such as the north shore of Mendota known for it's Maple trees on the Bluff.
4. First off, I prefer to not use the term "Invasive species" but rather use the term "pest species" or something similar. Invasive species is too general and pejorative, whereas pest species is directly related to whether the species in question interferes with the site's management goals, regardless of its native or non-native status. In my management planning I ask four questions: Does this species interfere with the site's management goals? If not, why not leave it alone? If the species does hinder reaching the goals, then maybe it should be controlled, contained, or eradicated. The second consideration in deciding whether pest species should be managed is whether or not there is the potential of the species spreading beyond the boundaries of the project site. A third consideration is where the species is officially listed as "Noxious" by the City, in which case, by law, it must be eradicated from the site. A fourth consideration is whether the species threatens human health and safety—species such as poison ivy or nettles or ragweed; all native species by the way.
5. Invasive species control is often a management goal on DNR managed properties. When planning for invasive species removal it should be considered on both a species level and a site level. In Wisconsin, invasive species are classified under NR40, Wisconsin's Invasive Species Rule. For a species to be considered to be invasive, the following criteria are considered:
   (a) The species' potential to directly or indirectly cause economic or environmental harm or harm to human health, including harm to native species, biodiversity, natural scenic beauty and natural ecosystem structure, function or sustainability; harm to the long−term genetic integrity of native species; harm to recreational, commercial, industrial and other uses of natural resources in the state; and harm to the safety or well being of humans, including vulnerable or sensitive individuals.
   (b) The extent to which the species is already present in the state, or in portions of the state, including whether there are isolated pioneer stands.
   (c) The likelihood that the species, upon introduction, will become established and spread within the state.
   (d) The potential for eradicating the species or controlling the species' spread within the state, including the technological and economic feasibility of eradication or control.
   (e) The socio−economic value afforded by the species, including any beneficial uses or values the species may provide for recreation, commerce, agriculture or industry within the state.
   Species that are classified as "Prohibited" under this rule are typically early detection targets, have a limited distribution in both the local and wider statewide landscape, and removal is required. Species that are classified as "Restricted" are much more widespread and are more difficult to contain. When considering a species for control, it is important to understand the species' legal classification. If the species is "Prohibited" efforts should be taken to eradicate the populations unless there are other circumstances that prevent success such as the lack of an

adequate control method. For species that are "Restricted", considerations should be made based on the intended management goal of the public property. Management should be prioritized to properties with high quality habitat, exhibiting biological diversity across taxa including plants and animals, serving as a reference ecological community, possessing rare/endangered/special concern species, or have other unique ecological or geological features.

6. It depends on the species, the density and coverage of the species, and what the overall goals of the public land management are. Large, dense patches of invasives (like Phragmites) can take many years to control and may never fully be controlled. If the goals of a particular project are to increase diversity and native habitat, then invasive species removal should be included, but know that time, funding, and capacity may potentially have to stretch across many years.
7. It is often a problem to find funding for invasive species management, but this is a critical component of restoration and a way for us to safeguard natural resources and ecosystem services for future generations. Invasive species have many impacts – ecologically, economically, and to human health. Invasive species control must be a community effort in order to reach long-term mitigation or eradication goals. Invasive species know no boundaries, and so cooperation is critical. By increasing the focus on invasive control on public lands, we can (1) set an example for private landowners and (2) create areas where native species can begin to move back in and re-establish.
8. Obviously yes.
9. Removal of introduced plant species should be included. Provided that removal of introduced plant species is a) required because the presence of that plant(s) is a driver of native plant loss or change in habitat function in a given area, b) is just one component of a larger stewardship plan, c) is completed by minimizing herbicide use, d) is goal directed, and e) is complimented with additional stewardship activities.
10. Removed!
11. Yes
12. Yes
13. Yes
14. Yes, definitely. In particular, invasives compromise stormwater management goals by reducing native species that hold soil in place and in some instances damage infrastructure (e.g., Japanese knotweed). Invasives also compromise biodiversity. Invasive shrubs such as honeysuckle and barberry are associated with a higher incidence of ticks and tick-borne diseases such as Lyme's disease, which are a threat to public health.
15. Yes, I believe that invasive species management should be included in the management of public lands for many reasons.
16. I believe that working to create and maintain space in our environmental community for native species is essential to providing the cultural, aesthetic, and natural resources that a diverse native species ecosystem provides to the benefit of everyone in the community. Providing this space often required the monitoring for and/or removal of invasive species that would otherwise displace the native species in our community. By providing urban spaces that contain native species communities present we are also providing an opportunity for our community members to reconnect and learn about these communities thereby increasing their investment

in beings that are present in them and understand how these native communities differ from the invasive species dominant systems.

17. Yes, invasive by defintion means that they will spread if not controlled. 1-Eradicate small patches. 2-Prevent larger patches from seeding or spreading vegetatively. 3-Use managed native competition to reduce them to minor components of plant communities.
18. Yes, where native vegetation, biodiversity, wildlife and pollinator habitat, and aesthetics can be sustainably maintained while also maintaining stormwater needs.
19. Yes, while common invasive plant species in Madison stormwater facilities, such as Reed Canary Grass/Buckthorn, can provide sediment and erosion control services, they offer little to our native wildlife as far as productive habitat. Vegetation species that were present in the Madison area prior to European settlement have adapted and evolved alongside native wildlife species by providing ecosystem services to each other for thousands of years. As native vegetation is displaced/outcompeted by invasive vegetation or removed via urban sprawl there is a reduction in functional habitat for native wildlife.
20. Yes, within reason. Often for established invasive species, absolute removal is not practical or possible. The goal is to manage the invasive species, not necessarily remove every single stem. The exception might be for novel invasives for which, with quick action, one might prevent the invasive from gaining a foothold in the area of interest.
21. Yes. Invasive plant species can outcompete and displace native plant species, but not perform the same ecosystem services as those native plant species. Not only do these invasive plant species fail to support and provide the same habitat for our native wildlife, birds, and pollinators, they can have other detrimental impacts on public lands and public waters. Invasive plants, such as non-native phragmites, can alter a wetlands nutrient cycling and hydrology; increasing flooding risk to areas or leading to drying out of wetlands (increasing fire risk) in other cases. Many invasive plants can also lead to increased shoreline/streambank erosion, which can lead to increased flooding risk, runoff, and sedimentation in waterways harming aquatic habitats and reducing water quality. In addition to increased risk of soil erosion some invasive plant species have other detrimental impacts to soil quality/health/fertility, for example knotweeds can alter the structure of soil reducing its ability to retain water and nutrients. Many invasive plants have very shallow and/or dense root systems which leads to reduction of water infiltration, increasing flooding risks and affecting water quality. The aggressive spread and growth of many invasive plants also can have affects on infrastructure; such as growth through pavement (roadways, sidewalks, etc) and concrete structures (building foundations, stormwater drainage, pipes, etc).
22. Yes. Based on the Public Engagement Report published for this effort invasive plants appear to be a “top” or “somewhat” concern among over 90%respondents (per Figure 15 on page 17). Thus, invasive species control is important to the communities within which the facilities are located and should continue to be a priority.
23. Yes. The work should be done in a commonsense manner. For example, planting into Reed Canary Grass(RCG) without first treating it will not replace it. Areas of invasive dominant plants should be completely wiped out. This can be done without destroying ground cover through the use of cover crops and herbicide application. Additionally, this work should be completed starting at the top of a drainage to prevent seed distribution downstream.

5. What about including removing native species that may not have been part of the original forest or ecosystem community? For example, removing box elders, slippery elm, silver maple, cottonwoods, etc. in areas that also have older populations of bur, white, and red oaks?

Responses

1. Yes, however, this should be done only after determining that conditions are suitable for restoration of the pre-disturbance plant community. For example, you probably should not attempt to restore oak woodland/savanna in areas where you can't include regular prescribed burning or at least removal of non-native or invasive shrubs and ground layer species.
2. Again, this may be a site-specific consideration, but if particular species are conflicting with management goals (perhaps the presence of certain tree species cause water retention time to be lessened and the management goals call for long periods of standing water or if the historic community wants to be maintained), then those unwanted species should be removed.
3. Yes, this should happen. If the community is converting away from the target community type habitat management should include whatever species are not part of the target type.
4. It is likely that a habitat change enabled intrusion by invasive species—the area was adapting. My preference would be to also remove these species—we are in an area that wasn't traditionally forested, and creating something more like an oak savannah is going to give us much more ecological bang for our buck. These species also need to be managed. Indigenous people have been doing this for millennia.
5. By "original ecosystem" you probably mean the ecosystem prior to European invasion, which was managed with fire by indigenous humans. Without fire, more mesic trees will be more "natural" on wet and mesic sites (cherry, walnut, hackberry). It may be difficult and unwise to try to exclude them all forever from a natural succession. However, the species you cite are all floodplain species famous for invading bare soil anywhere, so I would try to control them in stands mixed with oak woodland diversity. Especially thin them out when competing directly with better oak woodland species, e.g. in the woodland fringe east of the Hanson Road ponds.
6. I am a sucker for a big open grown white oak but I think woody species with the exception of buckthorn and honeysuckle are secondary in priority to removing non-woody species. From my understanding, trees are trees when it comes to nesting birds and rodents and shade/cover. Many of the undesirable trees mentioned are quick growing, provide nesting cavities for a variety of birds and mammals, and can provide shade cover which can be used to combat invasive plants. As long as forests still have some mast producing trees and are not being managed for timber value, we can accept the presence of some other species.
7. I am not in favor of blanket removal of native trees simply because they were not part of an original forest. If removal is part of a larger forest management plan that includes planting of oaks and a plan to manage the oak forest/woodland over time, that's fine.
8. I think that removing some successional native species can be a good goal for some landscapes and locations for a similar reasoning as question 1. By reducing or removing some of these native species we are creating a space for the other native species that are adapted to open light regimes or regular disturbance like low intensity fire which provides much needed habitat for these disturbance adapted species thereby increasing the community diversity and resilience into the future.
9. I would need to know about a site's history and disturbances that caused these species' to establish, as well as know about nearby vegetation that would likely reinvade following removal. It's important to know what assumptions are being made before major mgt projects are planned and implemented. I'd need to know if the historical species are dying out, i.e., not self-replacing. Also, are

the newer colonizers helping to shade out buckthorn? Has the habitat changed enough to preclude reestablishment of savanna, under climate projections? Is this replacement pattern widespread, indicating that it's likely to develop regardless of SM?

10. If the goal of an area is to regenerate those oak trees and other native trees are preventing that regeneration, then removal may be appropriate. But removing those `native species because they don't fit some ideal of original forest doesn't seem like a compelling enough reason. These are mostly urban, disturbed areas in a highly disturbed environment with a highly disturbed climate. The past can be very informative, but there's no going back to it. I would again consider what is the function of this land and how do or if these species play a role in that. Another concern which ties into resiliency is that by limiting the species allowed to provide canopy coverage (e.g. only oaks spp) we put the existence of any canopy at risk. Sothern WI has seen a decline in the population of old oaks due to a complex of stressors (climate, disease, insects, etc.). Diversity tends to help us maintain canopy in the face of increasingly stressful environments.
11. Interesting question that restoration ecologists grapple with all the time. It depends upon what the goal of the management unit is. If the goal is to create a replica of the pre-settlement ecosystem down to the last species, then the manager might be justified in removing a box-elder or maple from a prairie restoration. If scientific replication of a native community is not the goal then why not leave the non-native species alone, all other factors being equal (see answer 3A). If, on the other hand, the management goal is to create or re-establish a particular ecological function, such as nutrient retention, or flood control, or erosion control , carbon sequestration, then the removal or retention of existing non-native trees should be justified on the basis that they hinder or help in achieving the management goal.
12. It depends on the restoration goal. If the goal is to restore/recreate what we know was generally part of the southern WI landscape then yes, oak savanna without the other fire-intolerant species makes sense. However, if fire is not a management option, then leaving those other native species in-place may not be a bad idea. If the area to be managed is riparian then it is very appropriate to keep cottonwoods and silver maple in place.
13. Mesophication or the encroachment of native woody species that prefer shadier more moist environments or cannot tolerate repeated fire events within multiple years (i.e. maples , slippery elm, poplars, birch, and cherry) is one of the greatest threats to community health and diversity within wooded communities. It shades out the groundlayer and overtime starves the vegetation of the amount of sunlight it requires to grow. Once a mesophytic canopy is established it introduces leaf litter that is resistant to burning and in most cases requires mechanical clearing to allow sunlight to penetrate to the groundlayer and dry out the litter to a point where fire can be reintroduced. Reversing mesophication is something that should best be done in phases as taking too much of the canopy at once can release brambles and other aggressive native vegetation which can overtake the groundlayer and make it difficult to establish a diverse native ground layer. Ideally removal would take place over 2 to 4 years depending on level of encroachment. For the first phase, looking at removing invasive brush across the site and mesophytic trees encroaching below and 10 feet beyond the canopy of oaks and shagbark hickories can be a good first step. From there, looking at breaking the remaining encroachment into several diameter at breast height size class ranges such as under 4inch, 4 to 8 inch, 8 to 16 inch, and 16 inch plus, will help to minimize that flush of brambles and other aggressive native and invasive groundlayer species.
14. Prairie meadows are the easiest diverse planting to manage in an urban environment because you can mow them with heavy equipment. Any type of woody planting will be invaded by all the woody landscape plantings and must be removed by hand. In addition prairie seeds are available and

woodland seeds are not available at a reasonable price. Managing for oaks. The acorns from oaks feed dozens of species of wildlife and the dappled shade allows native savanna wildflowers to grow and these savanna seeds are relatively inexpensive. Of course the dense shade producing competitive trees should be removed, but do not forget that the buckthorn and honeysuckle competes with the Oak roots. Removal of the shrubs significantly increases the growth rate of the oaks and improves oak's ability to survive disease.

15. Recoverable remnant oak woodland and oak savanna should be prioritized for selective clearing of shade tolerant understory trees, where a prescribed fire program can be re-introduced for long-term management.
16. Removal of native species can be included under the same guiding principles as the removal of introduced plant species. Removal of plant(s) should be informed by achievable goals and set within a larger stewardship framework.
17. Since European settlement, there have been major change to the ecosystems of Wisconsin either by direct manipulation or by changing the dynamics of the ecosystems to allow for the colonization of other native, but not historically resident species. Replacement of these species is an option if there are appropriate alternatives. Considerations should be made to determine what the proposed benefits of replacement for the current ecological conditions, future ecological conditions caused by climate change, and the proposed economic costs for management. Removal of the listed species in question will leave areas vulnerable to both regrowth of the removed species, as they are part of the seed bank, and colonization of invasive species. If removal were to occur, it is recommended to start in areas where the older and more mature populations of bur, white, and red oaks are found. Oak species require longer times to reach reproductive maturity, this will help with recruitment of new oaks. Continued management will be needed to help provide conditions conducive to oak regeneration.
18. The answer to this question is dependent on the overall goal for each individual project or site, and the existing soil/water conditions that will be present post-construction. If the goal is to restore Oak woodland/savanna ecosystems the aforementioned tree species will need to be removed if they now dominate overall canopy cover.
19. This can be a controversial topic, but it really depends on your restoration or management goals. Are you trying to create "pristine" habitat? Or are you simply trying to create "better" habitat than what is currently present? What will the land be used for? I used to do habitat restoration and invasive plant management on State Natural Areas (SNAs). These are some of the highest-quality examples of native ecosystems that remain in the state. In these places, we would often remove native species that could negatively impact the remaining remnant habitat. On other sites that are more disturbed, we may leave them as they provide habitat for native species or prevent establishment of other invasives (forbs).
20. To the extent that this can be included as a cost-effective management action, then yes. Controlling these to restore or conserve more rare or remnant natural communities would add value to the community and biodiversity.
21. Whenever possible, it is good for many reasons to remove plants that are not native to an area. An important factor is the invasiveness of these plants, and their ability to avoid nearby ecosystems where people are managing for natives. The City should not make management by neighbors more difficult.

6. For the Madison urban area, what invasive species do you think pose the greatest threat to native plants, native habitats, and biodiversity today? And in a changing climate?

Responses

1. Non-Native Phragmites (Phragmites australis) Non-Native Knotweed Complex (3 species): Giant Knotweed, Bohemian/Hybrid Knotweed, and Japanese Knotweed This is from an wetland plant perspective. Both are aggressive in their growth habit/spread, outcompeting native plants and forming large monoculture stands. These monoculture stands will not provide the same habitat for native wildlife, birds, and pollinators. These are plants are resilient in a changing climate, giving it further opportunity to outcompete native plants.
2. Dense shade forming woody species like European buckthorn and alder. Also honeysuckle. These are manageable, with lots of effort of course. Reed canary grass is a major problem, but less manageable, unless you are willing to conduct sod removal and replant AND seed with native species. Very expensive and time consuming. Hybrid cattails are also a problem. They can be managed with aquatic herbicide and cutting/flooding, but those options are not always possible.
3. There are several invasive plant species that are found throughout the Madison urban area. Each of these species poses specific hazards to ecology, economy, and human health. There is not a short list of species that pose the "greatest threat", and each should be considered by their impacts, abundance, and location. The following is a list of species that should be considered for removal: Any plant species classified as Prohibited per NR40, Wisconsin's Invasive Species Rule. Wild parsnip (Pastinaca sativa): Wild parsnip has chemicals that cause chemical burns (phytophotodermatitis) when the sap makes contact with skin. This plant should be removed in areas where there is high visitation such as along trails, parks, and greenspaces or likelihood of contact. Giant hogweed (Heracleum mantegazzianum): Giant hogweed is another species in the carrot family related to wild parsnip. This species causes more extreme phytophotodermatitis. Knotweed species including Giant knotweed (Fallopia sachalinensis), Japanese knotweed (Fallopia japonica) and their hybrid Bohemian knotweed (Fallopia x bohemicum): These species cause issues with riparian corridors. In urban areas, the rhizomes of these plants can destabilize building foundations. Non-native Phragmites (Phragmites australis): Non-native Phragmites is a major issue for wetlands and waterways in eastern and northwestern Wisconsin. This species can be an issue for wetlands, reduces property values, and can be a highway visual hazard especially at intersections. A list of potential new invasive species, influenced by climate change, may be found at the Early Detection Distribution and Mapping System (EDDMapS). This list is found on their Range Shift Listing tool. This tool provides list of terrestrial invasive plants expected to expand their ranges into the chosen county or state with climate change by 2040 to 2060.
4. Buckthorn, honeysuckle, oriental bittersweet, winged euonymus, plenty of ground covers, moneywort, garlic mustard, Canada thistle, bull thistle and plumeless thistle, Siberian elm, Norway maple, Norway pine, black locust. I think woody invasives such as buckthorn and honeysuckle are some of our biggest threats, but in Madison reed canary grass is also a huge problem. One huge problem is that many aggressively invasive species such as vinca and squill are widely sold at nurseries and box stores. People assume that if you can buy it, it must be OK. These species appear to be "well-behaved" in an individual garden but are quickly overtaking our woodlands. Lots to watch out for, lesser celandine has me worried.
5. Buckthorn, honeysuckle, reed canary grass, non-native bittersweet, Japanese hedge parsley, and many others…
6. Buckthorn, Japanese honeysuckle, reed canary grass (RCG), hybrid cattails, oriental bittersweet are the most problematic in my experience.
7. Common buckthorn and reed canary grass, today and in the future.
8. Common buckthorn and reed canary grass, today and in the future.

9. In today's climate invasive species posing the greatest threat to native plants, native habitats and biodiversity today in Madison are: Phragmites, Hybrid cattails, Purple loosestrife, Reed canary grass, Common buckthorn, Bush honeysuckles, Multifora rose, Dames rocket, Knotweed. In the face of climate change: Japanese stilt gras,Kudzu
10. It seems that for many madison area spaces invasive shrub species like non-native honeysuckle and buckthorn are a primary concern as they can create monocultures, shade out other understory plant species thereby greatly reducing species diversity, increase erosion potential by reducing the herbaceous ground layer, and change the habitat type for many native animals including plant pollinators on which we depend.
11. Phragmites, Cattails, and Crown Vetch. Followed by humans. The impact of careless individuals littering, planting, spraying, transporting seeds on lawn equipment, etc cannot be overstated.
12. Reed canary grass and cattail in wetlands and teasel along roadsides.
13. Reed canary grass, honey bees, jumping worms, garlic mustard, buckthorn, honeysuckle, parsnip, sweet clover, spotted knapweed, japanese knotweed, Callery pear, etc.
14. Reed canary grass, invasive Phragmites, common buckthorn, tartarian honeysuckle, garlic mustard, Asian bittersweet; emerging threats including porcelainberry, European frog-bit.
15. Reed Canary Grass, Non-native Cattail species, Phragmites, Common Buckthorn, Honeysuckle, Common Teasel, Himalayan Pokeweed, Canada Thistle, Garlic Mustard, Crown Vetch, Dame's Rocket.
16. Phragmites australis and Japanese knotweed, plus any other invasive species newly encroaching on the Madison area.
17. Speaking from an absolutely biased perspective, Phragmites is a species that is not too common in Dane County, but can have massive, negative ecologic, economic, and aesthetic impacts on aquatic ecosystems. Though not in Wisconsin, the presence of bighead or silver carp would also have a great negative impact on our surface waters.
18. The most significant invasive species in Wisconsin now is probably reed canary grass, where over a quarter of herbaceous wetlands in the state have become dominated by rcg monotypes. In woodland/forest settings, jumping worms may be the most significant. Many invasive species will come into the state in the future and may pose a more significant threat.
19. The most significant invasive species in Wisconsin now is probably reed canary grass, where over a quarter of herbaceous wetlands in the state have become dominated by rcg monotypes. In woodland/forest settings, jumping worms may be the most significant.
20. The problems that pest species pose varies by the situation. In undisturbed diverse native ecosystems, in general pest species pose more of a management problem that they do in disturbed—stormwater, for example—situations. Typically, pest species come in on the heels of a disturbance—erosion, stormwater, disturbance of the soil, etc—and the key to controlling, containing, or eradicating them is to control, contain, or eradicate the disturbance. Given this, reed canary grass is a pest of both wetlands, and dry uplands. As for garlic mustard, Dame's Rocket and other biennials, they follow an up and down population cycle and over time will generally fade away.
21. This is a challenging question for me to answer, as I am somewhat new to the Madison area and am not as familiar with urban ecology. My background is also focused in the southeast part of the state. Based on my experience, the plants that I have seen making the biggest impacts are a lot of the most common ones: buckthorns (glossy and common), honeysuckles, purple loosestrife, garlic mustard, dame's rocket, wild parsnip, spotted knapweed, Canada thistle, non-native cattails, and non-native phragmites. Often times rhizomatous species are the most challenging to control – especially rhizomatous woody species.This is also a great place to talk about early detection and rapid response efforts. Because Madison is a hub of people, trade, and culture, there are many opportunities for

new invasives to be introduced. Early detection of these species and rapid response control efforts are critical in allowing us to prevent establishment of new harmful species. Species regulated as Prohibited in WI are examples of this. A few Prohibited species that I have heard about in Madison in particular are lesser celandine, princess tree, and porcelain berry. You can learn more about Wisconsin's regulated species here.

22. Two characteristics are especially challenging: Legumes with hard seeds and long dormancies, and rhizamatous clones which resprout from small root fragments not reached by herbicides. Or they have both characteristics like crown vetch. And in a changing climate? All the new invasives within 200 miles south of our climate zone may get here eventually with climate change. We should watch for them and eradicate their populations early when small, if possible.
23. Woody shrubs: Common buckthorn, Eurasian honeysuckle, and in some locations, glossy buckhorn and winged wahoo (Euonymus alatus). Vines: oriental bittersweet, porcelain berry. Herbs: reed canary grass, lesser celandine (Ranunculus ficaria). Still problematic but less of an overall threat are garlic mustard, Dame's rocket, Japanese hedge parsley. A changing climate will likely eventually bring species such as Japanese stilt grass, which would be devastating to stormwater/erosion minimization, as it is an annual and dies back in the winter, leaving floodplains with completely bare soil during fall, winter, and early spring.

7. Outside of projects where we have the opportunity for larger scale ecological restoration, should aggressive native plants be targeted for removal in highly developed urban watersheds, with surrounding high nutrient and pollutant land uses? For example, native aggressive plants that are found in our ponds and greenways and require significant resources to control include: prickly ash, sumac, Canada goldenrod, poison ivy and stinging nettles, hybrid cattails and reed canary grass.

Responses

1. They should only be targeted if there is a restoration plan post removal//something may be better than nothing in these cases.
2. In terms of providing the biggest bang for the biodiversity buck, I think those areas should be low priority for sure. However, in terms of aesthetics and neighborhood relations, maybe they would be a higher priority.
3. Those will be tricky. Aggressive natives should be controlled when possible, and I imagine people would be unhappy with the proliferation of poison ivy. The huge stands of reed canary grass and hybrid cattails that are causing monocultures are a problem as they make for less resilient wetlands. Again, I believe this will need to be accompanied by some serious educational efforts to ensure that residents don't get raving mad to see that cattails are being removed, for example.
4. Aggressive natives in greenways are probably not a priority for management. Reed canary grass and hybrid cattails should be considered invasive; the strains we have in Madison are not native. However, control of these species may need to be targeted—e.g., only if it makes sense as part of a larger more comprehensive project with a long-term commitment, as they are difficult to control.
5. Diverse native communities can filter and hold more water than degraded sites impacted by aggressive native plants. The mentioned species tend to establish a canopy that limits the amount of vegetation establishing underneath them. In stormwater ponds, drainages, and

greenways this can create opportunities for erosion problems. While maybe not a priority for management working to control these species, it may be beneficial to do so once areas of higher ecological quality have been managed to a point where there are resources to do so.

6. First, reed canary grass and hybrid cattails are invasive non-native species - not aggressive native species. They should be prioritized for removal. Regarding native aggressive species, this depends on the use of the property. I would suggest removing plants that have the potential for harm (poison ivy, stinging nettle) from areas where people are expected to use, such as along walkways, but I would leave them in interior areas where you would not expect people to encounter them. Otherwise, Canada goldenrod, prickly ash and sumac perform important ecological functions and are highly tolerant of disturbance. Unless there is a restoration potential in a degraded site I would not remove them.
7. Goldenrods are an important food for reproductive bumble bee gynes (new queen) during the fall shoulder season when few other plants are blooming. Of course we need to think of the whole landscape, but since it can be hard to find replacements for the role they play in fall foraging resources, I would put these as a lower priority for targeted removal. In addition, I've heard reports from partners creating pollinator habitat that once they've improved the overall habitat, the other forbs and grasses balance it out naturally.
8. I am less concerned with these aggressive natives than invasive non-natives (with the exception of RCG, which is so invasive and hard to control)
9. I think this would take local nuance rather than a blanket response. What's the quality of the invaded land? Is it otherwise turfgrass or former ag fields? Well then, let those aggressive natives grow. Is it a high-quality oak woodland with reproducing oaks? Well, perhaps removing those invasive natives makes some sense.
10. If these species are minor components in more diverse native communities, they should be controlled. If they are monocultures or mixes of such aggressive plants, it will be inefficient or impossible to eradicate and replace them. In that case, we should try to prevent their spread to new areas.
11. In highly developed urban the question of whether aggressive native plants should be targeted for removal is complicated. While invasive plants are a significant concern due to their ability to outcompete native species and disrupt ecosystems, aggressive native plants also pose challenges. In such environments, the decision to remove aggressive native plants depends on specific ecological goals of the restoration project, the extent of the plant's impact on biodiversity and ecosystem health, and the resources available for management. Aggressive native plants can contribute to urban ecosystem services and may have adapted to thrive in disturbed or nutrient-rich environments caused by urbanization. If funding is limited, prioritize areas with non-native invasive plants first before addressing aggressive natives.
12. In many instances, these species are symptoms of a larger problem and not the problem themselves. Many native plants simply can't handle the nutrient (or salt) loads dumped into our urban watersheds. Removing those plants in some instances could either cause nutrients that would have otherwise taken up that nutrients to end up in our waterways, or else managing those species will be endless, unless larger restoration of the watershed can be accomplished. If these areas are frequented by pedestrians, it may be best to target some of the more dangerous species (poison ivy/stinging nettle) or to provide signage that allows them to be identified and avoided.

13. Maybe, maybe not. It all depends. These questions should be asked on a case-by-case; species-by-species basis. What is the management goal of the unit? Is the species in question standing in the way of achieving the goal? If so, maybe remove it. But, is there the time, money, and know-how to control the species? If eradicated is there a species of value that can replace the one removed? Think of the species listed in the question. Prickly ash, sumac, and Canada goldenrod are all clonal. Does staff have the time an resources to control these species? These three species are not likely to spread far and wide so why bother? Maybe prickly ash and stinging nettles, and poison ivy are along a path where people walk, then in this case staff might want to try to set them back; if they grow elsewhere, perhaps let them alone. Hybrid cattails and reed canary grass might be a problem if they threaten to invade a high quality area but the premise of the question is that we are not talking about high-quality areas.
14. No. The plants listed (prickly ash, sumac, Canada goldenrod, poison ivy and stinging nettles, hybrid cattails and reed canary grass) can provide necessary vegetative cover and insect habitat. They should only be removed if their removal directly contributes to the regeneration and permanence of existing native plant species found in that same habitat area or leads to further habitat creation or restoration (see guiding principles on removing plants, above). In many cases, the areas where these plants are present lack existing stewardship activities, the surrounding land use facilitates constant disturbances (physical or chemical), and few, if any, other native plant species are present to benefit from their removal. In sum, if the conditions and disturbance regimes that favor the aggressive native species aren't changed, then efforts, cost, and time to remove those species are not going to be successful or self-regulating.
15. RCG should be a top target as well as hybrid cattails. The others, while not fan favorites, are always better than the inevitable replacements: Buckthorn, RCG, Oriental Bitterwseet etc..
16. I think this is lower priority than other management. Some of the species listed provide important forage for pollinators and other wildlife despite being more common native species. These are not pristine or preserved ecological communities in general, so having a diverse assemblage of mostly native plants is a good target for cultural landscapes.
17. Shrubs (native or not) should be controlled if the target community type is grassland. Cattail and reed canary grass should be controlled in wetlands.
18. Substantial evidence points to hybrid cattail and reed canary grass being non-native, invasive species. Native strains have long ago been 'swamped' out by non-native strains introduced from Europe. In general, the species listed are aggressive and may require significant inputs of ongoing effort and expense to manage. A better approach would be to prioritize management approaches, in locations where sustainable management programs can bring these aggressive species into balance, as part of a more diverse, highly functional ecosystem. That may include using mechanical mowing, clearing, herbicide, prescribed fire, native seeding, and even managed grazing to improve diversity and ecosystem function. '
19. This question implies that hybrid cattails and RCG are native species. I'm not sure what you mean, since the cattails are hybrids of the native broadleaf x non-native narrow-leaved cattail, T. angustifolia or uncommonly, T. domingensis, and the RCG that dominates SM land is very likely to be alien (I understand that one or more native strains of RCG might occur in a few places, but my information is incomplete).
20. Unless the aforementioned aggressive native species are being removed as part of a more involved ecological restoration project with native seed mix installation and multi-year invasive

species removal efforts, I would not use extensive budget to focus on controlling these species, except for Reed Canary Grass and hybrid cattail as those species will outcompete most other native vegetation.

21. You can not manager natural areas without herbicides. If you do not intend to use herbicides to treat the stumps of cut woody material….why waste your time. Yes you can go with heavy mowers to cut the brush….but it just resprouts into a bigger problem. We use chemicals all the time….just try to maintain the roads without petro-chemical products.

8. Should public lands encourage ecosystem shifts related to climate change? What are your thoughts on assisted migration, particularly with regards to plant selection for restoration of urban, public lands?

Responses

1. I don't believe that this should be a priority for stormwater and greenway related lands. These are "utility lands" and while they most certainly can contribute ecosystem services, trying to incorporate specific climate change mitigation efforts seems out of the scope. Simply maintaining a mostly native plant community should be the main goal.
2. I think that we should beware of shifts in ecosystem structure and function, but it's still hard to assign the cause of each shift to climate change vs. shorter-term environmental variation vs. human influences. Also, all three potential causes might be interacting.
3. I like corridors. There may be a few that need assistance to not blink out. Assisted migration is not my first choice, as we don't have a good way of knowing how these species will act in our area and it seems like there are plenty of plants native to our area to choose from.
4. Another question requiring local nuance than a blanket approach. I'm not sure what an ecosystem shift is – like from a forest to a prairie? Generally, I am perfectly fine with assisted migration so long as the species are not known to be invasive. I think an acceptable, conservative approach for "natural spaces" would be to complement your native species with species that are native to more southernly parts of the Midwest. For highly disturbed urban spaces (eg along streets, next to buildings), I think non-native species, even if their native range is many thousands of miles away, are fine. We need things that can survive these incredibly difficult areas.
5. Aside from temperature changes, we have very little understanding of how existing plants or plant communities will respond to the complexity of climate change, particularly in urban environments. I do not think public lands should encourage ecosystem shifts solely based on expectations of climate prediction. There are a wealth of native WI plant species that tolerate varied growing conditions: including dry to wet soil moistures, drought or flood tolerance, and tolerance to warmer temperature extremes. Assisted migration of some plant species may be appropriate provided 1) that there's a conservation need to respond to range shifts associated with changes in temperature tolerance that may influence a plant's or associate/host's survival; 2) for the purposes of experimentation; 3) for horticultural value (who doesn't love flowering dogwood?); or, 4) use regionally native species from south of WI that match our future ecological conditions as substitutes for introduced trees on boulevards or other plantings (e.g. use native trees from elsewhere in southern US that provide same functional benefits as introduced species).
6. Assisted migration is a powerful strategy that is being studied and implemented on a number of levels by agencies including the US Forest Service. It is likely to be a key tool in the climate adaptation toolkit. For example, species at their northern range limits in Wisconsin are successfully used as street tree plantings, such as sycamore; and species that don't quite make it to Wisconsin as

native species, are doing very well here, including redbud, Osage orange, tulip tree, and even bald cypress. These species may prove increasingly hardy and adaptable in the future, while native species like eastern hemlock and white pine, decline.

7. At this time, I am hesitant to assist in migrations of species as a way of adjusting for the future with climate change. I do not know enough about, and I am not sure if we as a community have enough information to feel informed in this type of an action. This may be different in the future with new information and research or with more immediate need for the conservation of species or habitat systems.
8. At this time, I would caution against introducing native vegetation species found south of the Wisconsin border into local Madison ecosystems, unless we understand or know that each individual species introduced will not have a negative affect on local vegetation and wildlife.
9. For the most part, the plants native to the Madison area will fare just fine with climate change if their ecosystems are managed appropriately (e.g., oak, hickory, maple, etc.). Assisted migration is probably not necessary, but habitat management is needed to ensure native spp thrive (e.g., maintaining oak forests through underplanting, strategic removal of invasives and native subcanopy species that cast dense shade).
10. I believe that it is pretentious to think that we know how to do this. We do not know how insect populations will be able to adapt to the "assisted" species nor how these species will affect native plants. Mostly what I have observed of southern species introductions is negative - aggressive species that out-compete native plants.
11. I have heard of some efforts to incorporate genetics from slightly southern geographies into new plantings to help mitigate the impacts of climate change. What this actually looks like is purchasing seeds or plugs from (for example) Illinois and planting them in Wisconsin in hopes that these plants are more well-adapted to what we anticipate Wisconsin's climate will be in the near future.
12. Climate change adaptation can also look like promoting native species that are thought to be more resilient to climate change. There are several tools related to this found online. NatureServe has a Climate Change Vulnerability Assessment tool to help you determine how vulnerable your species are to climate change. The US Forest Service has a climate change adaption workbook (focused on forested lands) that can help you identify tactics to reach your climate resiliency goals.I think it is wise to start thinking about what kind of landscape we will have in the next 20-40 years. If we don't incorporate this into our current plans, it seems probable that a lot of our efforts may be wasted or less impactful.
13. I think assisted migration is an important tool in land management, and is not at all problematic in Urban areas.
14. I think it's too early to tell. In general, I think this is not a priority at this time.
15. I'd be conservative on this. What if you bring a plant from S. IL but do not bring the rest of the community that it is in balance with in S. IL? I also dislike trees in the wrong place (sycamore and tulip poplar on prairie landscapes, etc.). Trees and shrubs native to N. IL would be better additions.
16. If we are mostly talking about roadsides and retention ponds, I don't think we have to worry much about ecosystem shifts. These are herbaceous dominated communities that aren't particularly diverse or large and aren't remnant. In these cases, it's not about creating communities that are close to remnants. It's just about getting more native plants on the ground. Also, most of the community types that would be created are grasslands, either wet or dry, so there isn't much to shift. I don't think there are projections saying that grasslands are going to become more wooded, other than via fire suppression/lack of mgmt. I wouldn't worry too much about ecosystem shifts.

17. Introducing plants that do not have a native range within Wisconsin or the midwest could present a suite of issues to the fauna that have adapted to the native communities over the course of thousands of years. The fauna native to our local ecological communities take cues from the plants that inhabit these communities. Plant development stages signal to migrating wildlife that it is time to hatch, feed, or move on, and to nonmigratory wildlife that it is time to begin the next growing season scramble for resources. If plants are introduced that begin to grow or flower outside of these established cycles that could lead to migrating species coming back or leaving earlier than they should, and having a hard time finding the resources they need to survive on their migration. Potentially causing a dramatic decrease or loss of the population, which would have rippling effects on the food web causing other species to disappear or grow to troublesome levels which impact availability of resources for the remaining species in the food web. A strategy that may be less impactful on the existing food web and ecological communities is to work on diversifying the gene pool with species found within Wisconsin that are at the northern end of their range to create a core level of diversity within our communities. Then adding to that with our native species (same scientific name), but sourcing seed from further south as close as we can get to the predicted climatic shift of Wisconsin. Doing this sooner than later will allow for a blending of the genetic diversity and a healthier community able to resist impacts of a changing climate, without dramatic swings in the availability of resources for the food web supported by the community.
18. It might be better to ask: Can public lands resist shifts related to climate change? The answer might be that resistance if futile. But, we don't know how severe the climate change shifts will be.
19. The Wisconsin Initiative on Climate Change Impacts (WICCI) is developing a detailed assessment tool and guidance document on the use of assisted migration in Wisconsin. At present, this tool is intended for use on the preservation of rare, threatened, and endangered species. Management of public lands such as greenspaces and parks should adapt to the future ecosystem states caused by climate change. The literature suggests a variety of adaptation approaches, including managing for resistance & resilience. Ecological resistance refers to the ability of an ecosystem to resist damage from external disturbances. These disturbances can be natural events such as fires, floods, windstorms, insect population explosions, or human activities such as deforestation, pesticide sprayed in soil, and the introduction of exotic plant or animal species. Ecological resistance is the capacity of an ecosystem to withstand these disturbances without undergoing significant changes to its structure and function. Ecological resilience, on the other hand, is the capacity of an ecosystem to absorb disturbances, reorganize itself, and adapt to a new environment while essentially maintaining its previous structure and functions. It is the ability of a natural system to absorb the effects of change, reorganize itself, and adapt to a new context without altering its basic structure or with only minor modifications. Management may need to cycle between "managing for resilience" and "managing for change" as ecosystems and species reach their limits of recovery.

9. What are your thoughts on using herbicides for invasive species management as part of an Integrated Pest Management (IPM) approach?

Responses

1. Use of herbicides as part of an Integrated Pest Management approach can often increase the success of invasive species control efforts. Other methods used in conjunction with herbicide can weaken plants prior to herbicide application, leading to a more effective application and less regrowth of invasive plants after application. Use of these other methods often also lead to needing to apply less herbicide at time of application and needing a fewer number of herbicide applications overall.
2. Judicious use of herbicides is necessary!

3. Herbicide is just another tool in the IPM toolbelt. In many instances, it is the only method that has any efficacy for invasive management. It's just important to apply it correctly, to include it in a broader IPM approach, and to perhaps adapt your application approach as things change (broadcast spray to hand wick application).
4. Judicious use is okay with me—for a greater good. I think herbicides can be used responsibly and for larger restoration projects are often necessary. However, I have seen large scale use of herbicides that then weren't followed up with restoration and maintenance (for instance, along the Starkweather bike path by the MATC baseball diamonds), and those areas are still choked with invasives. When using herbicide (and really for any restoration/management plan) it is important to have a follow up plan to manage the area so that the use of herbicides can be phased out and minimized due to active management of an area. Herbicides are only one tool in consistent follow-up – my current honeysuckle pull was much easier this year due to treating last year. We didn't have to use nearly as much herbicide. But if we hadn't gone back in this season, we would be back at square one.
5. Depending on the target species, herbicides are the only effective means of control. Herbicides should be used judiciously, and efforts should be made to prevent off-target impacts to other plants and to reduce any excess herbicide from creating residual impacts on soils. There are instances, however, where a target invasive plant is widespread and broadcast spraying is the only reasonable method.
6. Herbicide is just one tool in the toolbox of habitat stewardship, it has appropriate uses. However, whenever possible, alternatives to herbicide use should be implemented. These decisions should be made in consideration of a longer term management plan and according to an IPM protocol. For example, multi year mechanical methods for plant control can be useful in mitigating herbicide use. I recommend that any/all herbicides used be authorized via an internal evaluation process that prioritizes the least harmful pesticides that will still provide effective results. These include herbicides that rapidly degrade on or in vegetation, that have no to low biological activity in the soil, that have no or low toxicity on non-target organisms, and that have a low probability of escaping off site in the air or through water run-off. Avoid bee toxic herbicides.
7. Herbicides are a part of IPM, sometimes required due to time and resources, and can be a valuable tool if used responsibly. Ways to minimize herbicide impacts can include selecting the least hazardous of chemicals whenever possible, and avoiding the ones on the most hazardous lists. I recommend against neonicotinoids due to their sublethal impacts on pollinators. Likewise, it's best to avoid spraying on flowers when they are in bloom, since visiting pollinators can then be affected. One of the NHC team members recently did some habitat management at a state prairie in an endangered Rusty patched bumble bee high potential zone. I can attach the Section 7 that we completed for that, since it involved herbicides, though your projects will likely have some differences.
8. Herbicides are an essential tool. Consider herbicides as a prescription, like prescribed fire. It is how we treat the plant community to help it recover.
9. Herbicides are an important and necessary part of an IPM approach.
10. Herbicides are an important tool for vegetation management, in an IPM framework. Selective herbicides should be used when possible. Treatment timing is critical to achieving targeted results that minimize off-target damage to native species. And trained and skilled applicators are very important.
11. Herbicides are an invaluable tool in combatting invasive species. They are cost effective and when used properly can be done so without impacting plants, areas, waters, or people outside of the

targeted areas. Limiting the use of herbicides will render the cities vegetation management plan worthless.

12. Herbicides when applied correctly by trained applicators can be one of the most efficient and effective tools to manage invasive species. Most biennial invasive plants need countless hours of manual labor to handpull them without the use of herbicides. Which can be cost prohibitive when utilizing contractors for management concerns. Evaluating when a specific population is more effectively managed via herbicides or other methods should occur on at least an annual basis. Considerations should include population size, proximity to rare or conservative plants, public perspective and willingness to educate, project resource availability, and budget.
13. Herbicides, when used and applied correctly, are the most cost-effective and invasive species management tool available today, when compared to prescribed burning, hand weeding, mowing, etc. There are many invasive species, such as Reed Canary Grass, that cannot effectively be controlled through the use of non-herbicide methods due to their extensive root system and growth mechanisms.
14. I caution against widespread use of herbicides as a routine practice. However, there might be few situations where a specific herbicide can be applied after careful consideration of timing and application. An example is a grass-specific herbicide combined with spring burning to combat RCG in the first 1-3 years of mgt of monotypic RCG. This combination has been shown to facilitate eradication. Any plans to herbicide should undergo detailed review before broad application.
15. I know that in some cases, herbicides are necessary to contain or eradicate a pest species. But, as I've said above, a species should be managed only if it interferes with reaching management goal and not on its status as native or non-native or so-called "invasive" status. Always give the use of an herbicide a second and third thought before deciding to use chemicals.
16. I think herbicides are also important tools in land management.
17. I think using herbicide (as part of an IPM) is often required, but largely depends on the species you're treating and the scale at which you need to work. For small populations, hand-pulling or repeated cuttings is more feasible. For larger populations (especially of woody species), foliar spraying in combination with fall/winter cut-stump treatments may be necessary.
18. I'm not an expert at all. But in general, I think it's necessary to manage some species.
19. In order to make an impact on a landscape scale, at which many species require sufficient habitat to survive, I think that the responsible use of herbicide as one of our tools in the creation of space for native species may be essential. It would be very difficult to remove the current populations of invasive species in the area with volunteer or current personnel without a large shift in interest and investment without herbicide efficacy. Mechanical or manual control is often much more labor and time intensive and can require more long term actions. I do think that a range of tools are best employed to ensure as little herbicide is used while still achieving and maintaining the project goals of removing invasive species and increasing native species diversity.
20. Managing invasive species without herbicides will be nearly impossible. Definitely use herbicides as part of an IPM approach, especially emphasizing techniques that minimize damage to other desirable plants. Such techniques include cut-stump application, spot treatment with backpack sprayers, etc. In general, avoid broadcast spraying except when treating dense monocultures of invasives.
21. Of course small areas help species, especially insect species. I have rusty backed bees in my city of Madison yard and over 50 species of birds have visited over the decades.
22. They are an essential short-term tool for eradication of small populations of invasives, and for establishment of competive restored plant communities. They should not be a long-term tool for repeated application.

23. They are often necessary to control invasives and should be used.

10. What are your thoughts on using herbicides near wetlands, shorelines, retention ponds?

Responses

1. When used as part of an appropriate integrated pest management approach and where appropriately permitted, use of herbicide can play a role in reduction of invasive plant populations. There should be a restoration or maintenance plan in place after control.
2. OK to use, within label restrictions, as a short-term tool (along with other tools) in restoration and management process.
3. Same as above. Types of herbicides and timing might differ.
4. As above, I think it's sometimes unavoidable but should be limited to herbicides labeled for wetland use, and as part of an actual plan for a restoration and not just a one time application to knock back an invasive species with no follow-up. We should also consider other aspects of these projects. For instance, a lot of our waterways have been straightened which reduces their ability to be resilient to flooding and also can make it difficult to establish plants near the shore. As we are restoring these areas, can we also restore meanders to improve the waterway going forward? Agree with the above – I think an initial "hit" is appropriate, but we need to ask ourselves what is making it so easy for the invasives to rebound?
5. As long as the herbicide is approved for aquatic use, applied at the correct time, and part of a larger IPM approach, I'm fine with that method.
6. Each individual herbicide label contains information on where herbicides can be applied, as long as the label is followed utilizing herbicides in these areas should have minimal impacts to local wildlife.
7. Herbicide applications should be carefully considered in wetlands and other wet areas, but are sometimes the only alternative.
8. Herbicide use in aquatic environments is acceptable. The Wisconsin DNR requires a permit per the Aquatic Plant Management rule (NR107). Details on if an APM permit is required and other related information can be found at the following webpage, "AQUATIC PLANT MANAGEMENT (APM) PERMIT APPLICATION FORMS". The Wisconsin DNR has a list of approved herbicides with factsheets.
9. Herbicides will mobilize when and where stormwaters flow, and it's likely that aquatic life will be harmed in the process. Avoid herbicides whenever possible.
10. I approve of this as long as the herbicide being applied is approved for aquatic systems and WDNR has issued APM permits.
11. In order to make an impact on a landscape scale, at which many species require sufficient habitat to survive, I think that the responsible use of herbicide as one of our tools in the creation of space for native species may be essential. It would be very difficult to remove the current populations of invasive species in the area with volunteer or current personnel without a large shift in interest and investment without herbicide efficacy. Mechanical or manual control is often much more labor and time intensive and can require more long term actions. I do think that a range of tools are best employed to ensure as little herbicide is used while still achieving and maintaining the project goals of removing invasive species and increasing native species diversity.

12. Using appropriate labeled herbicides for these types of habitats may be necessary for managing certain aggressive species. Using a combination of approaches (following BMPs) will likely result in the best control of the target species v an overreliance on chemical controls. Use herbicides judiciously, and in accordance with the label.
13. Of course, permits are required for such applications. The permitting process requires your plan to be reviewed by experts and ensures that you know the laws and obligations of wetland or aquatic applications. It is more risky to use herbicides in these settings, but again it is sometimes required to achieve desired outcomes for management.
14. Ok if they are approved for wetland use.
15. Only aquatic approved formulations can be used on or near open water. It is very difficult to manage reed canary grass and aquatic invasive species unless herbicides are used.
16. Same answer as above but with the provision that only herbicides listed for use near or in water should be used.
17. See above with attention to herbicides that are formulated for use in or adjacent to water/wetlands. Decisions to use herbicides should be made w/in a larger stewardship plan (see earlier mention on decisions/principles guiding plant removal/control). For wetlands, shorelines, etc. special consideration should be used to determine if a pesticide application is warranted and elimination of a plant(s) won't simply contribute to exposed soil or dominance by a different undesirable plant.
18. There are herbicides designed for exactly this kind of work and certifications for the people using them to ensure that the work is done in accordance with good science and the law. I can understand how this might be scary but there are systems in place to ensure compliance and safety.
19. Use of herbicides near aquatic areas should use aquatic-approved formulations applied by trained applicators using techniques that minimize the amount of chemical needed for effective controls.
20. Yes, use herbicides strategically near wetlands, shorelines and ponds as along they are aquatic-approved formulations and use follows the label.

11. Fire was an important component of the historical ecological cycle in our region. How important do you consider returning fire regimens to the landscape for natural areas management? For urban natural areas land management?

Responses

1. This is outside of my programmatic expertise, but controlled burns are used across the state.
2. Very important tool! Also a great outreach opportunity.
3. Probably could be a good idea. If it can be done safely, sure. Fire is hugely important. The land around Madison was shaped by Indigenous Americans with fire and with naturally occurring fires for thousands of years. It is so important for controlling the woody brush that is choking out all of our natives and keeping our oak savannahs actual savannahs instead of maple forests. It is equally important in urban landscapes, just needs to be done on a smaller scale. Thinking about different burn times (not just spring) and how that promotes different plants is also important. People's perception is again at play here – for those of us who are a wee bit older, the Smokey the Bear campaign made people terrified of fire.

4. Absolutely critical to success. Fire is the single most effective management approach we have to restore the diversity and function of natural ecosystems in southern Wisconsin. Prescribed fire is already being safely, effectively, and widely used in Madison Parks, with excellent results.
5. Depending on the size and scope of the areas to be managed using prescribed fire, it may be more difficult in urban areas. If there are proposed treatment sites near residential areas or areas where there are people with compromised respiratory systems (e.g. hospitals, nursing homes) then prescribed fire may cause issues with those persons. For very large areas, like Madison's major conservation parks and greenways, prescribed fire may be the only reasonable management tool.
6. Fire can be the most efficient land management tool we have. And I think it's really great to incorporate it into natural areas management where and when possible. However, it can be very difficult to hold burns in urban spaces and favorable conditions are not guaranteed whatsoever.
7. Fire can take the place of myriad management activities at half the cost and time included. Fire in urban areas is just as controllable as fire in rural areas. Prescribed burning, when used appropriately and for the appropriate circumstances is one of the most powerful restoration tools available. It is not a fix all, but more of another tool in the tool box. Many native species are dependent on fire or some kind of disturbance regime. Prairies, savannas, and many wetlands are early successional ecotypes that cannot exist without disturbance and fire is the naturally occurring disturbance and also the most effective and affordable.
8. Fire is a very useful mgt tool but burning should occur only after careful assessment and planning. The purpose must be clear and potential side effects identified. For example, a tussock sedge meadow could be harmed if tussocks are ignited and valuable stored carbon is released. For fire to prevent woody-plant invasion, it should be clear whether and which woody plants are invading and where. Serious woody plant invasions should be mapped and monitored to help decide if and when to burn. In some cases, mowing might be preferable, but again, only after careful assessment and planning. I doubt that historical fire regimes could be returned, even if we knew what they were. Today's fire crews are subject to many constraints due to humidity, wind, fuel loads, and lack of natural fire breaks. How could they expect to replicate an earlier regimen?
9. Fire is essential to natural areas management in general. In urban areas, fire should be prioritized in larger properties like conservation parks, but where it can be done safely, smaller parks are fine too.
10. Fire is pretty essential to many plant communities. I did approve the use of mowing as an alternative to burning in an urban fire-dependent plant community but the result was that too much litter remained on the ground. Eventually, some native plant species were not capable of competing. Burning may be controversial or difficult for some urban residents to understand but my experience has been that once educated, people approve of prescribed fire.
11. Fire, carefully administered, is an important tool even in urban areas.
12. I believe that returning fire to our community is a very important action to returning the disturbance cycles to the landscape. I also believe these prescribed burns can be wonderful outreach and education opportunities and opportunities to gain the involvement and investment in the community while modeling a mindset of care for the land and community in which we reside.
13. If fire can be used safely and effectively, than it is a valuable natural area tool that should be considered as part of the utility vegetation management and IPM approach.
14. Important for natural areas management. For roadsides and retention ponds in highly urban areas, it may be more difficult, so I can imagine other techniques would be more appealing.
15. It is critical for natural area management. It provides so many benefits to our native species and simultaneously deals a blow to invasive populations. I think urban areas would see many of the same benefits from prescribed fire, but I also wonder if the positive impacts would be as pronounced.

Natural areas often have seedbanks of native species that are just waiting for a fire to remove the duff layer, knock back shady invasives, and scarify the seed surface, creating prime conditions for germination and growth. Disturbed areas in urban setting may no longer have this seedbank, so I would think applying a native seed mixture in combination with invasive control efforts and prescribed fire would be most effective.

16. It is Important to return fire to natural area landscapes but will be increasingly difficult and constrained by climate change: hotter and drier weather; increased severity of rainfall and increased frequency of storms, etc. Also increased population density will likely increase the difficulty of smoke management. So, alternatives like mowing might have to be employed.
17. Prescribed fire is crucial (integral) to the longevity and stability of native habitat and should absolutely be used as possible and in alignment with a conservation plant: taking into account impact (both positive and negative) on invertebrate populations and resulting vegetation response. We recommend, as site conditions permit, burning ⅓ of a given area or, at the very least, leaving areas of refugia for wildlife that - for whatever reason - may be unable to escape (e.g. insects overwintering in downed debris or standing stems).
18. Reintroducing fire into non-urban and urban native landscapes is critical to restoring the native vegetation that once dominated the Madison area pre-settlement times. Removing fire from the landscape has played a role in invasive species population growth, our fire-adapted native vegetation species can withstand fire, while many invasive species cannot.
19. Reintroduction of fire in natural landscapes can have great positive impacts. The logistics of doing burns in an urban setting may be more challenging, but as a learning experience, volunteer experience or for demonstration purposes, burning could be just as important of an educational practice as a ecological one.
20. The return of fire to the landscape is equally as important as the removal of invasive species to the health and function of native ecological communities. While at most sites removal of invasive trees, brush and monocultures of herbaceous plants need to be controlled first. True recovery of native communities through stimulation of the native seed bank cannot occur until fire is introduced to the system. Many native plants evolved and adapted to the presence of fire over thousands of years, as indigenous people used fire to protect themselves, hunt, reduce bug populations, and farm native foods. So they need the presence of fire in order to germinate and establish within the greater community. Fire also reduces nitrogen loading within the soil and most modern native communities having had fire secluded for the past century or more contain higher than historical levels of nitrogen. Higher nitrogen levels tend to favor populations of invasive species which evolved in communities that did not have the regular presence of fire. By reintroducing fire over time nitrogen levels begin to drop and invasive species begin to lose their competitive advantage favoring native species recruitment. With typically smaller acreages, greater pressure from invasive species, and greater inputs of nitrogen loading the importance of fire may be greater within urban natural areas.
21. Very important. For prairie-savanna to be ecologically significant on the landscape, large areas need to be restored. Fire is the best and most efficient way to do so on large sites, also including wetlands. My sense is that small urban sites (wetlands, prairies, woods) are more expensive per acre to burn, and more problematic due to close neighbor impacts. Parks and Engineering are probably gathering data that will allow them to estimate costs and set priorities. I expect that process will result in fewer small burn sites that could be alternatively managed with mowing.

12. Are there meaningful opportunities on public urban land to provide habitat for species of concern, uncommon species, or species that are threatened or endangered? Can small urban native plantings provide meaningful benefits for pollinators? Wildlife?

Responses

1. Build it and they will come. Native plantings and rain gardens have grant opportunities to cost share through the surface water grant program up to 1000$ per practice.
2. There are already some rare plants that are common in the nursery trade like Echinacea pallida and Asclepias sullivantii. These species are found in plantings regularly. I'm not sure it is making much of a difference in terms of the species' conservation status in WI because that is driven by the remnant populations, but its probably not hurting much either.
3. Generally yes, but it depends on the species of concern. Certain pollinators for example might just need native flowers in a backyard garden. B. affinis can be found in relatively small patches of native wildflowers.
4. Yes, the Rusty patched bumble bee (Bombus affinis) is a federally endangered species and extremely prevalent in urban landscapes. Almost the entire city of Madison is in the Fish and Wildlife Service High Potential Zone (ArcGIS - Rusty Patched Bumble Bee Map) , and we have had two nests found at City of Madison property over the past decade. We had about 100 Rusty patched bumble bees sightings reported in Dane county alone last year. Of our 100 observations from 2023, 50 were on public sites and 47 were on private, typically yards. The remaining three were either unknown or some kind of mix. The area seems to have at least a few larger public properties that consistently provide Rusty patched bumble bees that are reproducing successfully (i.e. gynes or new queens and males) each year, with many incidental observations occurring across the landscape. I don't have a clear guide on what the minimum size of habitat might need to be – or rather, while we advocate that every flower helps, in order to use resources most efficiently you may find it necessary to do some kind of tiered approach. I defer to you at the City of Madison Engineering on this; we've been cross promoting materials with the City of Madison Engineering Department lately and they/you have been doing excellent work. The recent Biobasin project for example involved a lot of native planting and within the same season one a Rusty patched bumble bee used the site. If you would be interested in using Bumble Bee Brigade data for this project please contact us at DNRFWPWIBumbleBeeBrigade@wisconsin.gov. We've been enjoying partnering with Emily and her team members and would be happy to provide the data for free (though we'd need you to sign a data sharing agreement).
5. Yes, that is what Wild Ones is all about and Doug Tallamy. Can small urban native plantings provide meaningful benefits for pollinators? Certainly! They are busy when no one is watching. Wildlife is little trickier. How about bringing back muskrats and beavers? Small urban plantings can definitely make a difference. I have been volunteering at the Dixon Street Greenway planting almost since it started, and the increase in insect populations, including the endangered Rusty Patch Bumble Bee, is astounding. One small area of public land might seem small, but if we were maintaining all of the land along Starkweather Creek, that would end up being a pretty large wildlife corridor. Smaller urban plantings are absolutely a great strategy. In addition to the ecological importance, it serves as a means of enhancing community and people's return to

stewardship of the land. Our Wild Ones chapter is finding that so many people want to build habitat in their city yards; they just don't know where to start.

6. Absolutely for any species of concern/threatened/endangered any opportunity to maintain or create space for them will help to ensure their perpetual survival. However these opportunities may be best restricted to areas where they are already present if contact with the public is inevitable and ensuring there is proper education for the public on how to not impact their populations, or creating these opportunities in areas that are harder to access. In today's fragmented landscape any island of native species can help ensure that migratory insects (pollinators), birds, and mammals will have layover areas where they can find food.
7. I think there are such opportunities, but the potential would depend on each rare species' traits, such as tolerances to potentially limiting conditions. Growing milkweed for monarch larvae does not require large areas or very specialized growing conditions. More particular plants and larger animals would require larger areas to test a range of conditions, prey species for predators, and attention to requirements for reproduction, not just growth.
8. In short, yes. Urban native plantings have been short to provide essential resources for native species including species like bats, arthropods(including plant pollinators), amphibians, birds, and other invertebrates. If we provide space in our community for these native species community members, they can be provided the opportunity to thrive along with us.
9. In terms of threatened or endangered species, the opportunities for habitat for these species is probably limited. Most of these species either have very specific niches, need a lot of area, or are sensitive to degraded systems, all of which may have been consequences of increased urbanization. Small plantings can potentially provide areas for pollinators but its important that they don't create habitat islands which may not provide long-term support for these pollinator species.
10. One issue for regarding the management of habitat for select E/T species may be the inadvertent creation of habitat sinks. These locations appear to be appealing for the species of interest, but there may be limitations on the amount of available resources, space, and other critical features necessary for successful reproduction and evolutionary fitness for the species. The E/T species may occupy the area, but then fail to reproduce, which can lead to progressive losses of E/T individuals over time.
11. Overall, I believe it is unlikely that Madison's stormwater greenways and retention ponds can provide the ecological factors/conditions needed for these species to effectively survive long-term without intervention. These sites, compared to more rural restoration sites, are subject to higher amount of invasive species introduction, chemical/salt loading, stormwater runoff from paved surfaces, etc. that in do not provide a sustainable ecosystem for native vegetation species that may have more specific condition requirements of their ecosystems. It may be worth trying to introduce these species as plugs after more generalist native vegetation species have become established at a site.
12. Pollinators yes. Threatened and endangered wildlife species are more often than not specialized species requiring larger tracts of habitat than these small parcels can provide. If I was in charge of these areas I would focus on making them attractive to generalists: installing nesting boxes, provide a variety of cover types, promote native plants that serve as food sources, etc.
13. In terms of threatened or endangered species, the opportunities for habitat for these species is probably limited. Most of these species either have very specific niches, need a lot of area, or

are sensitive to degraded systems, all of which may have been consequences of increased urbanization. Small plantings can potentially provide areas for pollinators but its important that they don't create habitat islands which may not provide long-term support for these pollinator species.

14. Yes. Absolutely and without a doubt small, urban native plantings totally provide benefits for pollinators and other wildlife. Period. Rusty Patched Bumble Bees have been well documented across large and small native plantings in the Madison and surrounding areas. Planting and restoring native habitat to provide for more spring blooming flowers and shrubs may be especially crucial to sustaining their populations, as well as those of other pollinators: including dutchman's breeches, virginia waterleaf, virginia bluebells, shooting star, currants, plums, serviceberry, and gooseberries. You can find a list of plants that the Rusty Patched Bumble Bee favors via the USFWS, this academic article by WI entomologists, or in Judy Cardin's publication.
15. Yes. To do so, the City of Madison should consider enrolling stormwater utility lands in the Monarch CCAA to demonstrate their commitment to pollinators while also obtaining regulatory certainty to aid future maintenance in the event of a monarch butterfly listing under the ESA. There is also a similar agreement in development for atrisk bumble bees that would provide some conservation and regulatory benefits to the City. Learn more at: Monarch CCAA Bumble Bee CBA.

13. How can we improve biodiversity and habitat for wildlife and birds as part of urban vegetation management?

Responses

1. Wildlife staff.
2. #1 control invasive species. #2: maintain mature forest canopy to provide migratory bird stopover habitat and travel corridors for wildlife. I have been discouraged by several stormwater proposals in my neighborhood that floated the idea of clearcutting all trees in a narrow wooded corridor and turning the area into a stormwater pond/two-stage ditch. This is a one-dimensional solution solely based on an engineering perspective. Stormwater management should be one aspect of a more comprehensive plan that also takes into account biodiversity and aesthetics. For example, explore alternatives such as installing more rain gardens in the terrace zone, offer technical and financial assistance to homeowners to install rain gardens on their properties, install permeable pavers, work with business owners to reduce parking lot runoff, etc.
3. Plant more native shrubs that produce berries, get rid of feral cats. There are three big issues that I see—invasive species growth, inappropriate herbicide use and indiscriminate mowing. I have only been working on habitat restoration projects in Madison for about 5 years, but in that time I have heard every year from someone managing a volunteer restoration project where their restoration was mowed during flowering or even worse, their project was sprayed with herbicide. This is extremely disheartening. Obviously invasive species management is also a huge hurdle. I wonder if a complete change of the way we hire people for doing this sort of work for the city could change these problems. Instead of hiring summer workers to just mow (and if you have a mower every plant looks like a thing to be mowed), what if we hired and trained people to take care of and manage a certain number of greenways? There is restoration work to do all year, it just takes different forms. Empowering people to manage their areas and giving them the necessary training and skills would mean that they are connected to their greenway and what is around it. Even better if we can recruit from people living near the areas they are managing. This is obviously more expensive than what we

are currently doing, but I think worth it. Hiring year-round positions that offer benefits may seem overly expensive, but it pays off in the long run. Having a staff of committed, educated individuals who aren't just seasonal help makes a huge difference.

4. Encourage diverse native plantings on public and private land.
5. Fulfill the commitments provided by the two agreements noted in the previous response will demonstrate commitments. Additional improvements can be considered in site-specific plans by setting objectives and targets for local sites, or groups of sites.
6. Improving the overall health of the ecological communities present by reintroducing fire, controlling invasive species and introducing native plants, will have a cascading positive effect on the populations of wildlife and birds. Increasing the number of native species present will allow for greater and more diverse populations of insects and soil invertebrates to develop on individual sites. As these populations increase small mammals which feed on them begin to increase in population which attracts the birds and larger mammals that feed on the small mammals. Furthermore looking for opportunities to create nesting structures such as snags, dead and down logs, and other hibernacula will also help to attract and keep more wildlife in natural areas.
7. Larger tracts, targeted removal of non-native species, re-introduction of tolerant natives, customized approaches for large areas, consultation with wildlife professionals on a case-bycase basis.
8. Manage for wildlife and bird habitat by enhancing native plant diversity and structure; timing management to accommodate grassland bird nesting periods, and to avoid impacts to species like turtles, salamanders, and snakes; and facilitating connections among fragmented habitats, by valuing stormwater conveyances as habitat corridors.
9. Many birds need a lot of particular habitat to meet their lifecycle needs. Unless large swaths in many areas can be restored or protected, it would be difficult to improve biodiversity. If these large areas exist (potentially in parks) it may be worth managing these areas to encourage other species. Other practices may cause public safety concerns like leaving dead standing trees. It is never a bad idea to plant a diversity of native plants – providing food sources for a variety of birds will generally promote them if other requirements of their lifecycle can be met nearby (again, you won't want to create habitat islands in these cases as well).
10. Plant and steward more native habitat. Encourage the public to do so via a micro grant program. Advocate/Require any development to plan larger areas of native vegetation for water management.
11. Plant more natives.
12. Promote species and structural diversity. That is, make sure there are lots of different species at lots of different sizes and shapes and concentrations.
13. Select native plants that have variable flowering times throughout the year and occupy different parts of a resource continuum, such as plant height, soil moisture needs if there is a gradient, and represent different functional groups of plants. This will help provide continuous resources for wildlife throughout the year and help build in species redundancy if there are changes in population sizes for any of the habitat building species.
14. SM can include experiments that test the ability to establish diverse species in various assemblages. I doubt that we know enough to plan specific plantings for varied sites.
15. Target your efforts. Not all spaces can accommodate all species. Plant appropriately, manage with the target species in mind. Aim for a variety of habitat types across the City.
16. This can be done by selecting certain sites that have greater restoration potential, and continually managing those sites in perpetuity through an IPM approach. Ideally, management at these sites will become less cumbersome over time, allowing more time/budget to maintain further sites down the road.

17. Use as many native plants as possible, plant with diversity and fit with the location in mind.
18. We can increase in areas that have native plant species present as well as native species plants and restored wetland hydrology to help provide and improve habitat for birds and wildlife.
19. Where we have opportunities we need to work to restore native plant communities. This means a great deal of work determining what impacts have occurred (e.g., water quality and flow, plant community changes, groundwater withdrawal, etc.) and whether those impacts are reversible. We also need to provide for continued maintenance of these areas in perpetuity.

14. How should urban forestry be incorporated in areas where historically canopy cover was less than 40%? In Madison, native ecosystems were dominated by prairies, wetlands, oak savannas, and woodlands that did not have the same extensive canopy cover as forests.

Responses

1. Most of the vegetation and the wildlife supported by it are already adapted to urban environments. Expanding canopy cover should be a priority, as identified in "City of Madison, Urban Forestry Task Force, Final Report For Discussion and Review – 2019". Ideally focus on expanding forest canopy cover in residential and light commercial areas where there is abundant open space and ornamental lawns. Continue and expand project with Urban Tree Alliance initiatives to identify areas in Madison for planting trees. It is not recommended to augment the canopy cover oak savannas or wetlands without prior review.
2. I think the biggest problem with this is public perception. Changing the perception of Madisonians that "forest = good" is a necessary issue. Our urban forestry should focus more on oaks (as the most important feature of oak savannahs) with other species chosen for diversity and resilience. We could also add more native thicket species to create shade with a shorter stature but higher wildlife value than our current woody invasives—these thicket species do need to be managed but are usually easy to mow a fire break around which both keeps them safe from fire but also prevents them from spreading too far. Many of our shrub species (serviceberry, elderberry, hazelnut, plum, black currant) also provide opportunities for human foraging as well as wildlife habitat. Many younger (less than 40 or so) aged people really haven't seen a true savanna. They grew up as the honeysuckle and buckthorn invasion was already here, so they feel that a dense, solid wall of green is what a forest should look like. In addition, so many people just don't really go outside as much – rather, they observe nature through their car, office, or home windows. Finding ways to personalize restoration and have people see healthy woodlands up close is a good way to reconnect them to the land.
3. All ecosystems and habitats are valid and deserving of protection or restoration. Though surely there may be local reasons to transition a woodland to forest, or a forest to a prairie, on the whole quality ecosystems should be maintained. However, Madison is mostly a highly disturbed place and what existed in a given location 150 years ago may not be very relevant anymore after so much disturbance. In addition, urban forestry canopy coverage can happen at any level – 40% canopy coverage does not define an urban forest. While not an expert on the local historical ecotype – even oak savanna whether an oak barren, opening or woodland type savanna, according to the WI DNR ER site, is defined as canopy coverage of 5 to up to 60% tree canopy in good-quality sites and up to 80% in oak woodland savanna. USDA says canopy coverage can vary but most definitions range from 10%-30% canopy coverage. Given that Madison's current canopy coverage is around 23% and development and disease, insect pressures continue to reduce canopy as a whole – preserving, supporting, and increasing canopy can be desirable where possible and appropriate.

4. Ecological restoration can not re-create the conditions of the past—no matter how much we may want to because the conditions that led to, and maintained, pre-settlement conditions no longer exist. So, the pre-settlement plant communities listed in Curtis, Vegetation of Wisconsin are not really what is attainable in urban environments. Instead, aim for a range of acceptable plant communities and species composition that are attainable in the urban environments you are working in. Plan and restore for future conditions.
5. Focusing on promoting oak and shagbark hickory establishment should be a priority within these areas; by removing invasive tree and brush species, removing mesophytic tree species especially those impacting established oak and shagbark hickories. A further consideration to help mitigate the impacts of climate change would be to leave large established mesophytic tree species (that do not interfere with the growth of established oaks and shagbark hickories) in addition to oaks and shagbark hickories. Leaving these additional species would allow for a canopy to exist in an area if a species-specific disease or pathogen came through.
6. For savanna/woodlands, inventory forests to determine if and where open-grown oaks exist. Where they do exist and if feasible, you may be able to restore oak savanna/woodland habitat. If possible, you should start by removing trees that are crowding the open-grown oaks in order to minimize urban dwellers' inevitable opposition to tree removal. Eventual removal of non-oak/hickory trees may be easier after the large oaks are cleared. In forested areas that may have originally been prairie, it is extremely difficult to control woody vegetation that has invaded the site, particularly if you can't regularly burn (every year for many years). In the case of wetlands where species like silver maples, cottonwoods and willows have come in to historical sedge meadow habitat, it may or may not be feasible to try to restore sedge meadow. It all depends on water source, quality and disturbance. In many urban areas, removing trees may result in invasion of non-native invasive species like hybrid cattails, reed canary grass and non-native Phragmites.
7. Forestry amongst buildings, sidewalks, streets and other common city infrastructure provide a lessening of the heat island affect which can be a major problem in major metropolitan areas. Since native prairies, wetlands, woodlands cannot be restored in these urban areas (not including stormwater greenways, greenspace, etc.) incorporating a larger canopy cover can provide many benefits here. In greenspace areas, you need to decide what type of vegetation community you are aiming to restore, that will tell you the canopy cover you should have in those areas.
8. Forestry is not my expertise. However, I suspect that such sites now have different hydrology, soil conditions, and grazing than they did at the time of settlement. Because trees are colonizing former savannas now, the trees are telling us that they can grow there—we just don't know exactly why.
9. Habitat management should consider the values of the current condition, as well as what the past pre-settlement "original" condition was. It may be significantly easier and less expensive to manage for a diverse, functional forest habitat than to attempt to restore a prairie, in some cases.
10. I would personally be ok with street trees being replaced by oaks and/or native prairie plantings, but I'm guessing a lot of other people would not. I think certainly larger natural areas in the city should be maintained as prairies/savannas/woodlands but street trees are probably ok.
11. I'd lean towards creating habitats that more closely reflect historic native ecosystems – and creative ways to utilize this 'green infrastructure.' Prairie plants are often more drought tolerant, don't grow through concrete, and are deep rooted enough to also be able to handle stormwater or larger rain events. Wetland plants can also be used in retention ponds, urban stormwater systems like curb cuts in parking lots or along street parking that leads to rain gardens. Again, all these potential installations create educational opportunities to learn more about theses systems, improve the

plant diversity throughout the urban areas of Madison, and also act as small habitat refuges for other wildlife that may be utilizing the city.

12. Repeated and regular prescribed burning in combination with targeted invasive removals will be the best way to get back to these types of areas. Slow and steady progress, removal of a few trees at a time while paying close attention to the understory. There is undoubtedly invasive seedbank in these areas that will flourish after the removal of canopy. Converting a forest into a savanna is similar to converting degraded areas into prairie with the added steps of tree removal, allowing the seed bank to sprout, and then killing it back.
13. Restoration of historic communities needs to be done thoughtfully in consideration of neighborhood values for buffering and screening alongside considerations for long-term maintenance and climate resilience.
14. The "native ecosystems" were human-maintained with fire in a forest climate, and are still the best targets for quality restorations and efficient management of large areas. However, if climate change is trending toward a warmer, wetter, more woodland climate, we should also be planning for future forested areas. In urban forests we should consider all the services performed by trees, like aesthetics, shading heat islands, etc.
15. This is very context dependent. Will the intensity of stewardship in these areas be more destructive to its current ecological makeup and habitat value? Are the resources and stewardship plan in place to ensure success? Are there remnant plant species that may flourish following tree removal? Novel, hybrid woodlands of mixed plant species (introduced and native) can still have habitat value and may not require attentive stewardship, thus allowing you to maximize resources elsewhere. This decision making can help avoid the temptation to overextend resources that may result in poor or incomplete stewardship activities in woodlands, leaving them worse off.
16. Yes, incorporating urban forestry would be appropriate in some areas, provided it was part of a comprehensive plan. Managing for native ecosystems take a great deal of pre-and post-work to pre-treat invasive species and follow-up with near-annual treatments for many years after. That said, managing for historical native ecosystems may not a realistic goal in many smaller parks, depending on current vegetation and public use. For example, some parks have areas of species such a black locust that area extremely difficult to control, and it may be best to just leave them as part of a forested corridor.

Carbon/Soil Questions

15. We often hear about carbon sequestration by trees and forests. How does carbon sequestration and storage differ for different ecosystems found in our region, such as prairie, grasslands, oak savannas, wetlands, and forests?

Responses

1. First, it's important to understand the Carbon Cycle. This is a pretty simple image of the carbon cycle that I frequently refer to: https://www.energy.gov/science/doe-explainsthe-carbon-cycle Within each of these ecosystems, there are carbon pools. Carbon pools are reservoirs that have the ability to emit and remove carbon from the atmosphere. This publication by the WICCI Forestry Working Group does an excellent job of explaining the different carbon pools in forests and how species and age can impact carbon sequestration. One thing to note, is that the soil is still largest carbon pool in a forest ecosystem. In prairies, grasslands, and wetlands, our largest carbon pools are in the soil. Carbon enters the soil through plants and their roots, and leaves through aerobic decomposition. In prairie systems, the deep rooting structures of plants add large amounts of

carbon to the soil. Our wetland systems are similar in that a lot of carbon is added to the soil through plants, but not as much leaves because aerobic decomposition is slowed due to the moisture levels of wetlands.

Carbon sequestration can be maximized in the soil by increasing inputs through diverse, living rooting structures and decreasing losses by minimizing disturbance. Soil disturbance through tillage or development can accelerate decomposition and result in a higher loss of carbon from the soil. It's also important to note that carbon sequestration in soil takes a very long time—decades long.

It should also be noted that Dr. Gregg Sandford at UW-Madison has done a lot of work on carbon sequestration in prairies and has extensive knowledge on soil carbon sequestration: https://jacksonlab.agronomy.wisc.edu/directory/gregg-sanford/

2. People might use the term sequestration in different ways - the first relating more to total C that is currently stored, the second relating more to how that stored C is changing (ideally increasing). An ecosystem at equilibrium may not be increasing its C storage, but just maintaining it. By maintaining the ecosystem and reducing disturbance, we can ensure that C remains stored. In that vein, one ecosystem isn't necessarily better than others for keeping C stored, other than the total stock might be bigger in one than the other. As a general rule, forests tend to store proportionally more C aboveground than grasslands and prairies do, since there is so much large tree biomass, whereas soil C stocks can be a greater portion of total ecosystem C in grasslands and prairies, due to deep-rooting plants. Wetlands have among the highest stocks of C, because decomposition is so slow in anaerobic environments. If we are thinking about changes in stored C, if it's not at equilibrium, a given ecosystem's history is relevant - restored prairies that were previously tilled for agriculture may be actively accumulating carbon, just as young, growing forests would also be.

16. The stormwater utility's land management practices have focused on removing invasive species and ecological restoration using south central Wisconsin's natural communities as reference systems. Is this a good or bad approach for carbon sequestration, and what do you see as the impacts?

Responses

1. I don't think the specific property of being invasive or not would necessarily affect C sequestration - it depends heavily on the individual species and its role in the ecosystem. Ecological restoration should be a good approach for C sequestration - in general, from a soils perspective, keeping soil covered with plants as much as possible and decreasing physical disturbances are important keys to keeping C in the ground, and even increasing it.
2. Yes, restoring native systems, especially our prairie and grasslands is important for carbon sequestration. Removing invasive species is part of the restoration process. Invasive species can have significant impacts on carbon sequestration as some invasive species can alter the carbon pools within the ecosystem. As an example, Buckthorn is allopathic and creates dense shade making it very difficult for other species to grow under buckthorn. Buckthorn essentially disrupts the natural processes that accumulate biomass and cycle carbon throughout the ecosystem. From a soil carbon sequestration perspective, it is also good to have diverse rooting structures within the soil, so having an ecosystem dominated by one type of rooting structure won't be as effective at sequestering carbon. Additionally, removing invasive species will have many other

benefits besides sequestering carbon. Management of invasive species can help ensure that ecosystems can preserve functions effectively.

17. How does carbon sequestration and storage in soils compare to that of trees for the Madison area? How does soil erosion impact carbon storage? How do different types of vegetation impact carbon storage?

Responses

1. I can't speak to Madison-specifc stocks, but I'm attaching a nice table from my go-to soil ecology textbook. If you look at the Terrestrial C Stock columns, you can see how much C is typically stored in plants vs. soil. In temperate forests, there is more C belowground than aboveground, but both stocks are large, and, of course, closely related, since it is through plants that C arrives in the soil! This is an interesting one. Dr. Asmeret Berhe and others have actually shown that - on a landscape level - soil erosion can increase soil C storage. A simple explanation is that the C rich topsoil can end up buried, where it ends up decomposing more slowly. That said, no one should ever recommend erosion as a C storage solution!! It will also depend on where that eroded soil (and soil C) ends up. There's a nice explanation of the phenomenon here: https://www.nature.com/scitable/knowledge/library/soil-erosion-controls-on-biogeochemical-cycling-of-122160904/
2. It's hard to say as there are many factors that determine carbon sequestration potential. In soils, these factors include climate, soil texture, landscape position, nutrient pools, and management. In forest ecosystems, tree species and age are additional factors. To get a better idea, look to local studies. Additionally, there are tools that can help quantify carbon sequestration:
   Soil carbon: USDA has developed COMET-Planner and COMET-Farm. It may be difficult for the City of Madison to use as the tools were developed for agriculture systems. Reach out the COMET team if interested, their customer service is excellent.
   Carbon sequestration in Trees: USFS has developed iTree. I've only played around with iTree, I haven't used it extensively. As soil erodes, it loses topsoil, which is where the highest amount of carbon is within the soil. If we are losing topsoil, we are losing the ability to sequester carbon. We will find in higher amounts of carbon in the soil in depositional areas of the landscape and lower amounts of carbon in the eroded uplands. It should be noted that there are many other issues associated with soil erosion. Soil can provide many functions such as infiltration, filtering pollutants, cycle nutrients, etc. Loosing soil through erosion will not allow the soil to function to its ability. When looking at degraded ecosystems/lands, it is best to first address soil erosion. In a forested ecosystem, I'd refer to the Carbon in Forests document above. As far as different types of vegetation impacting soil carbon sequestration, research is still needed to fully answer this question, but the main recommendation is diverse vegetation with diverse rooting structures.

Heat Island Questions

18. What is the relative impact of different types of natural land cover on urban heat island – comparing an urban forest or areas of high tree canopy cover, prairie/grassland areas.

Responses

1. The type of vegetation is less important in less developed regions; all plants respire water through a process called evapotranspiration which offers beneficial cooling (e.g. like your skin sweating during exercise), and all plants have a lower capacity to store heat which is much different than buildings, concrete, etc.

19. Would removing trees raise temperatures in a neighborhood? To greater portions of the city in general?

Responses

1. Tree removal will worsen urban heat island (UHI) effect. Trees play a crucial role in mitigating urban heat through several mechanisms by providing shade, evapotranspiration, absorbing solar radiation, pollution control, and providing wind flow. Trees provide shade, reducing the amount of solar radiation that reaches buildings and surfaces like asphalt and concrete. This shading helps keep the surface and air temperatures lower than they would be without tree cover. Trees also cool the air through a process called evapotranspiration. This process involves the absorption of water through the roots and its evaporation from the leaves, which cools the air around the trees. The absence of trees due to tree removal reduces this natural air conditioning effect, leading to higher temperatures. In areas without tree cover, buildings, roads, and other urban infrastructure absorb more solar energy and heat up more during the day. This retained heat is released more slowly, contributing to higher temperatures at night, which is a characteristic feature of the UHI effect. Trees also help improve air quality by absorbing pollutants. Their removal leads to poorer air quality, which can exacerbate the heat island effect as pollutants like ozone are known to increase with higher temperatures. Trees can influence local wind flow patterns by acting as windbreaks or channeling breezes, which can help cool down urban areas. Removing trees can alter these patterns, potentially reducing natural cooling.type of vegetation is less important in less developed regions; all plants respire water through a process called evapotranspiration which offers beneficial cooling (e.g. like your skin sweating during exercise), and all plants have a lower capacity to store heat which is much different than buildings, concrete, etc.

20. What scale of tree planting and removals are required to make a significant difference in temperatures? Is there a general ideal canopy coverage that will lower temperatures?

Responses

1. Please read “Scale-dependent interactions between tree canopy cover and impervious surfaces reduce daytime urban heat during summer” by Ziter et al. (2019). This study was conducted in Madison, WI. This article discusses tree canopy cover percentages and percent reduction in surrounding temperatures.

21. How effective are different types of vegetation at reducing the urban heat island effects? Can urban heat islands only be combated with trees, or can other plants or types of ecosystems decrease temperatures?

Responses

1. Trees are the most effective vegetation in reducing urban heat island effects, however, other vegetation including vines, shrubs, grasses, and forbs can also contribute to reducing

temperatures in the immediate area. Maintaining a biologically diverse area with plant species representing different ecological functional groups, will allow for more surface area, transpiration, and other ecosystem services as described in the response above. There are also green infrastructure methods that can be used including green roofs.

22. What temperature variations does Madison experience due to heat island effect and what areas of the city are most impacted?

Responses

1. The influence of the urban heat island effect is most pronounced during the warmest weather months and during the night. Temperatures can often be more 7-10ºF warmer in the most developed sections of the city (e.g. the isthmus) compared to rural locations (e.g. farmland/natural veg areas). The average temperature difference during summer daytime during the day is often 3-4ºF. Trees are most important in the highest developed areas that have the most impervious surfaces so radiation is intercepted and those materials are not allowed to absorb that radiation and then release it back overnight causing the elevated temperatures. rees are the most effective vegetation in reducing urban heat island effects, however, other vegetation including vines, shrubs, grasses, and forbs can also contribute to reducing temperatures in the immediate area. Maintaining a biologically diverse area with plant species representing different ecological functional groups, will allow for more surface area, transpiration, and other ecosystem services as described in the response above. There are also green infrastructure methods that can be used including green roofs.

Lake and Water Quality Questions

23. What type of stormwater vegetation can also improve freshwater ecosystems and biodiversity?

Responses

1. Having completed numerous pond restorations in the UW-Madison Arboretum including incorporation of littoral shelves and stepped underwater planting shelves (Pond 4), it would be interesting to see what pond edge and conveyance channel vegetation has been most successful as a sustained native plant community. While I don't have specific information on this, it would seem to be a good UW-Madison Capstone project that could be coordinated through Brad Herrick and Michael Hansen at the UW-Madison Arboretum. I would also be interested in fostering this in some fashion. We also have some experience in floating eco-islands (Home | Eco Islands (eco-islands.org)) on watercourse projects that are touted to have a benefit to freshwater ecosystems and biodiversity.
2. No need to overthink this one. Consistently prioritizing the selection of diverse native plant species that are suitable for the given locations will also benefit freshwater ecosystems and biodiversity. Equally important, good vegetation management planning and follow through will be critical to protecting the initial investment.

24. How do non-aquatic invasive plants impact surface water quality?

Responses

1. I don't know that I've got an expert opinion on this; however, most of the tools available to engineers for assessing the water quality treatment benefits of any stormwater feature rely on either sedimentation (and so they target suspended – and not dissolved - pollutants) or via infiltration (which don't necessarily treat the dissolved particles, but credit them as no longer being 'stormwater'). It seems to me that the potential benefit of plants would be to target the dissolved pollutants. However, this benefit only occurs if the plant material is harvested or otherwise sequestered in the pond. If the vegetation dies and is passed through the pond (either as a whole plant or as plant parts), it would seem that there could be risk of potentially making water quality worse.
2. Invasive plants are prone to creating environments dominated by single-species monocultures. These monocultures may have shallow root systems or have other features that are not as effective at slowing, infiltrating or filtering runoff. They are also more susceptible to die-offs due to disease or other environmental stresses that can create openings in the protective blanket that would otherwise cover the soil.
3. My experience is mostly related to phragmites, reed canary grass, buckthorn, and honeysuckle management. To the extent that species can be removed and then managed in quality stands of native vegetation, I strongly support the eradication in these areas and then management to keep them out. Without adequate funding to manage expansive stands of these species, they appear to otherwise provide stabilization of potentially erosion-prone lands and thus could have some surface water quality benefit, ecological biodiversity harm notwithstanding.

25. What are the impacts of soil erosion in the Madison urban area on water quality?

Responses

1. Soil erosion is significant and disproportionate problem related to any area of disburbance or exposed soil surfaces. In our urban areas, it is mostly related to construction sites where there is a failure to maintain adequate erosion control measures. It can also be associated with erosion of urban stream banks due to execessive streamflow flashiness, inadequate floodplains, sparse or shallow-rooted bank vegetation, and/or adjoining high-runoff surfaces and stormwater discharge points.
2. While soil erosion is a natural process along waterways, it is exacerbated by the hydromodification effect discussed herein. As such, as a water resources engineer attentive to the issue, I often witness eroded streambanks throughout the Madison area and surrounding communities. It seems a daunting task to address on a large scale, though in some cases invasives such as reed canary grass do a formidable job of populating these disturbed areas. While that is the case, they also can tend to mask the severity of the erosion by draping over areas of vertical erosion during growing months only to be revealed as problems in the winter. Laying back slopes (where space allows) with turf reinforcement mats/native vegetation and some level of toe protection could go a long way as a cost-effective means of stemming erosion and thus increasing biodiversity. Likewise, soil erosion in an urban area can result is sediment being transported to storm sewer systems that eventually drain to a stormwater BMPs or natural waterbodies. This can result in more frequent maintenance of BMPs for private land owners or the City and also result is a higher pollutant loading to natural water bodies.

26. What improvements to vegetation can the city make on public ponds and stormwater lands to improve freshwater ecosystems and biodiversity?

Responses

1. Soil See other responses, herein.
2. Plant and properly maintain the right vegetation as discussed in the previous responses. Strive for native perennial plant diversity within all vegetation layers (aquatic/wetland, upland herbaceous, shrub, and tree canopy).

27. What types of vegetation are most resilient to fluctuating urban hydrology?

Responses

1. Look to plants that have naturally evolved to survive in areas with fluctuating moisture/water levels. These would be species that you would expect to find growing along the margins of wetlands, streams and lakes, or that are recommended for rain gardens. An example would be species in the sedge family.
2. Native vegetation that is provided with adequate sunlight to thrive. With recognition that greenways are highly-valued by adjacent homeowners, consideration should potentially be given to "single-side takings" where the side of the channel with most access to sunlight (ie: north side) is cleared and restored with native prairie vegetation while the south side is perhaps more hard-armored while retaining a woodland/bush/savanna-type restoration. Likewise, native vegetation that is salt tolerant helps provide resiliency.

28. Some species, like non-native reed canary grass, can provide phytoremediation opportunities. What are your thoughts on this ecosystem-disrupting plant for improving water quality?

Responses

1. Because reed canary is such a prolific spreader, I would hope it is used only as a last resort and at the most degraded sites, if at all, and with containment strategies to minimize seed dispersal. Reed canary grass was historically used to help stabilize eroding streambanks (a worthy objective) and look where that has gotten us. Today, I would guess that reed canary grass is among the most widely spread and uncontrolled weeds in the state, crowding out much more desirable species and creating vast monocultures that are lacking in habitat value.
2. Where this appears to provide a specific phytoremediation benefit, I would support its use but would want the feasibility of managing the reed canary grass stand to not propagate to other areas be considered. This could potentially be managed by repeated mowings prior the reed canary grass going to seed each year. After the phytoremediation is complete, I assume it would be killed with herbicide or other means per WDNR and NRCS guidance (see links below), noting that the WDNR released the Phragmites Statewide Management Strategy in 2023. Reed Canary Grass Management Guide_0.pdf (usda.gov) Chapter 6. Invasive species and wetland management (wisconsin.gov) Phrag_StatewideStrategy_FINAL_May2023_SIGNED.pdf

29. The stormwater utility's land management practices have focused on removing invasive species and ecological restoration using south central Wisconsin's natural communities as reference systems. Is this a good or bad approach for improving water quality and what do you see as the impacts?

Responses

1. I see this as a good approach, and for all the reasons discussed in prior responses.
2. Native restorations are good but can be hybrids with adjacent easily managed turf areas (lawn or no-mow). Native restorations must be replete with a minimum of 3 years of initial maintenance and ongoing maintenance by the City (such as is being done along Wingra Creek in front of our office). The ongoing maintenance is noticed by residents and shows the City's commitment to converting a woodland area to a native-prairie area including keeping out weeds.

Conservation Land Management

30. We frequently hear concerns about mowing in herbaceous communities of various quality. Is infrequent mowing (1-2 times a year) problematic for prairies? Mixed grasslands of native and non-native cool season grasses?

Responses

1. Depends upon what the management goals are (grassland birds, species diversity, etc.) and on when the mowing is done. Take into account the needs of the species being managed for and time the mowing and its frequency to be beneficial or have the least impact. For grassland birds, one would not mow during the spring and early summer nesting season, for example. Is it clear what the purpose of mowing is? If it is to curtail woody plant invasion, that might only require mowing every 2-3 yrs. I discourage routine mowing of roadside ditches, especially where native wildflowers and native insects are harmed. Mowing strongly tends to select for grasses over forbs. Thus, native forbs need time to flower and produce seed before their habitat is mowed. If the aim is a diverse herbaceous community; avoid mowing except at 2-3-yr intervals when mowing might have justification based on science.
2. Mowing a newly planted prairie has been shown through research and on the ground practice to be an effective way to suppress annual and biennial weed species during the first 2 years after a prairie is planted with native wisconsin species. The mowing is completed usually a times per growing season for the first two years and a high blade height of about 10 inches to reduce the seed production of weed species while the prairie species are still short and putting most of their energy into below ground root system establishment. Mowing where there is a mix of cool season non-native and warm season native grasses present, mowing after the first couple of years after planting may inhibit the continued growth and survival of the warm season grasses while not negatively affecting the cool season grasses that can persist under more consistent herbivory or mowing events. This may then provide conditions in which the cool season grasses have an advantage and can outcompete the warm season grasses.

31. What are best practices for using mowing as a management tool for grassed systems with varying levels of native plant population/diversity? Prairie mowing? Mixed prairie and non-native/invasive herbaceous vegetation? Primarily non-native/invasive vegetation?

Responses

1. I need more information to recommend when and where to mow SM lands. I would avoid considering mowing as the default. What purpose is intended? What negative impacts are possible? What's the worst thing that is likely to happen if mowing were ceased or greatly reduced in frequency?
2. For systems that are primarily non-native/invasive vegetation broadcast mowing at any time is not an issue, the invasive grasses will survive. For prairie and mixed invasive/native vegetation we need to be more careful about how, how often, and when we mow. There are numerous factors such as flower bloom timing, habitat, bird nesting, etc. that can be adversely affected by mowing activities. This will need to be a site-specific decision based on long term vegetation goals. Instead of broadcast mowing to reduce woody plants, we need to ask can prescribed burning, cutting/treating, spot mowing be an option instead?
3. In all cases, there should be a specific targets and goals, e.g. reducing invasive spread, suppressing woodies to prevent reforestation, etc. In grassed systems which have cool season grasses as a component there is a chance that mowing could favor the further encroachment of cool season grasses. Cool season grasses are fast growing and able to respond to increases in sunlight faster than our slower growing warm season grasses and wildflowers. Limiting mowing in these systems to areas that have biennial and perennial invasive or non native vegetation to achieve the goals of management may be the best practice to limit the potential of stimulating cool season grasses or setting back native plant diversity.
4. No one management practice is suitable or appropriate for all grassland systems, which may have different management goals and different management needs. When mowing, mow high, say at 6", time the mowing to reduce seed producing on pest species. Mowing may also become a substitute or used in addition to prescribed burning. If the grassland is used for grassland bird habitat don't mow during the nesting season.
5. This really depends on the animal species, including pollinators, that you are trying to support. Infrequent mowing is best, after pollinators that overwinter in plant stems have emerged. The timing and frequency are not so important on non-native vegetation.

32. What are your thoughts on excluding herbicide as a tool for invasive management for large scale land management?

Responses

1. Benefits of herbiciding would have to be very large compared to damages. Are the pros and cons quantifiable? Avoid using harmful chemicals as the default.
2. Excluding herbicide would make invasive species management much more difficult. Herbicide is fine and appropriate if used strategically and following the label.
3. Given the acreage involved herbicides can become even more important to utilize especially as monetary and labor resources begin to get stretched thin. Tactic changes may also be necessary depending on available resources. One such tactic could be focusing most management on remnant habitat and high quality plantings, and outside of that using herbicides to push satellite

populations toward main populations working from the high quality areas towards the low quality areas.

4. Herbicide is needed to control specific invasive species and not all species can be controlled by using alternate means. The only instances where large scale land management of invasives is successful is through the release of biocontrol agents.
5. Herbicide seems like a necessary evil. There are certain species (e.g., reed canary grass, cattail) that manual removal doesn't make much sense at a large scale and there are others that can get so dense (e.g., garlic mustard, parsnip) that manual control would be too labor intensive to make a dent.
6. I think this would be very challenging, time-consuming, and costly… But not impossible!
7. If herbicide is excluded from large scale land management, certain invasive plant species will not be able to be managed effectively. The cost to do large scale restoration projects within the city will be much greater and more time consuming. Invasive plant species such as Reed Canary Grass, Buckthorn, Honeysuckle, Phragmites, non-native Cattail, will end up overtaking restored native plant communities in the long-term.
8. If there is a cultural or mechanical method (mowing, or grazing for example) of controlling pest pest species that is effective and affordable at scale, then use it, If not, use the most efficient herbicides sparingly and in a targeted way that is affordable at scale.
9. It is usually not very successful to completely exclude herbicide.
10. It would be folly to completely eliminate herbicide use. You might be lucky and successful on a few sites, but you would fail on many good opportunities. Herbicide treatment of small patches of some invasives is essential for controlling their spread. Others may be managed without herbicide, but not all.
11. This may be possible in some situations if enough other resources are available to manage the invasive species. This feasibility may also depend on the species that are being managed.

33. The stormwater utility's land management practices have focused on removing invasive species and ecological restoration using south central Wisconsin's natural communities as reference systems. Is this a good or bad approach for conservation and land management, and what do you see as the impacts?

Responses

1. This is a good approach. If the concern is shifting communities with climate change, I don't think prairies and savannas are particularly vulnerable other than that remnant examples are small and isolated, brush is predicted to increase, and burn seasons may be affected. But with mgmt. it should be possible to maintain these community types.
2. Good approach in general, though recognize that some species/ecosystems will take a great deal of effort to restore and maintain. Also recognize where this conflicts with older stormwater management engineering techniques such as paving stream channels. In general, I'd like to see more natural solutions, which both benefit people and wildlife.
3. I support these complementary actions: remove invaders; restore natives. Regionwide biodiversity should increase, which should promote persistence of those restored species and their services. The alternative (allowing invasive plants to dominate and spread) could result in land that is more productive of biomass and more *resilient to flooding and climate change than restored SM lands. The cost to the region (namely, further loss of natural ecosystem structure

and function) should not be considered acceptable. *Resilience needs to be clearly defined here—I mean the persistence of a system (either native or not) through disturbances and climate extremes. Under this definition, invasive RCG and hybrid cattails are very resilient. Overall recommendation: Employ adaptive restoration approaches to "learn while restoring." Field experiments can compare plantings of different species, different numbers of species, different sequences of species' plantings, different soil amendments, different maintenance, etc. Experimental treatments could be designed to help answer some of the varied questions that arise in deciding how to restore a specific site. For wetlands, consider planting tussock sedge, Carex stricta, which once dominated large areas of Wisconsin and neighboring states. Information about its propagation, planting, and *services can be found in "Tussock sedge: A wetland superplant" which is downloadable free from the Town of Dunn web site (Historic Document page at townofdunnwi.gov). *Tussock sedge can provide 8 or more ecosystem services: Supporting biodiversity, Storing carbon, Reducing flooding, Cleaning stormwater runoff, Removing excess nitrogen, Oxidizing methane, Fixing nitrogen if limiting, and Supporting wildlife, plus cultural services of Providing useful materials and Offering inspiration through nature appreciation, photography, etc.

4. I think it's good practice.
5. The question is, is this approach described above, effective in achieving stormwater utility's management goals, rather than is it good or bad. Variables I would look at: are the pest species posing a threat to move downstream and infect other areas; are they a public nuisance; do the pest species reduce biodiversity and negatively impact desirable native species? I would not remove pest species just because they are called pest species; there has to be a more critical reason for removing them.
6. This is a great approach for conservation and land management of our local ecosystems. These reference systems are the goal that restoration practitioners should aim for when planning out seed mixes, management tasks, and timelines for individual sites. Our goal should be to recreate these reference systems to pre-settlement conditions as close as we feasibly/financially can, in order to provide the best habitat for our local wildlife. Although, many human-created extraneous circumstances may prevent the most biodiverse vegetation restoration projects from being feasible in our urban ecosystems today.
7. This is a great approach, utilizing historical communities as a reference point allows for a shared understanding of a target that is being worked towards. It can further aid in appropriate species selection when looking to increase plant diversity. Selecting what disturbances are appropriate for the area also becomes easier when using a reference system. One thing to keep in mind however is that in today's landscape natural communities are highly fragmented and completely achieving the look, function and diversity of the historical version of these communities is near impossible.
8. This is the best place to start, but we should be cautious not to be too rigid with it. Remember that this model is based on a human-maintained fire regime that may not be achievable now. E.g. what was the role of less frequent, more catastrophic fires in reducing tree cover? If re-establishing native oak-hickory is successful in establishing a full canopy, are we going to cut down some of those natives to establish 50-70% canopy openings? We can grow oak-hickory in the full sunlight of priairies and savannas. Will we let them grow, burn them back, or artificially kill them to maintain open area? Adaptive management will be necessary.

34. What are some best practices for maintenance with regards to protecting existing wildlife? You may speak to your area of expertise, i.e. birds, pollinators, soil microfauna, aquatic fauna etc.

Responses

1. It really depends on the species of concern. For pollinators, management after species that winter in stems have emerged, but before the season's first herbivore eggs and larvae are present is ideal. Because no management misses everything, leaving refuge is important.
2. Most importantly, removal of pesticides - recent studies show pesticides such as neonicotinoids contaminate water, soil, plants, kill pollinators outright, sicken wildlife and birds, and are found in animal and human tissue. Plant for biodiversity and resilience. Use of cover crops, smother crops, companion plants, grazing, prescribed fire, and interseeding are preferred methods for pollinators. Interseed and/or overseed at regular intervals.
3. Reach out for specific needs. This can be very species specific. In general, adhering to timing restrictions, avoiding disturbance in certain locations or time of year, and encouraging habitat are all important considerations.
4. Reduce and eliminate pesticide applications, plant native habitat, mow less often and/or at a taller height (i.e. leave more residual), avoid soil disturbance.
5. Reducing impacts of invasive species (removal, management, etc.) and also reducing or eliminating pesticide inputs.
6. Repeated and regular prescribed burning in combination with targeted invasive removals will be the best way to get back to these types of areas. Slow and steady progress, removal of a few trees at a time while paying close attention to the understory. There is undoubtedly invasive seedbank in these areas that will flourish after the removal of canopy. Converting a forest into a savanna is similar to converting degraded areas into prairie with the added steps of tree removal, allowing the seed bank to sprout, and then killing it back. There are also many instances where specific animals or even populations should be removed for the health of the land, the community, and other wildlife within the area. Removal of herptiles in front of construction projects is a perfect example of this. Several communities within the Madison area have also contracted out the reduction of deer, turkeys, and geese in their neighborhoods. While this is a difficult decision the city should remain supportive of such efforts and employ wildlife professionals to approach these problems scientifically when they arise, and to prevent them in the future.

35. Is mowing in grass systems problematic for insects and other wildlife?

Responses

1. If by grass systems we are talking about systems similar to lawns, the research is still undecided about mowing by itself, especially related to 'no mow may' initiatives. Current best practices supported by research out of the University of Minnesota – Twin Cities include: Raise the mowing height to the highest setting to promote a healthier lawn and protect flowering plants and pollinators (in many mowers this is ~4"). Or, if possible, " letting the lawn grow to 6 in to then cut it at 4 in is exactly what we recommend for people if they're growing a traditional lawn or a pollinator lawn. That's the sweet spot for promoting both the turfgrasses and the selected flowering plants one might try to promote." – Jon Trappe, University of Minnesota – Twin Cities

Extension - More potential for flowers - Healthier, more resilient turf- More drought tolerant- Fewer pests (ex. Crabgrass, Japanese beetles) Mow when you need to, not based on what day or month it is.- Follow the 1/3 rule. "Never remove more than 1/3 of the turfgrass leaves with a single mowing."- This, combined with having a higher mowing height, results in fewer mowing events 3. Consider looking into a bee friendly lawn - Lower-input cultivars or species - 'Bee friendly' lawns with flowers (https://extension.umn.edu/landscape-design/planting-and-maintaining-bee-lawn) 4. Additional resources- The University of Minnesota Bee Lab is pivoting to "Slow-mow Summer" to encourage pollinator-friendly lawn care. They (along with Twin City Seed Company) held a zoom webinar on March 30, which was excellent (https://youtu.be/ZgFMlNFJDi0?si=DP0nEDv5gWncv_QE .). - One of the panelists (et al.) published this paper ((https://link.springer.com/article/10.1007/s11252-023-01339-7) last month. - MN Bee Lab created this catchy video last year (https://www.youtube.com/watch?v=DIbD0Y7_0Rg) If we are talking about native grass restoration systems, please disregard – mowing can be used as a management tool.

2. Depending on the vegetation composition. If there are flowers, mowing less often and leaving more residual provides cover and forage is valuable for insect life. Straight sod harbors little habitat value. Aside from a cosmetic value or public access and use (i.e. for playing fields), is there value to mowing sod? No. No there isn't. However, mowing as a stewardship tool - as an incomplete substitute for prescribed fire, to suppress woody species, to manage grass or plant dominance, or prevent flooring by noxious species - in prairies or woodlands can certainly be helpful to the plant community and completed in a way that minimizes the deleterious impacts on insects and other wildlife. Mowing annually in winter, and on a rotation of subunits throughout the year can be a way to keep grassland areas open from woody encroachment, while providing refugia of habitat, shelter and food for insects and other wildlife. Except for those that migrate, insects are present year round, and knowing where they live and the resources they need during each season should be factored into management decisions.
3. Depends. If important habitat or floral resources are mowed at key times such as June-July, then yes. Avoid bird nesting times. If mowing is timed for conservation, then the benefits to control plant competition can outweigh the temporary loss of flowering resources and habitat.
4. For some insects, possibly, while others may be unaffected. Rather than simply mowing or not, I think there can be important considerations such as mowing less frequently and at higher levels which can help in many ways. Also, allowing flowering plants (e.g., clover) in turf areas can provide resources to insects and other wildlife.
5. It depends on the timing.
6. Mowing can be detrimental if done at the wrong time: when birds are nesting or when insects are flying and foraging, or if all of the wildlife habitat in a given unit is mowed at the same time or in the same season. Leave some un-mowed lands to serve as a habitat refuge.
7. Mowing is problematic for all wildlife except Geese. Non-growing season mowing is the best option if mowing is required. Mowing should also be used to target biennial invasives such as parsnip or Queen Annes Lace, typically this is accomplished using spot mowing and only needed for 2-3 years. Repeated, regular mowings can turn high quality habitat into lawn.
8. Mowing native planted areas does increase insect mortality and predation. In part due to the actual mowing, and then in part due to the limited cover left behind, birds predate insects at a higher rate than typical. I've seen it many times, a high number of birds swooping down to catch

insects behind a mower. I've come very close to catching a bird in the face several times. However, mowing in native areas promotes native regeneration and hinders invasive plants. So, in my opinion, it is worth it, as native insects, pollinators, birds and other wildlife receive fuller nutrition and better habitat from native ecosystems in comparison to invasive dominated ecosystems.

9. Mowing twice a year with hay removal in medium-to-high-productive grassland verges promotes ground-dwelling arthropod diversity and abundance, while mowing once a year without removal leads to low diversity and abundance. For regions that have been identified as having or potential to have rare, threatened, or endangered species as identified by the Wisconsin DNR's Natural Heritage Inventory, please consult with the Endangered Resources Review staff on identifying avoidance periods.
10. Turfgrass produces minimal diversity for insects. Reduced mowing can increase thatch used for overwintering and nesting and allow for increased floral resources. The benefits to pollinators by reduced mowing is described in the new Pollinator Planting Implementation Manual developed for solar sites: https://rightofway.erc.uic.edu/wp-content/uploads/PHASE-Solar-Pollinator-Implementation-Manual.pdf. Guidance within this resource may also be useful and applicable for stormwater facilities.

36. What stormwater conveyance vegetation can also improve habitat for pollinators, birds, mammals, etc.?

Responses

1. A high quality mix of grasses, forbs, and low growing woody species when appropriate.
2. Any native plants.
3. Flowering plants that provide nesting materials, shelter, and food. A variety of heights from ground layer to mid-story to canopy levels are good.
4. I don't know of specific plants. In general, flowering plants can provide resources (pollen and nectar) to insect pollinators.
5. In general, native plants will do the trick. Specifically planting a matrix of multiple native graminoid species and forbs. The following species tolerate running water and also drier soil between rain events: (sedges) Carex stricta, Carex emoryi, Carex pellita, Carex vulpinoidea, Carex hystericina, and Carex molesta; (grasses) Calamagrostis canadensis; (forbs) Asclepias incarnata, Solidago ridellii, Symphyotrichum novae-angliae, Rudbeckia subtomentosa, Iris virginica, Eutrochium maculatum, Chelone glabra, Pycnanthemum virginianum, Verbena hastata, Eupatorium perfoliatum, Physiostegia virginiana, and many others.
6. Reach out for specific needs. This can be very species specific.
7. So many - grasses are great for lepidoptera because they hang out towards the base for shelter (see attached grasses list). Also great for nesting birds. Don't forget about woody shrubs like native and pussy willow, chokeberry, (attached tree/shrub list) The usual suspects include swamp or marsh milkweed, black eyed susan, columbine, marsh marigold, Virginia mountain mint, golden alexander, stiff goldenrod, prairie loosestrife, prairie phlox, yarrow, Canada anemone, Maximillians sunflower, Canada tick trefoil, swamp thistle, cup plant, purple prairie coneflower, gray-headed conflower, marsh vetchling, bottle gentian, wild bergamot, cardinal flower.

8. Vegetation in stormwater practices can provide a variety of ecosystem services, including benefits for pollinators and other insects. Pollinators and insects help promote vegetation establishment, growth, and long-term survivability. The Xerces Society has compiled a regional plant list highlighting native plants that are highly attractive as food sources for adult pollinators, support caterpillars of butterflies and moths, and serve as nesting material or sites for certain bees in the Midwest.
9. We think your existing raingarden programs and rainwater plant recommendations are a great way to combine stormwater management with pollinator habitat.

Pollinator/Willdlife/Entomology Questions

37. What species should we be most concerned about protecting and providing habitat for?

Responses

1. Animals, invertebrates included, are going to require more varied and diverse native habitat that mitigates the effects of climate change - particularly for protection from hotter temperatures. Planning native habitat to be a matrix of shade to full sun may provide a shelter for insect life that cannot maintain their activity during the hottest part of the day.
2. I'm not sure about concern, but a good generalist opportunity that will also help a suite of similar pollinators would be the Rusty patched bumble bee (Bombus affinis). They are federally endangered, a state species of greatest conservation need, and known to be present in Madison, WI. There is a lot of interest, education efforts, and ways to report observations already happening with them, which can help enhance your own efforts and reduce the workload.
3. Most species other than deer.
4. Native insects.
5. Overall, I'd say efforts should focus on species that are most "in need". That'd generally include insects and songbirds.
6. Preserve habitats that have or likely to have rare, endangered, or threatened species. Preserve biologically diverse areas.
7. Small urban systems should be focused on providing habitat for species that have already proven themselves in urban environments. If the city has larger systems or habitat islands it manages(>100 ac) those may be focused on species of special concern.
8. Species that can be positively-affected by utility management. If not already complete, I recommend identifying potential at-risk resources in or around the sites. Pollinators like rusty patched bumble bee (Federal endangered) and monarch butterfly (Federal candidate) are both likely examples.
9. wild native bees and wasps

38. The stormwater utility's land management practices have focused on removing invasive species and ecological restoration using south central Wisconsin's natural communities as reference systems. Is this a good or bad approach for insects/wildlife and what do you see as the impacts?

Responses

1. Good practice!

2. I generally feel this would be a good approach. Invasive species can potentially outcompete and displace native plants, which could then impact insects and other wildlife that rely on those plants, so any efforts to manage invasive species could help in that regard.
3. It generally promotes structural and floral diversity needed for insects and wildlife. However, I recommend increased consideration for cultural, novel ecosystems that can still achieve those goals, but with much less effort. Please reach out with any other questions or clarifications needed. Thank you!
4. This is a good approach.
5. This is a great approach but I would add that the cities approach seems a little scattered. In an ideal world the city could focus on the most upstream areas and work their way downstream. Areas of disturbance should have native communities established on them whenever possible.
6. Weighing out the overall impact to the environment in these situations is important for overall ecological health. For example, there are some species that are considered "invasive" plants which thrive in environments where not much else if anything can grow, and repeated efforts of removal are unsuccessful. We recommend leaving those plants alone rather than trying to repeatedly attempt to eradicate.

39. How would you prioritize conservation for species in urban areas during mowing, prescribed burning, and selective herbicide applications?

Responses

1. Addressed in previous questions.
2. Avoid treating, mowing, or burning all of a given management unit to provide habitat refuge for target desirable species.
3. Experts have already compiled resources to answer this question, I cited a source below. In my opinion though, always observe riparian BMPs, retain the proper distance from waterways when spraying non-aquatic herbicide. Perform burns in the proper windows in the spring and fall, preferably before the appearance of amphibians that were in torpor for the winter for the former. A common pitfall is that land is being managed using fire, then a rare species is observed on the property and burning is halted as a result. This typically leads to the land degrading and the loss of the rare species. Most animals have the sense to avoid fire; do not halt prescribed burns for a rare species that is there for a fire regiment. Brittingham, M. C. (2016, April 15). Management practices for Enhancing Wildlife Habitat. Penn State Extension. https://extension.psu.edu/management-practices-for-enhancing-wildlife-habitat
4. I'm not sure what the question is here: Prioritize conservation efforts in urban areas versus rural areas? or best practices in urban areas? We do not recommend use of synthetic chemical pesticides in any area.
5. Mow for a purpose and when seasonally appropriate to achieve defined stewardship objectives (e.g. woody plant control). For flower rch areas that must be mown, leave other unmown areas for refuge. You can also use a bar in front of the mower to chase flying insects away. If mowing must happen for public use or cosmetics, mow less often and leave it taller. Mow only those areas that are absolutely used, e.g. leave unmowed areas wherever possible. Use prescribed fire with purpose and according to a stewardship plan or goal. As possible, burn only ⅓ of a given area or, at the very least, leave areas of refugia for wildlife that - for whatever reason - may be unable to escape (e.g. insects overwintering in downed debris or standing stems). Resist the

temptation to achieve a 100% burned area (i.e. “all black”). Apply herbicide only when it is necessary as determined by stewardship goals; and, do so at a phenologically or biologically appropriate time that a) maximizes effectiveness and b) minimizes exposure to insect/wildlife species (e.g. when a plant is not in flower).

6. Mowing: See above note on lawns. Help operators identify invasive species and avoiding mowing before / during their seeding so that mowing doesn’t spread invasives such as the phytotoxic wild parsnip. Prescribed burning: Leave areas of refugia when burning so pockets of insects can survive and repopulate. FWS and some of our fire protocols include things like specific amounts of space, waiting 4 years or so, should we mention? Might not apply in areas as urban as this? More guidelines can be found here: Conservation management guidelines for the rusty patched bumble bee (fws.gov). Selective herbicide applications: We concur with the US FWS recommendations, “Targeted herbicide and insecticide use can be a useful management tool to control pests and invasive plants. Nevertheless, rusty patched bumble bees are unlikely to thrive if they are exposed to insecticides that are used broadly and systemically (e.g., seed coatings) or are foliar sprayed.” Select the least hazardous of chemicals whenever possible. Avoid neonicotinoids and systemic herbicides due to their sublethal impacts on pollinators. Whenever possible, avoid spraying on flowers when they are in bloom, since visiting pollinators can then be affected.
7. Tough question. I feel you’d almost need to have a baseline biotic survey to start with to let you know which species are present and also in greatest need of conservation. This could take quite a bit of effort as there could be distinct differences in the species present at various sites (wetland vs prairie vs wooded areas, etc.).
8. Upstream areas, areas of already high quality plant communities, and freshly disturbed areas will all be the easiest to convert/maintain. I would use mowing only when necessary to combat biennials or invasive brush. Large areas with potential to house species of special interest/concern should be high on the list. Completely degraded, down stream areas will be most difficult to maintain as long as there are seed sources above them. This kind of work will take several lifetimes but with a balanced approach using all the tools available in accordance with a good plan, it can be done. Herbicide use and prescribed fire are going to be the best tools for the job.

40. Given the constraints and restrictions placed on urban natural areas, should we prioritize management of urban natural areas as spaces primarily for "urban-adapted" generalist species wildlife over more specialized wildlife species?

Responses

1. I apologize, I’m a bit confused -- could you please give a specific example? My general initial thought is to do this on a location-specific, species-specific case by case approach rather than trying to limit yourself on the outset in this way. At least for insects, there’s still a lot we are still learning about the basic life cycle of some of them, and opportunities will likely arise organically on some sites.
2. I think managing sites for specific species like deer, owls, turkey, and others should not be a major priority as many of these urban sites are occupied occasionally with very few sites available for persistent use. Managing for biodiversity in an urban environment is better that single species management.

3. Specialist native bees, for example, can be found in urban and rural areas. Most of those specialists do not fly very far from their nesting area. So if they are in an urban area - that is their home range for all the resources they require. In the work we do, we do prioritize larger habitat area work over small pocket gardens. However, corridors that allow pollinators connectivity are useful.
4. Specialist native bees, for example, can be found in urban and rural areas. Most of those specialists do not fly very far from their nesting area. So if they are in an urban area - that is their home range for all the resources they require. In the work we do, we do prioritize larger habitat area work over small pocket gardens. However, corridors that allow pollinators connectivity are useful.
5. The potential for specialized species that are not already extant in the urban area is low. Generalists are easy to manage for, provide quick and notable successes, and are often enigmatic species that gain positive public attention (deer, foxes, ducks, squirrels etc) If specialized species already exist in an area, they should be given extra special attention but if they are not currently present the potential to attract them to new urban areas is very low. Slender glass lizards aren't going to stumble upon urban habitat, but red wing blackbirds will likely utilize any nesting space available and provide quite a show while doing it.
6. This question is not helpful. The two – specialist and generalist wildlife species – are not always mutually exclusive in their needs. Habitat, in many cases, can be designed and stewarded to meet the needs of both generalists and specialists. Fundamentally, if you are not meeting the needs of even generalist insects you are certainly not meeting the needs of any specialist insects. More helpful would be to approach stewardship strategies on a case-by-case basis for specialist species and species of conservation concern. And, I'd suggest starting with the question: "what more is required for a given species beyond our current stewardship plan for a given location".
7. Well, there is good evidence that quite a few species can utilize urban areas, so I wouldn't be too restrictive in the species prioritized.
8. Yes, in general. But, there may be exceptions where a given unit can accommodate more specialized species.

Stormwater Engineering Questions

41. An important function of vegetation within the urban stormwater system is to stabilize channels allowing them to convey a wide variety of flows and durations, prevent erosion and in some cases increase infiltration and improve water quality. What are the impacts of different types of vegetation for stabilizing urban channels?

Responses

1. Again, not my area of expertise, but my observation is that in areas of dense tree cover, the shading effect can prevent understory from growing resulting in bare-earth conditions which can facilitate erosion and channel degradation.
2. Generally, a V-bottom with gradual side slope, such as 20:1, will be efficient and keep the primary flow path centered in the low point of a channel. A flat-bottomed cross section may be more efficient, but it leads to channel meander/cutting. Channel meander/cutting will result in soil erosion, and it will be harder to maintain (occasionally mow) the channel.

3. My experience is that deep-rooted native plants are best at withstanding urban flows and should be accompanied by turf reinforcement mat in most cases to provide resiliency as well as appropriate toe protection. Shoulder or flank areas with lower velocities and shears can transition to no-mow or turf areas to offer a more manicured look if desired. One approach in the design of waterways or open channels is to provide different levels (i.e. low flow channel with "shelved" channel section) of vegetation based on the frequency and inundation time. This could be established based on stormwater H&H modeling results for different rainfall events at different frequencies to determine the water levels in the channel. The appropriate vegetation can be selected at different elevations along the channel based on this analysis. This approach could provide a comprehensive restoration plan that incorporates numerous plant species and supports diversity throughout the greenway.
4. Plant species that have deep root systems, provide dense soil cover, and are able to "lay down" during high flows provide the best erosion protection. Typical examples are grasses and sedges. Conversely, plants with sparse ground cover and unbending foliage (e.g. trees and shrubs) allow runoff to scour the soil surface leading to erosion and conveyance failure.
5. The benefits of streambank vegetation Riparian zones, or buffers, along the banks naturally consist of deep-rooting, flood-tolerant plants and trees that provide multiple benefits: Streambank stabilization • Native riparian vegetation has dense, deep, intertwined root systems that physically strengthen soils. • Riparian root systems remove excess moisture from the soil, making banks more resistant to erosion or slumping. • Exposed root systems provide roughness that dissipates the water's erosive energy along the banks while the plant stems and leaves provide roughness during flood flows. Water quality protection • Vegetated buffers intercept and filter out much of the overland flow of water, nutrients, sediment, and pollutants; accordingly, wider corridors are more effective at protecting water quality and promoting ground-water recharge. Riparian habitat benefits diverse riparian vegetation provides shade, shelter, leafy or woody debris, and other nutrients needed by fish and other aquatic organisms. • Wide, continuous, vegetated floodplains help dissipate flood flows, provide storage for floodwaters, retain sediment and nutrients, and provide shelter, forage, and migration corridors for wildlife.

42. What is the best design (slope, cross section, capacity) for conveying stormwater without causing flooding or erosion?

Responses

1. In my experience you cannot define a "best" design since all channel designs are site specific and must be compatible with the topography, soil conditions etc. Vegetation and energy dissipating features such as rip-rap (hard-armoring) can reduce velocity and erosion for a given slope and soil profile. But hard armoring does not enhance aquatic habitat or provide filtering like vegetation. In general, you have to design the slope to convey the required amount of water while avoiding critical and supercritical flow conditions. Natural channels may approximate a trapezoidal cross-section for purposes of calculating the flow conditions.
2. See engineering BMPs for conveyance design.
3. This should really be on a case-by-case basis considering the upstream watershed and modeled flow rates, channel velocities, and shears as well as the ability for natural channel or channel lining (ie: rip rap, turf reinforcement mat system with native vegetation, soil bioengineering

techniques) to withstand those forces. In general, having a low-flow channel concept is desirable with progressive cross section 'shoulders' for larger storm events. This should all be with the recognition that mankind has altered the natural hydrology in urban environments creating a hydromodification effect. As such, hydrology and hydraulic (H&H) studies should consider how stormwater storage in watersheds can control these "everyday" increased flows to a more manageable level in the channel. Depending on the ability of the watershed to incorporate upstream detention and/or distributed green infrastructure, channel restoration may have to be less or more robust. One example of successful channel restoration is the Manitou Pond and Natural Channel in the UW-Madison Arboretum, the concept of which was incorporated into the channel upstream of Swallowtail Pond along Pleasant View Road.

43. What stormwater conveyance vegetation is best for accommodating extreme water depth fluctuations typical in urban areas and will persist through multiple storm events.

Responses

1. For conveyances, extreme water depth fluctuations should normally short (<48hrs), if longer then armoring (e.g. rip rap, concrete) is required.
2. I would suggest a UW-Madison Capstone project to evaluate UW-Madison Arboretum and City of Madison ponds to identify native plants that have thrived in comparison to the seeded and planted species. We have found that off-the-shelf native mixes available from the various native nurseries in the state that are appropriately specified to the moisture regime in the pond and greenway section have done a good job of establishing. We have experience with custom native seed mixes on all of our UW-Madison Arboretum ecological restoration projects that have worked well.
3. This is not my area of expertise but I would say deep-rooted native plants would be the best choice for the variable conditions experienced in stormwater management areas. In general, designs to encourage infiltration would be preferred over permanent pool ponds that might encourage nuisance plants, insects and animals.

44. What wetland vegetation is best around stormwater ponds and along streams?

Responses

1. Based on research by the UW-Madison and UW-Madison Arboretum staff (see leaflet link below), we have specified tussock sedge plugs on most of our stormwater pond projects to typically augment off-the shelf native mixes from native nurseries in the state. The 2nd link below discusses some of the research done by the UW-Madison Arboretum projects that we were involved with that provide interesting insight. A few other links below are included with similar information relative to this question.
2. For ponds, emergent vegetation at the foot of internal slopes can withstand periods of inundation and submersion.
3. Various sources suggest water plantain, Hyssop, chokeberry, marsh milkweed but it seems like the species that would do well in this environment may tend to be aggressive. Again- I'm not sure there is a "best" plant as it depends on the site.

45. What are the best management approaches to minimize installation and maintenance costs?

Responses

1. A minimum of 3 years of native maintenance for native restoration projects followed by ongoing natives maintenance. Pretreatment upstream of greenways and ponds and/or frequent greenway/pond cleanups by residents. Also, consider timeframe of installation, delivery of plugs and/or native seeding, and holding time and conditions of planting materials that are delivered to the site. We provide a thorough specification for all native plant plugs and seeding in our project specifications that sets the project up for success.
2. Installation cost should be seen as investment in future performance (i.e. you get what you pay for). Maintenance requires ongoing inspection to identify and remediate problems before they become expensive (or lead to failure).
3. Prepare the area to remove invasive species and make sure seed and plants are in good condition.
4. V-shaped channel with slight side slopes to help prevent channel meander/cutting. A no-mow vegetative cover.

46. What existing resources are available to communicate the goals of the stormwater vegetation management and to address concerns of citizens over changes to vegetation on stormwater utility property?

Responses

1. Certainly; however, in a general sense, I doubt that it is significant in terms of reduction of flood risk for events beyond a certain rainfall depth. I think it should be included in consideration, but it is difficult to contemplate allowing any sort of management credit for it (in the context of a development permit approval or stormwater utility credit application)
2. Greenway tours to show the proposed changes and their acceptability. Highly suggest tree and shrub plantings on the "shoulders" of native prairie restorations for long-term reestablishment of a tree canopy that is sparse enough to allow sunlight to the underlying native vegetation. Newsletters, City website updates, email chain, etc.
3. I suggest creating short video(s) for the public that explain stormwater management goals, vegetation policy, and the expected long-term outcomes/appearance of modifications to vegetation on utility property.
4. Native vegetation with a mixture of flowering species is attractive and increase wildlife diversity for the area including birds, butterflies, bees, etc. Turf grasses and non-native species generally support a much lower diversity of species and I believe most people find a diverse native species mixture to be more attractive than turf grasses. Plant native plants to help nature | | Wisconsin DNR
5. Signs in the greenspaces informing the public about what is going on and providing sources for more information. Public meetings with real opportunities for input and questions: provide a large enough meeting space. Provide enough time or narrow the scope of the meeting so there is time for input. Show pictures of successful projects- especially if construction sequence photos are available. Explain why a particular alternative is being considered and describe other alternatives.

47. Does infiltration happen during urban flash storm events, and should it be incorporated into channel design?

Responses

1. Infiltration does occur during flashy periods but to gain a significant increase there would need to be a greater effective infiltration area and additional area may be limited in urban areas, especially existing developed areas.
2. Infiltration invariably occurs in the watershed and along the watercourse during any rain event (depending on underlying soils) but plays little role in flood control during urban flash storm events. Distributed green infrastructure plays a minor role for flood control in watersheds but can help with hydromodification. As the City has detailed H&H modeling for most of its watersheds, these models would appear to easily allow infiltration to be incorporated into channel design, though specific infiltration along the greenway would be more difficult to model and thus would likely not be incorporated into channel design.
3. Stormwater conveyance designs should prioritize infiltration. Infiltration channel design implies low velocity. In a flash storm event the primary design concern is conveyance of high flows- since these are competing goals, channels designed for infiltration could have overflow structures to convey peak flows. Even in the high flow case bypass channels can still incorporate some infiltration.
4. Typically, infiltration is incidental in stormwater conveyances when runoff exceeds a minimum volume and/or duration (depending on the underlying soils). If an infiltration basin design is integrated into a conveyance (e.g. Arbor Hills Greenway) then significant infiltration can occur. However, the public often objects to dedicating what is seen as park land to stormwater infiltration.

48. The stormwater utility's land management practices have focused on removing invasive species and ecological restoration using south central Wisconsin's natural communities as reference systems. Is this a good or bad approach for stabilizing ponds and greenways, and what do you see as the impacts?

Responses

1. Removal of invasives and restoration with native plants will make the vegetation systems more resilient and reduce maintenance due to aggressive plants choking waterways and reducing the capacity of the stormwater management function. The stormwater utility should continue this practice and as possible increase the efforts.
2. This is a good approach to stabilizing ponds and greenways. However, there appears to be little harm in flanking native prairie with areas of more manicured lawn areas or no mow turf areas if it would appease residents.
3. To the extent that native species can provide the same or better performance, at an equivalent or reduced coast of installation and maintenance, native species should be preferred.